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# WORLD POPULATION 

 CONFERENCE, 1965Volume II: PROJFCHONS<br>MBASURIMMHNT<br>OF POPULATION TRIHNDS

## UNITEDNATIONS

# PROCEEDINGS OF THE WORLD POPULATION CONFERENCE 

 Belgrade, 30 August-10 September 1965Volume III: SELECTED PAPERS AND SUMMARIES

PROJECTIONS
MEASUREMENT
OF POPULATION TRENDS

UNITED NATIONS
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## PREFACE

The Proceedings of the World Population Conference, 1965, are published in four volumes, arranged as follows:

Volume I
Summary report
Organization of the Conference
Programme of meetings
Summary report of meetings
Officers of the Conference and members of committees
List of participants and observers

Volume II
Selected papers and summaries of the papers for meetings
A.4. Future population trends and prospects
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B.1. Factors and patterns of fertility in areas where fertility is relatively high
B.2. Factors and patterns of fertility in areas where fertility is relatively low
B.13. Studies relevant to family planning
A.2. Mortality
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B.12. Population genetics

Volume III
Selected papers and summaries of the papers for meetings
B.4. Projections of population size and age-sex structure
B.5. Projections of urban and rural population, economically active population, households and families
B.6. Methods of obtaining basic demographic measures where data are lacking or defective
B.7. New developments in measurement and analysis of factors of population growth and structure
B.8. Promotion of demographic research and training in developing countries
B.10. Population and natural resources
A.7. Demographic aspects of agricultural development and food supply

Volume IV
Selected papers and summaries of the papers for meetings
A.9. Demographic aspects of savings, investments, technological development and industrialization
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A.5. Demographic aspects of labour supply and employment
B.11. Definition and measurement of economically active population, employment, unemployment and underemployment
A.8. Demographic aspects of urban development and housing
A.3. Internal migration, with special reference to rural-urban movements

All papers contributed by authors invited by the organizers for their meetings and a few selected volunteered papers are published in the alphabetical order of their authors within each meeting. Only summaries of the other volunteered papers contributed by participants are included in the Proceedings.

In addition, twenty-six background papers were prepared to summarize the state and recent developments of knowledge on the topics of almost all meetings and to provide a basis for discussion at the Conference. Most of these background papers prepared for topical meetings of the Conference will form the basis of chapters on the revised edition of The Determinants and Consequences of Population Trends and hence are not included in the Conference Proceedings.

All cross-references to papers contained in these volumes are given in the following form:

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# PROJECTIONS OF POPULATION SIZE AND AGE-SEX STRUCTURE 

## PAPERS

# Types of data and studies needed to improve the basis for population projections in Tropical Africa 

Edith Adams and P. Sankar Menon

## I. Methods of population projection currently in use

1. While some countries of North Africa and the Republic of South Africa have a history of periodic population censuses extending over several decades, for most countries of tropical Africa census-taking, in the sense of door-todoor enumeration, is a fairly recent innovation. In many of the latter countries there is still uncertainty about the total count of the population, not to mention its age structure, rate of growth and fertility and mortality characteristics. In no country of this region has vital registration reached the stage where it provides an indication of birth and death rates. ${ }^{1}$ Some of the gaps are being filled by sample surveys in selected areas, but the results remain in large part to be verified. Given this state of basic statistics, projection work thus far carried out for countries of tropical Africa has had to rely very heavily on various types of demographic models. Models have been used for the adjustment of age data available for the base date, as well as for the calculation of expected survivors at future dates.
2. Recent population projections by sex and age groups have been prepared by various experts for nineteen countries of tropical Africa. Utilizing these projections, the United Nations has prepared estimates of future population for three major regions of tropical Africa, and for individual countries for which

[^0]no independent projection was available. ${ }^{2}$ A uniform level of mortality was assumed for the three regions, while fertility levels were assumed to vary according to the findings of recent sample surveys. The margins of uncertainty in the assumptions are large, and extensive revisions in the projections may be required as new information becomes available.
3. The lack of reliable data and the necessity of deriving mortality and fertility indicators for African countries has led to the development of a number of ingenious analytical techniques. Thus, a method has been devised by Brass for analyzing retrospective data on the total number of children born to reporting women in conjunction with current data on births occurring in a 12 -month period, to derive adjusted fertility rates which are believed to be more reliable than those furnished by either set of data alone. ${ }^{3}$ The same author has devised a method of computing life table functions for infancy and childhood from data on the total numbers of children born and those who died. ${ }^{4}$ Model life tables constructed by Coale and Demeny, ${ }^{5}$ which allow for greater age-to-age

[^1]variations than do the United Nations model life tables, are shown to have certain advantages over the latter for projections of African populations. ${ }^{6}$

## II. Needed improvements in basic pemographic data

4. While such methods of analysis are invaluable for dealing with the deficient demographic data currently available for African countries, it is agreed that they are only interim tools, and that efforts must also be directed toward improving the basic statistics, particularly with respect to the demographic components specified below.

## 1. Total population count

5. There appears to be no adequate substitute for a door-to-door census enumeration to obtain an accurate count of the population. As such enumerations have become more frequent in African countries, the deficiencies of previous population counts derived from administrative censuses (in a number of cases amounting to as much as 20 per cent) have been revealed. ${ }^{7}$ While sample surveys have proved a reliable means of obtaining data on the characteristics of a population, they are less satisfactory for determining its total size.
6. In view of the special difficulties of census-taking in tropical Africa, it would seem important that the census plan incorporate a system of post-enumeration field checks. Such a check in Ghana, for example, tended to confirm the census result, which was much higher than had been expected on the basis of previous enumerations.
7. In taking the census, special attention is required to ensure that certain groups which are difficult to enumerate, such as men in the mobile young adult ages, are not omitted. Census and sample survey statistics for most African countries show a deficit of males, and it has not been established whether these deficits are due to emigration, mortality differentials, or to shortcomings of the enumeration.

## 2. Age structure

8. The reliability of age data obtained from censuses and sample surveys in countries of tropical Africa is generally poor. Systematic biases in age reporting appear to be present, among the more common being the tendency

[^2]toward over-statement of age on the part of girls who have recently reached puberty, and the tendency for teen-age boys to understate their ages.
9. In some enumerations a differentiation has been made only between broad groups of the population, the simplest such division being between "children" and "adults", since efforts to obtain age reports in greater detail than broad groups were thought unlikely to succeed among a population where birth dates are not readily known. The fact that age in completed years has been asked in more of the recent censuses and sample surveys indicates a growing optimism that efforts to obtain detailed age reports are worthwhile. Despite the errors involved, there are advantages in recording age in single years and later combining them into broader groups according to specific needs. Moreover, attempts to obtain more accurate age reports by reference to calendars of local events and by taking into account indigenous methods of reckoning age have shown promising results. Blacker has outlined how "age grades", which have great significance among the Kikuyus, can be converted to age as customarily calculated with a fair degree of accuracy.s He points out that age grade systems vary even among peoples living in close geographical proximity, and that this method of obtaining improved age reports appears to be applicable only in small-scale sample inquiries rather than in censuses. Data derived in two sample surveys where this method was applied were more free of digital preference than were census age data, but it was not clear whether the biases of age reporting peculiar to African populations had also been reduced. Clearly there is need for further experimentation with various methods of obtaining more accurate age reports for African populations. While age reporting can be expected to improve with social and economic advancement of the population, for the time being special techniques for assisting respondents in determining age will need to be developed in the light of prevailing cultural patterns.

## 3. Vital rates

10. The attainment of an efficiently functioning vital registration system should be a long-term objective in Africa, as in other developing regions, and recommendations have been made to establish such a system, at first in a sample of registration areas which can

[^3]later be extended to cover the entire country. ${ }^{9}$ Since complete vital registration is not likely to be achieved in the countries of tropical Africa for some time, sample surveys will continue to be the principal source for measures of birth and death rates. In view of the reliance which must be placed upon these surveys for the present, there is an immediate need for verifying their results. Among the methods of verification which have been proposed are the checking of events reported in retrospective surveys with results obtained from periodic observations of the household, or contintuous recording of events by resident investigators, who are required to search out the events instead of depending on the community at large to report them. ${ }^{10}$ The relative high cost of this procedure is a disadvantage, and it has been suggested that individual matching may have to be confined to a sub-sample, and adjustment factors worked out to apply to the results of the sample as a whole. ${ }^{11}$
11. Methods of verifying birth and death rates derived from surveys have been little tried in Africa. Two experiments with periodic household observation in Guinea and the Ivory Coast, as a means of checking data from retrospective surveys, lend some support to the theory that there is a systematic tendency in Africa to report events which occurred outside the time reference period. Such a tendency was also found in an evaluation of retrospective survey data for Morocco. Considerable errors emanated both from post-dating and pre-dating of events, but the former outweighed the latter, and the net error of over-enumeration was 3 per cent in the case of births and 10 per cent in the case of deaths. ${ }^{12}$

## 4. Migration statistics

12. Although migration across national boundaries is known to involve considerable numbers in parts of Africa, and the direction of some of the more important streams of migrant workers is known, there are few reliable data on the numbers of migrants and their

[^4]characteristics. Such data are indispensable, however, for the evaluation of other demographic data now becoming available. Population censuses can provide useful data on migration if they include questions on place of birth and preferably also on length of stay in the area where enumerated. Data of this kind obtained in the 1960 census of Ghana showed that there was an important net immigration which helped to account for the large $1948-$ 1960 intercensal population increase. The collection of direct statistics on migration must also be attempted, although it presents extreme difficulties in the African setting, where ethnic groups are often divided by national boundaries which are frequently crossed on foot at entry points too numerous for observation. In addition, small-scale intensive studies will be needed to provide an understanding of the social and economic factors associated with migratory movements.
13. Data on international migrants by sex and age groups may help to explain the peculiarities of sex ratios and age structure observed in many African populations. If the deficits of adult males are due to out-migration, as has been suggested in a number of individual country studies, it would be incorrect to adjust the data for projection purposes by substituting the sex and age structure of stable population models. If, on the other hand, migration statistics do not confirm that many adult males have left the country, the deficits may rather be due to census omissions of a highly mobile group frequently absent from their usual place of residence; such a finding would necessitate adjustments in the base data used for projections. The fact that such deficits appear even in the statistics of some countries of presumed immigration-such as Uganda and the Ivory Coast-and that for the continent as a whole their sum has been calculated at a sizable figure, ${ }^{13}$ lends support to the latter hypothesis, but further evidence is needed to reach definite conclusions. The possibility that such imbalances in the sex ratio might be partly due to much higher male than female mortality at early adult ages must also be examined.
14. Data on internal migration, which can be collected in population censuses or sample surveys-or possibly in the course of continuous population observation experiments-are needed in tropical Africa, as elsewhere, to provide a basis for urban and rural population projections. Rapid growth of their primate cities is a major concern of some African govern-

[^5]ments, and projections of future population trends in these cities and in other urban and rural areas may improve the accuracy of national projections and provide a basis for sound regional programmes and policies.

## III. Needed studies and research

## 1. Evaluation of rates of population growth

15. In choosing assumptions for population projections it is important to know at what rate the population has been increasing in the past. Such information is difficult to obtain for countries of tropical Africa because census enumerations have varied in their coverage or efficiency. In some cases it is believed that improved enumeration in the recent census has led to an exaggerated inter-censal growth rate. There is also a suspicion, though no proof, that some recent enumerations may have given too high a population total. Detailed analyses of results of previous census enumerations and of existing administrative reports and studies of scholars might throw light on the rate of population growth in the recent intercensal interval; these findings would have to be checked for consistency with the rates of growth indicated by current estimates of fertility and mortality levels and, where important, the volume of international migration.

## 2. Fertility studies

16. Recent studies have brought out the remarkable disparity of birth rate levels in different parts of tropical Africa. Such variations in fertility levels apparently exist, despite the fact that the countries concerned do not differ much in the level of economic and social development. As shown in the United Nations study, gross reproduction rates range from an estimated low of 2.1 in Gabon to above 3.5 in Nigeria. ${ }^{14}$ It is important to discover whether such differences have long existed, or are temporary in nature, since the answer has implications for assumptions of future changes. Countries with lower fertility rates in this region have been generally found to have high sterility rates, and this suggests that health factors may play an important role in determining fertility levels. Evidence of a high incidence of sterility rests on the large proportions of women past age 40 reported in some surveys as having never borne a child. Verification of such reports is essential to ensure that estimates of fertility based on them are not biased by the misinterpretation of "non-response" as indicating "no children". If health factors prove to be the

[^6]major cause of the lower than average fertility levels existing in some parts of Africa, improvements in nutritional levels and control of steril-ity-producing diseases may well bring a rise in fertility; population projections prepared for such areas would need to take account of the likelihood of such a development.
17. Investigations of the effects of certain social and cultural factors on fertility are equally important. Little is known of the effect on fertility levels of detribalization resulting from migration to the towns, attitudes toward desirable birth intervals and methods of achieving them, polygamy, and the emigration of males to work for long periods. While some of these factors have been examined in isolated field studies conducted by anthropologists, the findings have often been inconclusive because a firm statistical basis was lacking. The greater attention paid to statistical methods in the planning of some recent anthropological field studies is, however, encouraging. ${ }^{15}$
18. The data on births by age of mother which have been collected in sample surveys carried out in tropical Africa show a rather distinctive fertility pattern characterized by high proportions of total fertility attributable to young women 15-19 years of age. Such a pattern is consistent with the prevailing custom for girls to marry soon after puberty. While it appears to be reasonable, the age pattern of fertility shown by the survey data needs to be further verified, since it is not known how it may be affected by errors in age reporting. Such analyses may lead to the development of model age-specific fertility rates for use in population projections for the countries of tropical Africa.

## 3. Mortality studies

19. Information on mortality in tropical Africa is even more deficient than information on fertility, and at present it is not known to what extent sex and age patterns of mortality may differ from the various models which have been constructed on the experience of peoples of other continents. There is more knowledge of infant and childhood mortality rates than of adult mortality, owing to special investigations which have been undertaken and to the techniques devised for obtaining such information from retrospective survey data on the total number of children born and the number who died. The first tentative age-specific mortality rates now becoming available need to be verified by further surveys and registration schemes,
is See, for example, Edwin Ardener, "Divorce and fertility; an African study", Nigetion Social and Economic Studics, No. 3 (London, 1962).
with a view to eventually devising model life tables particularly applicable to African populations. As guides for setting assumptions of future mortality decline, studies of cause of death are needed. Where infectious diseases play the most important role in maintaining high infant and child mortality, the prospects for a rapid reduction in the death rate, with the extension of medical services, would appear good. If, on the other hand, high mortality results primarily from malnutrition and poor living conditions, improvement will depend on a significant raising of living standards-requiring a longer time period. Under present African conditions neither vital registration systems nor retrospective sample surveys can be expected to provide satisfactory data on cause of death; it is likely that such information
can be obtained only through small-scale surveys carried out by medical teams. Studies of differential mortality-particularly in urban and rural areas-are also needed. Preliminary indications point to higher rural than urban mortality, at least among children, despite poor living conditions in the latter areas, ${ }^{16}$ but results are far from conclusive. If urban death rates are substantially lower, owing to better coverage of medical services and better sanitation, rapid urbanization-which now seems to be taking place-will be a factor favourable to mortality decline.
[^7]
# Schematized local projections in connexion with a population census 

Bjørnulf Bendiksen

## I. The interest in regional statistics is INCREASING

1. The interest in statistical data for various geographical subdivisions of a country appears to be increasing. This is chiefly due to the fact that the political authorities are increasingly interesting themselves in regional development. In this work the authorities require more regional statistics. In the private sector the interest in regional statistics is also increasing. This is especially the case regarding market research institutions and sales departments.
2. In regional planning we soon arrive at the point where regional population forecasts are required. Such forecasts are of considerable value in planning the future building of dwellings, official investments in schools, hospitals and homes for the aged and in estimating the future active population of a region, future social budgets, etc.
3. Regional population forecasts will usually be less accurate, the smaller the regions are. This may lead some demographers to think that they should not engage in making projections for small regions. The need for such forecasts is so great, however, that they would be made whether the demographer participates or not. If the demographer is not willing to help, others who usually have less experience in forecasting will have to take his place. The forecasts must, however, be regarded as "normal-forecasts" and they should be adjusted by others containing accurate knowledge of local conditions.

## II. Principles in making population forecasts for geographical subdivisions of a country

4. In general, population forecasts for regions of a country should be based on models which include not only demographic factors, but also economic and social factors. In this way it should, in principle, be possible to take into account the real combination of forces contributing to the population development of the region. It is, however, impossible to use such "all-inclusive" models for small regions
today. In the first place we have too little knowledge of the underlying casual relationship, and secondly, even if we had a good and tenable theory, we have usually not the statistical data needed for a more sophisticated model. As a consequence, regional population forecasts must be based on very simplified assumptions, and in most forecasts only demographic factors are taken into account. Various methods have been used in regional population forecasting.
5. Forecasting by extrapolation is often used to estimate the total population within a limited number of regions. The most simple form of extrapolation is the graphic extrapolation. Even if this method is not used very much by demographers, it is often used by others. If extrapolation is made by means of mathematical functions, some modifications and refinements may be introduced. The Gompertz curve and the logistic curve have been widely used in extrapolation. If we are interested not only in the total population of the region, but also in the age distribution, extrapolations are usually insufficient.
6. The relationship between the growth of population in a region and other variable has often been used in regional forecasting. Often the other variable has been the growth of the population in the country as a whole or in another region, but factors such as employment, industrial production, income etc. have also been used. Even the relationship method is seldom suitable for age-distribution forecasting.
7. The "growth-component method" (also called component method or input-outflow method) is a group of methods most widely used in population forecasting. These methods usually take into account the age distribution of the population and "explain" how a future population distribution develops from an existing one. If the necessary data are available, these methods are also well suited for regional projections. Some of the problems met in such projections will be discussed in this paper, and it will be demonstrated how the method has been applied in local projections in Norway in conjunction with the 1960 population census.
8. Population forecasting by means of the growth component method and with specification of detailed age-distribution requires a great number of arithmetical computations. As long as the demographer could only make use of "conventional" facilities, it was not found practicable to make such projections for the many hundreds of administrative subdivisions of a country as a routine service of the central statistical offices. $A d$ hoc projections were instead made when they were demanded, but they were, however, as a rule made by simplified methods.
9. The appearance of the electronic computers in the 1950's threw a new light on this problem. The manual work was in the main eliminated, and it was possible to concentrate on the problem of choosing an appropriate model for the projections, and to get reliable data to feed into that model. Even in Norway, where a rather detailed model was applied to local projections in connexion with the 1960 census, and where the computations were executed on a small computer (IBM 1401) the computing time for each commune (including reading and writing) was only a matter of seconds.
10. As is well known, the growth-component method can in general be described by the formula:

$$
P^{t}+\Delta t=P t+B \Delta t-D \Delta t+I^{\Delta t}-O^{\Delta t}
$$

where $P^{t}=$ the population at the time $t$;
$B^{\Delta t}=$ the number of births during the time interval $\Delta t$;
$D^{\Delta t}=$ the number of deaths during the time interval $\Delta t$;
$I^{\Delta t}=$ the number of in-migrants during the time interval $\Delta t$;
$O^{\Delta t}=$ the number of out-migrants during the time interval $\Delta t$.
Instead of the two components $I^{\Delta t}$ and $O^{\Delta t}$ the net migration $M^{\Delta t}=I^{\Delta t}-O^{\Delta t}$ may be applied.
11. If the formula is applied in the above mentioned form, only the total population of the areas is taken into account and not the age distribution. The method is in this case very similar to the extrapolating method. The number of births are estimated by means of the crude birth rate, the deaths by the crude death rate and the number of migrants by means of the crude net-migration rate. In local projections the net migration rates should vary from one subdivision of a country to another. In most cases the birth rates should also be adjusted according to local experiences.
12. The great advantage of the growthcomponent method is, however, that it can also
be applied in forecasting future sex and age distributions. In forecasting future age distribution in subdivisions of a country, most problems met are of the same nature as in forecasts for the whole country, but there are also special ones:
(a) The time intervals applied in projections are usually one-year or five-year intervals, but ten-year intervals are also applied;
(b) The intervals used for the age distribution should be a factor of the time interval. This means that if the time intervals are one year, only one-year age groups can be used; if the time intervals are five years, one or fiveyear age groups are appropriate. If the projections are given only for ten-year intervals, we may choose between one, two, five or ten-year age intervals;
(c) As a base for the projections we need a detailed sex and age distribution of the population in the various subdivisions. Census data are usually very appropriate as base;
(d) The number of births can be estimated by such means as the general fertility rate, agespecific birth rates or by means of fertility rates specified by duration of marriage. A special problem in projecting the population within the various subdivisions is the geographical variation in birth rates. In most cases such variations should be taken into account. When this is done, it is possibie to have a "better" projection as to the number of births in the country as a whole by adding up the estimated number of births in various subdivisions. Estimating the births by districts implies that the observed fertility rates are weighted by the future geographical distribution of the population;
(e) In most cases the regional differences in mortality are so small that they have only a minor effect on regional projections. As a consequence they may often be neglected;
(f) In projections for small subdivisions of a country migration plays an important part. It is usually more important the smaller the subdivisions are. In taking the migration factor into account, two main problems arise. The first one is purely statistical: how to obtain reliable data on migration in the various subdivisions of the country. Countries having population registers will usually be able to produce all the migration data needed for local projections. Other countries may, for each local district, estimate the average net migration for various cohorts between two population censuses. The second problem is how to apply the migration data in the forecasting procedure. If we wish to obtain consistence between total in-migration and out-migration, we cannot confine ourselves
to the migration rates alone. Either adjustments have to be made in the results obtained when the migration rates are applied, or we have to base the migration assumptions on a model which automatically brings total in-migration and out-migration data in consistence with each other.
13. In some papers on projections of population in subdivisions of a country it is held that since future internal migration is very difficult to forecast, it is better to make projections without taking migration into account at all. It is claimed that it is better to leave it to the planning authorities and other interested parties to make their own assumptions with regard to migration. The author of this paper is opposed to this viewpoint. It is of course true that the planning authorities, who often deal with only one or a few communes will be in a much better position than the central statistical offices to estimate the future migration to or from these municipalities. The problem of forecasting cannot, however, be solved only by adding or deducting the number of migrants to and from sets of "base" projections which do not consider the migration factor. We must also take into account the further demographic consequences of the migration factor. Especially do we have to consider the fact that the most typical age groups for internal migration are the groups between 15 and 30 years of age. But these age groups are also the most fertile ones. If we leave it to the "consumers" of the projections to make their own assumptions regarding migration, we also leave it to them to make allowances, especially regarding births, but to a minor extent also regarding deaths, for the induced consequences of the migration. In most cases it seems to be better for the consumers to have projections including a "normal" migration to or from the various municipalities. If the consumers feel that the future migration will differ from the migration allowed for in the projections, the corrections they have to make will usually be less if "normal" migration is included in the projections than if no assumption about migration has been made at all.

## III. An example of a population projecTION FOR COMMUNES

14. In comnexion with the population census in 1960 and with the census data as base, the Norwegian Central Bureau of Statistics in 1961-1962 made population projections for each of the approximately 700 communes in Norway. As mentioned in paragraph 9, the computations were done on a small computer. The data were published in booklets (one booklet for each
commune) containing all the main census results for the communes), ${ }^{1}$ Some details as to the method used, assumptions etc. were as follows:
(a) Five years time intervals were applied and projections made for 1965, 1970, 1975 and 1980;
(b) Projections were made for one-year age groups up to 44 years for women and up to 14 years for men. Projections for each commune were only published for age groups 0-6 years (pre-school population), $7-14$ years (primary school population), 15-19 years (secondary school population), $20-29$ years, $30-39$ years, etc., up to 70 years + . All input data on sex and age distribution were produced automatically during the census processing and stored on magnetic tape. In this way manual punching of the data was avoided;
(c) In accordance with the declining trend in mortality, it was, with some modification, supposed that the age-specific death rates would decline geometrically. Since the regional differences in mortality are small, it was not found necessary to consider such variations;
(d) As to fertility rates it was not considered sufficient to take the differences in birth rates between the various countries or main districts into account. Within each county or main district there are great differences in fertility according to the socio-economic type of the communes. After having multiplied the one-year age distribution of women in each commune by the corresponding (1-year) fertility rates for the whole country, the result was multiplied by a "correction factor". This factor was, with some modifications, derived by comparing the actual number of births in a preceding period with a theoretical number assuming the same fertility in the commune as in the country as a whole. It may be regarded as superfluous to use 1-year age-specific fertility rates in estimating the number of births in each commune. The reason why this was done in the Norwegian projections was the desire to add the commune data for regions and get "good" projections both for these and for the whole country;
(e) In the Norwegian "migration-model" the communes are grouped in three categories: communes with net out-migration, communes with net in-migration and communes with inmigration and out-migration approximately in balance. The out-migration communes were again divided into four groups according to the relative size of the net migration. Based on the migration-frequencies in each group of communes in 1957-1959 and specified by sex and
[^8]5 -year age groups, the future out-migration was projected. After allowances were made for future emigration, the total population lost by out-migration communes was divided between the in-migration communes. For each 5 -year group this was done according to the distribution of net in-migration for the communes in 1957-1959.

## IV. Adding projected commune data

15. The projections for communes may be added and thus give projections for greater subdivisions of the country. In conjunction with the Norwegian projections another interesting application of the commune forecasts has been demonstrated. ${ }^{2}$ The various communes were grouped according to their socio-economic type in the following groups (based on census results):
Densely populated communes:
(a) Towns;
(b) Suburban communes;
(c) Industrial communes;
(d) Other.

Sparsely populated communes:
(a) Agricultural and fishing communes;

[^9](b) Other.
16. For each of the groups, the projected commune data (by sex and age) were added. The results indicate among other things that whereas the population in the administrative towns will increase only in approximately the same proportion as the country as a whole, the population in the suburban communes will increase by $60-70$ per cent in the next 20 years. As many young families are moving into these communes, the number of pupils in secondary schools will increase by 75 per cent if only the same proportion of persons in the age group $15-19$ years goes to these schools. This proportion is, however, also expected to increase. In contrast to the densely populated communes ( 1960 status) the population in the sparsely populated communes is expected to decrease. In the agricultural and fishing communes the population, according to the projections, will decrease approximately 10 per cent.
17. The forecasts by communes, regions of the country and "types of communes" have attracted a great deal of attention in Norway. The results have been much discussed in the newspapers and among officials and politicians. The Central Bureau of Statistics has consequently decided to refine the methods used and in the future to make more frequent projections.

## Success and failure in population forecasts of the 1950's; a general appraisal

John V. Grauman

## I. The profession's embarrassment in 1954

1. Failure of population projections of the 1940's overshadowed this topic of discussion at the 1954 World Population Conference. ${ }^{1}$ Prediction is the aim of science, demography is a science, but disarray had induced such humility that a demographer speaking in 1954 of "forecasts" rather than "mere projections" might have been censored as rash; yet predictive relevance would ordinarily be implied in such an exercise. Times have changed much since 1954.
2. In the 1940's, the world's most favoured provinces had been re-visited by nationally organized violence; yet only in these parts had efforts aimed at economic and social betterment by then become systematic. Another pro-fession-not demography-had been more disastrously misguided, and possibly still is. But during the calmer 1950's technocratic development efforts of varied inspiration became world-wide and the need for population forecasts is now universal. The standpoint of 1965 differs from that of 1954, but this is no cause for complacency: already, times and requirements are changing again, yet forecasts must be directed into that uncertain future. As parents of a generation destined to live into the coming century, we are intimately concerned with conditions of welfare during the decades ahead.
3. Seven of the 1954 conference papers dealt with projection methods on the national scale, ${ }^{2}$ including one of well-intentioned pessimism ${ }^{3}$

[^10]and another (this author's) of naive optimism. ${ }^{4}$ Two papers covered those respects in which forecasts had not done too badly, ${ }^{5}$ and one showed a method that, had it then been used, could have identified stabler trends below the temporarily disturbed surface. ${ }^{6}$
4. It is worth noting that only two papers then had concern with methods for the world's countries of poorer statistics, and of these, one referred to methods then already out-dated. ${ }^{7}$ Consequently, the 1954 conference saw only one paper which showed a successful adaptation of modern procedure to the needs of a modernizing country. ${ }^{8}$ Elsewhere at the conference, as was then usual, projections for technologically retarded countries erred by much underestimation of their fertility. ${ }^{\text {a }}$

## II. Why that disarray?

5. The causes of embarrassment in 1954 can now be clearly seen. First, a victory of more

[^11]refined over cruder forecasting methods had taken place in the 1930's and had led an interested public to expect much of demographic techniques. Secondly, the new refinement was insufficient for the rapidly changing circumstances of the 1940 's and the public, having expected too much, was all the more severely disappointed. In the third place, the more refined method failed for essentially the same reason as did the earlier crude method.
6. The earlier method had been the extrapolation of population totals by mathematical curve, but no curve was fine enough to pay respect to each of the trends developing separately in the "component" factors of births, deaths and migration. The new method extrapolated the "component" trends, with evidently greater flexibility and refinement, and yet remained insensitive for the detection and projection of significant shifts in "sub-components", such as age at marriage, intervals between births, ultimately desired family size, etc.
7. We now understand that prediction of any social phenomenon can at best only be an extrapolation but, with varyingly refined judgment, such extrapolation can be applied to relevant components or sub-components of any statistically attainable level. At different times, and under varied conditions, good population forecasts may have to be made in quite different ways.
8. The chief virtue of the newer methods was not the attention paid to "components", but the necessary "age-specific-ness" of the projection. Vastly more information results from a population forecast by age groups than from an extrapolated aggregate, and that information became especially useful when interest in economic and social needs became so detailed. Cannan had recognized this as early as 1895 with a success sufficient to shame his critics even 36 years later. ${ }^{10}$ In the 1920 's, Bowley pioneered in serving the League of Nations with socially interesting age-specific projections. ${ }^{11}$ The method became respectable practice in Europe,

[^12]North America and Japan in the 1930's; ${ }^{12}$ additional work along the same lines might have consolidated ground being gained but, in the $1940^{\prime}$ 's, the ground itself was severely shaken.
9. Projections done during that insecure time were clearly labelled by their authors as "illustrative" or "speculative," and the experts warned against the dangers of their misuse. Juridically, therefore, they were "not guilty" of misleading the public. But responsibility is not escaped so lightly. More than speculative work had been hoped for during such crucial years for which the experts had not been prepared. As far as an anxious public could understand, the forecasts had gone wrong. The whole profession suffered a loss of prestige which it took the work of another to recover. It is tragic that a disenchanted public attached small importance to demographic research during that decade when 500 million individuals were added to the world's population, most of them in misery.

## III. Some lessons learned

10. Publicized failure frankly discussed carried the seeds of eventually greater success. Among the best known projections that had failed were those of eminent demographers, namely Sauvy, Whelpton, and Notestein and his associates. ${ }^{13}$ They all implied the onset of population decrease within the present living generation in countries where population growth was conspicuously revived from about 1946 onwards.
11. Two comforts have been drawn from Sauvy's admitted "failure". First, the dismal prospect of imminent decline in the population of France provoked such changes in attitudes and legislation that the trend was promptly reversed; that reversal, in a sense, is a measure of the "success" of the projection. Secondly, the events led to Henry's analysis of fertility by parity progression ratios, ${ }^{14}$ an instrument for fresh insight which permitted fairly successful

[^13]population forecasts to be made for Europe even during its post-war rehabilitation. ${ }^{15}$
12. Whelpton's discomfiture spurred him on to an even greater achievement. His study of fertility trends by successive cohorts of women ${ }^{10}$ became the key for repetitive surveys which now constitute a veritable population barometer ${ }^{17}$ and for decidedly improved methods of population forecasting lately introduced even in the citadel of the United States Bureau of the Census. ${ }^{18}$
13. Calculated during a war which changed the face of Europe, Notestein's projections had small chance of success, but they had another merit of transcendent importance. A scheme was shown that could serve in the simultaneous preparation of an entire set of population projections, including some for countries with faulty statistics. Whether his particular scheme fitted postwar Europe or any other part of the world is immaterial. The significant fact is that it offered an inspiration, much needed then, pointing the way towards the adventure of making population projections for those large parts of the world where, for fear of the poor statistics, this had not been dared before.
14. All schemes eventually fail and new ones must forever be devised. Notestein's particular projections had a varied fate, but the effective suggestion of seeking ever new schemes has been their lasting success.

## IV. United Nations work on data and methods

15. The United Nations Statistical Office now assembles world population data on an unprecedented scale, and these are supplemented with analytic estimates of the United Nations Population Branch, and from other sources. The analytic methods developed as rapidly as data permitting their testing became available. Starting from little, progress was gradual and cumulative, and it still leaves much to be desired.
16. Many censuses taken around 1950 were analysed in subsequent years. Censuses taken around 1960 now provide checks for previous estimates and a deepened time perspective for new analysis. In the decade many countries took

[^14]their first census and some already have two, whereas up to 1950 there had been none. Scientifically designed surveys have multiplied and the accuracy of some of these can now be appraised. Eventually, the characteristic population trends of the 1950's emerged clearly enough for their systematic worldwide survey. ${ }^{19}$
17. Enough was known by 1956 for publication of a United Nations manual on methods of population projections for countries with only moderate amounts of statistics. ${ }^{20}$ Essentially they replicate "component" projections, but model patterns are substituted for otherwise deficient detailed fertility and mortality statistics. The projections so calculated are justifiable provided that (1) not much disturbance of trends is anticipated; (2) "sub-component" trends are unlikely to interfere much with trends in the simplified components; and (3) basic quantities have been estimated with tolerable accuracy. The first two conditions have mostly been met by actual experience of the 1950 's, but more help was needed to ensure the third.
18. Practical applications of stable-population theory eventually facilitated improvements in estimates of fertility, mortality and age composition in many instances of otherwise defective statistics. ${ }^{21}$ It is unfortunate that the overworked United Nations staff has not yet been able to make these methods widely available.

## V. The United Nations projections

19. Improvement in data, methods and basic estimates enabled the United Nations to prepare with increasing assurance population projections for parts of the world where this had scarcely been done before. Success is hard to judge since the earlier calculations were admittedly less assured whereas the more recent ones have not yet stood a test of time.
20. World-wide projections were calculated in 1951, 1954, 1957 and 1963.22 The 1951

[^15]experiment was still done in the midst of a large statistical void. Projections of 1954 relied rigidly on rates of growth, often considerably under-represented, which are implied in the routine series of official annual population estimates for many countries. The 1957 forecast used the component method to represent population growth for a number of demographic types to which the actual current data were assimilated; where these data still compromised the official extrapolation of earlier rates of increase, the forecasts erred by under-estimate. Only in 1963 was the bold step taken of forecasting the population of each world region by separate estimation of regional age composition, current trends and future prospects, often in much independence of official data; the success of this latest effort cannot be judged until the 1970 round of population censuses.
21. United Nations forecasts for particular regions show similar development. Those of 1954 and 1955 for Latin American countries, ${ }^{23}$ for the lack of improved appraisals of official data, erred by under-estimates of fertility. Stablepopulation analysis enabled improvements to be made in the forecasts for Asian countries published in 1958 and 1959, 24 the latter also including a stable-population forecast for India by the Princeton Office for Population Research which has proved singularly successful. ${ }^{25}$ Other Asian censuses taken in 1960 and 1961 confirmed the essential correctness of the United Nations estimates, and their decided superiority over many of the routine series of annual official estimates then still in use. ${ }^{26}$ The United

[^16]Nations estimates for China, derived from stable-population analysis of existing fragmentary data, unfortunately remain unverified.

## VI. National projections

22. In countries with good statistics, this has been a decade of much progress and success in population forecasting. In Europe, births are commonly projected from nuptiality and rates by duration of marriage ; in the Soviet Union, they are projected separately for the urban and rural segments; in the United States this is now done by an elaboration of Whelpton's "cohort" methods. Opinion surveys in Eastern Europe, the United States and Japan are used as guides in forecasting current fertility expectations. Mortality prospects have been restudied in the light of trends in causes of deaths. Migration, an elusive subject, is still mostly calculated with ad hoc models.
23. In many countries of poorer statistics, the United Nations methods of population projections have been brought into use. Time has been too short to judge success in the national adaptation of these methods, and a large share of responsibility will be attributed to the United Nations in the event of their failure.
24. There has been much advance in the "specific-ness" of forecasts, no longer confined to the conventional five-year age groups. Forecasts often show the school-age, voting and pensionable population in the precise age groups specified by law. Numbers of households and families of varied size, economically active and dependent persons, widowed persons and old persons living alone, are also projected, and attempts are made to forecast the composition of manpower by branches of activity and by levels of skill.
25. Much of this may still be unduly advanced work in the countries of poorer statistics, though there also the size of the labour force, school population and numbers of households need to be anticipated within tolerable margins of error. One development of increased "specific-ness," in great need of attention, is the separate projection of urban and rural population. Little has been done on that so far.
26. International comparability of national population forecasts has been much enhanced

[^17]by regional coordination, especially in Europe, ${ }^{27}$ and attempts have also been made elsewhere. ${ }^{28}$ Modern computing equipment may some day facilitate the mechanical tasks in preparing detailed population forecasts covering large areas of the world.

## VII. Possible sources of deluston

27. A tendency to generalize too widely from a few recent observations may again vitiate the judgment of the future. Undue caution, on the other hand, leads to cryptic statements which the users of population forecasts often fail to understand. According to temperament, some forecasters take their job too lightly, and others take it too heavily, to render the kind of service which the public has a right to expect. Much progress remains to be made in drawing up those common-sense statements which reflect the degree of confidence to be placed in the forecasts, the uses to which they may be put and the reserves which should be observed while using them. Mutual understanding between makers and users of forecasts will have to be constantly cultivated.
28. One problem where understanding should be much improved is that of separating fluctuations from trend. Meaningful population forecasts consider periods such as two or three decades, and it is reasonable to expect that short-run fluctuations will deviate at any time from the longer trend. The problem is to know how much of a deviation can reasonably be regarded as a fluctuation, not necessarily invalidating the entire forecast.
29. All, or nearly all, population forecasts share one common source of bias. Being prepared with planning purposes in view, the forecasts must foresee conditions neither so good as to make all planning unnecessary, nor so disastrous as to make all planning futile. "Guarded optimism", therefore, is the general watch-word.
[^18]An independent observer, however, such as one who inhabits another planet, will recognize that the likelihood of success and of reversals are unequally distributed among particular areas upon this earth. An equal measure of "guarded optimism"-and this is what all planning forecasts have in mind-is not conducive to the greatest objectivity. With time, new delusions accumulate and some day another storm may break loose.
30. For this reason, a place ought to remain for independent demographers-other than those more directly engaged in planning and programming enterprises-who, upon suitable occasion, can act as prophet or Cassandra.

## VIII. What is "success" IN population FORECASTS?

31. Demography is both an abstract science and applied technology. In the abstract, a forecast is successful if the ensuing sequence of events literally bears it out. There is every reason to expect that success of this type, in population forecasts of the 1950 's, will eventually prove to have been very small indeed.
32. Technologically, the population forecasts can serve in the decision-making processes of economic and social policy. Risks and possible benefits must be weighed in terms of probabilities which change as time proceeds and new observations are made. In the 1950 's, increasing use was made of population forecasts for such purposes, and as it is understood these must be frequently revised. It can be said that they have become increasingly successful. More success will depend on an added specificity of forecasts so that they may come to serve a growing variety of purposes.
33. In a deeper sense, it is to be hoped that population forecasts of the 1950 's, and others yet to be made, have begun to contribute to an eventually successful accommodation of the human species to its limited natural environment. There has been much talk of "economic development," and the 1960's have also been referred to as the "development decade." But what if efforts, as now conceived, only prove their eventual insufficiency? Already there is evidence of much new thinking on this subject. May this become fruitful enough to regenerate an authentic hope for mankind's future. Have recent population forecasts provided some of the stimulus for ground-breaking new thought? Will population projections yet to be calculated intensify that motivation? Here is another matter on which "guarded optimism" will have to be strenuously maintained.

# Forecasts in some Asian areas during recent years: criticism and suggestions 

Shigemi Kono

## I. Introduction

1. The purpose of this paper is to review population projections recently carried out in some countries of Asia. Special references are made to the Republic of China (Taiwan), Japan, and the Republic of Korea. Various projections have been worked out for the countries of this region. However, in most of the countries, available demographic statistics are inaccurate and incomplete and greater efforts have sometimes been directed to the corrections of the base population and vital rates rather than to projections themselves. To this field, the United Nations Secretariat has contributed greatly not only in providing the standard method of population projections ${ }^{1}$ for the countries with fragmentary statistics but in performing the population projections for all the areas of Asia and the Far East, the results of which have been of invaluable use particularly for the countries where official projections have not been initiated. ${ }^{2}$
2. In most of the countries of East and South-East Asia, population projections have been performed by the component method (cohort survival method), with reliance on the standard method of projection devised by the United Nations Secretariat. For Indonesia, Laos, Viet-Nam and others where demographic information is too few to apply the United Nations standard method, the method of stable population model has been used. The official projections of Japan's population are basically of the component type with direct use of detailed and accurate population statistics.

## II. Methods and assumptions of population PROJECTIONS

3. As mentioned in section $I$, the cohort survival method has been most widely used

[^19]in this region particularly in relation to the United Nations standard method. Apart from the United Nations population projections for Asia and the Far East, ${ }^{3}$ the United Nations standard method has been directly applied to the population projections in the Republic of Korea and the Philippines. The projections of Taiwan's population done by Tun-yih Lu are also by the component method.
4. For the Republic of Korea, two sets of population projections have been made in addition to the United Nations projections, one by Kim Yun in $1960^{4}$ and the other by Taebin Im in 1963. ${ }^{5}$ The United Nations projections are of a constant-high fertility type without any variant, while Kim's projections consist of "high", "medium" and "low" variants. As to mortality assumption, the United Nations and Im's projections assumed a normal decline, whereas Kim's projections assumed a relatively rapid decline. As to fertility, Kim's initial fertility level is relatively low and the rate of fertility decline is considerably rapid on the medium and low assumptions, indicating 10 per cent per quinquennium for 1960-1965 on the medium assumption. Im's projections also assumed fertility decline but a rapid decline will only come in the later period.
5. The population projections made by Lu were based on the observed age-specific fertility rates and the life tables constructed specifically in Taiwan. ${ }^{6}$ In his projections, the use of the United Nations model life tables was discarded since the past studies in the Republic of China made it clear that substantial discrepancies were noticed between the mortality pattern observed in Taiwan and that implied in the model life tables. In his projections, mortality was assumed

[^20]to decline further but at a diminishing rate by 1971. As to fertility, there were three assumptions: (a) constant assumption; (b) the 1956 rates declining at 1 per cent per year by 1966 and thereafter declining at 2 per cent; (c) the 1956 values declining linearly to the 1950 rates of Japan by 1976.
6. Various population projections have been made in Japan. Four sets of official projections have been worked out since 1955 by the Institute of Population Problems, Ministry of Health and Welfare, namely in 1955, 1957, 1960 and 1964. ${ }^{7}$ The assumptions involved are somewhat different from each other, each series reflecting newly observed conditions of mortality and fertility.
7. Mortality in Japan has already been low but it is expected to decline further with a diminishing rate pursuing a trend similar to the western experiences. As to fertility, in the 1955 and 1957 series of projections, it was considered that total fertility might decline to an eventual value of 1.6 and tend to remain constant thereafter, this value to be reached, on alternative assumption, by 1 October 1960 (low), 1 October 1962 (medium), or 1 October 1965 (high). These assumptions were soon realized to be too low and were revised in the 1960 and 1964 projections.

## III. Evaluation of the results

8. In order to ascertain the degree of success and the sources of errors involved, calculations are made for obtaining percentage differences of the projected population by sex and age from the corresponding actual population. The following is an evaluation of the projections with reference to these calculations.
9. The percentage of deviations of the 1961 Taiwan population projected by Lu from the actual population generally remain small; less than 3 per cent for both sexes, males and females. There are no distinct differences among the projected figures on three different assumptions since Lu's projections were made relatively recently. It is interesting to note that scores are generally smaller among females than males. In the age groups 25-29 and 30-34 of males, 11 and 22 per cent differences are found and this would be an indication of the under-enumerations of male population aged 20-24 and 25-29 in 1956 when some males were

[^21]excluded from the civil population. Deviations of 7 to 10 per cent are noted in the age group $0-4$ where the projected figure is larger than the actual regardless of sex and assumption. This may imply that fertility decline was faster and mortality decline was slower than expected. The 1961 registered population used here for comparison was the one compiled with some necessary corrections in co-operation with the Taiwan Population Centre. ${ }^{8}$
10. The percentage differences of the 1960 totals for the Republic of Korea in the United Nations and Kim's projections from the actuals are about 3 per cent (minus) in both sexes, males and females. The percentage differences of the 1960 figures in the United Nations and Kim's projections from the actuals are considerable (more than 13 per cent) in the ages $0-4$ and 65 , and over. For age group $0-4$, the percentage differences are up to 14 per cent (minus) in the United Nations projections and up to 19 per cent (minus) in Kim's projections. For age groups $80-84$ and 85 and over, the differences are up to 21 per cent (plus) in both sets of projections.
11. In studying the deviations from the actual figures and in a comparison with Im's projections, the United Nations and Kim's projected population seem to be quite small, but with different reasons for each. This implies that the United Nations projections might have been too pessimistic with respect to the future decline in mortality whereas Kim's assumption might have been too optimistic with respect to decline in fertility.
12. In the case of the 1957 projections of Japan's population, the totals for both sexes, males and females, are about 0.5 per cent lower than the corresponding census totals. The agewise deviations range from 0 to 7 per cent. The largest percentage difference is found in age group $0-4$, being 7 per cent lower than the actual figure. The second largest deviations are observed in age group 75-79 (3 per cent higher) and in age group 80 and over (3 per cent lower than the census population). This is in line with the general tendency in this region to find the youngest and oldest age groups the most difficult segments of a population to forecast precisely, though Japan's scores are smaller than those in other countries.
13. The fact that the projected totals for 1960 for Japan are smaller than the actual totals can be largely explained by the smaller size of

[^22]the projected population aged $0-4$, which is, in turn, considered to be due to the lower estimates of levels of fertility for 1956-1960 and the following period than the actuals. For this reason, the projections made in 1960 were revised to adopt an assumption of moderately higher fertility, and another revision was made in 1964 on the basis of even higher fertility assumption than in 1960.

## IV. Criticism and suggestions

14. Two comments are made on the projections of Taiwan's population. Since the registered and census population of Taiwan have included only the civil population, there are some difficulties in evaluating their demographic data and in carrying out accurate population forecasts. It is, therefore, desired to include the armed forces in the statistics. Secondly, Lu's low assumption that fertility would decline to the level of Japanese fertility in 1950 by 1976, may be a little questionable, since demographic circumstances of Japan around 1950 were quite unusual, retaining the aftermath of the postwar "baby boom". As an alternative, it may be suggested that the experience of Japan in the prewar period of 1925-1938 be employed, since Japanese fertility was declining during this period, showing its gross reproduction rate substantially lower than that in Taiwan in 1954 and utilizing the distribution of relative age-specific fertility rates similar to those in Taiwan in recent years.
15. In the three different sets of projections concerning the population of the Republic of Korea, the future trend of fertility was estimated by the sex-age adjusted birth rate and by applying the United Nations standard set of weights, $1: 7: 7: 6: 4: 1$ to the five-year age groups of females aged 15-44. A word of caution should be given as to the use of this standard system of weights, because these values represent averages of relative agespecific birth rates of women for fifty-two countries in various years. It is observed that relative age-specific fertility rates in Japan and Taiwan for all the years for which the data were given differ considerably from the standard, whereas the weights in Taiwan in recent years are much more akin to those in Japan for the prewar years 1925-1940. In this regard, it is suggested that a regional standard set of weights for East Asia be prepared, relying heavily on the information in Japan and Taiwan. This is because there are cultural affinities existing in the Far East which presumably affect demographic behaviour in a similar pattern.
16. Likewise, another point is raised with respect to the application of the United Nations model life-tables to the projection of Korea's population. The United Nations model lifetables were used there as important tools not only for estimating the cohort survivors in each age group but also for determining the number of past births by reverse survival ratio. If discrepancies are wide between the mortality levels of the model life-table and of an individual country, double features of error will creep into projections even though errors may not be added up in the same direction. Since the United Nations model life-tables were constructed ten years ago in 1955 on the basis of available national life-tables for a limited number of countries, actual values for a country would sometimes deviate substantially from those of the model table. In this connexion, the necessity for conducting a moderate scale of well-planned sample survey on mortality in Korea should first be emphasized. Secondly, a proposal is made for analogous use for the Republic of Korea of mortality improvements in some underdeveloped prefectures in Japan for which life-tables have been available since 1921.
17. Generally, the errors creep into the population projection from several sources, such as errors in base population, errors in current and future estimates of fertility, mortality, migration and sex ratio at birth. In view of the quality of demographic statistics and recent trends of fertility and mortality, no appreciable errors were likely to occur in Japan's projections except in estimating the future fertility trend. Actually, a new change has been occurring in the timing of childbearing among low parity women, leading to an increase in age-specific birth rates for females aged 25-29 and in birth rates for first and second order of births and thus resulting in a slight rise in crude birth rate lately, in spite of the sustained decline in high order birth rates and in age-specific birth rates for other age groups. This is a clear indication of the transition in Japanese fertility towards early bearing of a few children in married life.
18. In view of this, it now becomes evident that the conventional method of fertility projection considering only age-specific fertility is no longer sufficient for assessing correctly the dynamic nature of the present structural change in fertility. It seems, therefore, important to incorporate the concept of "parity" into the framework of projection in an analogy to the work which Welpton and others conducted in the United States by making use of cohort analysis. In Japan, statistical materials neces-
sary for cohort analysis are not abundant, but efforts should be made to utilize more effectively for projection the currently available data which should be supplemented by information
through sample surveys, particularly on current parity structure and complete fertility of females and on social-psychological factors affecting fertility.

# Population projection for Iran, 1956-1976 

Nasser Maroufi-Bozorgi

## Introduction

1. In Iran the first census was not taken until 1956. Before that population data were mere guess-work. Even now demographic information is not available in such detail as is needed by the social scientists. The situation, however, has improved.
2. There has been scattered information that fertility in the country is rather high, as in many other Muslim countries, and that mortality may also be high enough to counterbalance this; but this is all speculation. All in all the growth rate has not been too high in the past. But in recent years, due to the availability of cheap and efficient drugs, public health programmes and so on, the rather high death rate in the country has been controlled. Improvements in the health status can also be anticipated at quite a high rate for some time to come. The economic, social and cultural climate in the country is not yet favourable for any appreciable fall in the birth rate. Thus the implication is that the growth rate will increase speedily and may even reach 3 to 3.5 per cent. The rapid growth of the population, lack of enough demographic data, the accent on planning in recent years, all have brought in their wake the need for, and importance of, population projection by age and sex at least for a period of 20 years.
3. This study attempts to project the population of Iran by age and sex from 1956 to 1976 by the component method. As a necessary preliminary to the study, the available data was evaluated and adjusted and the results were made use of. Incidentally, vital rates were also derived from the census figures as a by-product of the evaluation and adjustment, in view of the lack of reliable vital registration or survey data.

## Data

4. The 1956 census of Iran provides direct data on age/sex structure even though the enumeration figures may be faulty. Table 1 (first part) gives the enumerated population by
quinary ages and sex. No direct estimates of the sex ratio at birth, fertility or mortality are available due to the registration system being incomplete. Even survey data become of not much value due to inherent errors. The census figures, coupled with the fragmentary information from registration and survey, provide usable estimates of sex ratio at birth, fertility and mortality.
5. Regarding migration it is known that international migration to and from Iran has not been so considerable as to affect population growth and its structure. In the years to come, due to governmental policies, it may be reasonably anticipated that this factor will play a diminished role in the population growth and structure.

## Evaluation and adjustment of data

6. Demographic data are usually subjected to several different types of errors due to many reasons. Any error in the basic data, if not evaluated and adjusted, will be carried over and compounded and will thus vitiate the projections. It is therefore necessary first of all to look for these errors and then adjust the data for the specific errors.
7. In a thorough investigation into the age/ sex statistics of Iran from the census of 1956 which was carried out by the writer it was found that as in the case of other countries in the ECAFE regions some very young children were missed from the count. In the age range 10-69, as anticipated, there were tremendous age and digit preference errors and in the old age group the usual phenomenon of overreporting was observed. To remove these diverse types of errors in the various age segments the usual techniques were applied and table 1 (second part) gives the adjusted age/ sex distribution of Iran.

## Assumption

8. Even though no direct estimate of the sex ratio at birth is available, the census data

Table 1. Reported and adjusted age distribution for Iran - 1956 census

| $\underset{\text { group }}{\substack{\text { Age }}}$ | Reported |  | Adjusted |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Males | Females | Males | Femates |
| 0-4 | 1,683,713 | 1,663,985 | 1,766,837 | 1,745,614 |
| 5-9 | 1,419,050 | 1,403,925 | 1,419,050 | 1,403,925 |
| 10-14. | 974,786 | 847,697 | 1,110,061 | 1,104,777 |
| 15-19. | 710,029 | 710,495 | 964,408 | 962,117 |
| 20-24. | 699,369 | 797,809 | 788,241 | 769,077 |
| 25-29. | 736,460 | 776,775 | 676,644 | 654,314 |
| 30-34 | 704,469 | 686,471 | 626,165 | 612,211 |
| 35-39. | 569,543 | 450,925 | 555,531 | 536,580 |
| 40-44. | 487,167 | 439,806 | 484,852 | 445,446 |
| 45-49. | 348,080 | 294,588 | 414,965 | 372,902 |
| 50-54. | 394,111 | 409,654 | 342,151 | 311,403 |
| 55-59. | 196,080 | 173,604 | 280,448 | 256,842 |
| 60-64. | 327,223 | 290,220 | 225,042 | 211,079 |
| $65+$ | 392,078 | 359,529 | 192,899 | 207,608 |
| Unknown......... | 2,786 | 4,277 | - | - |
| Total | 9,644,944 | 9,309,760 | 9,847,294 | 9,593,895 |

are suggestive of a sex ratio of 106. Moreover, where data have been reliable, the sex ratio is usually within a very narrow range 105-107. It is assumed that the ratio will be 106 in Iran for the period 1956-1976.
9. The registered birth and death rates in the country are known to be defective. Thus direct evidence of fertility and mortality level and trend is unavailable. On the basis of the age/sex structure of the census of 1956 it has been estimated that the crude birth rate will be about 51 and the mortality level corresponds to an expectation of life at birth of 35 years during 1951-1956.
10. As pointed out earlier, the social climate in the country is as yet unfavourable for any appreciable reduction in fertility, and since the crude birth rate is affected by the age/sex structure of the population, it is assumed that the level of fertility as measured by the age/ sex adjusted birth rate of 57.7 corresponding to a crude birth rate of 51 will remain constant during the period of projection. Projection of births into the future have been carried out in the usual manner using this constant age/sex adjusted birth rate. The distribution by sex has been derived by using the sex ratio at birth of 106 .
11. The planned development of the country, the availability and knowledge of cheap and efficient drugs, etc., have contributed for the rather rapid decline in the death rates. It can be reasonably anticipated that there will be quite substantial gains in the health status and that mortality level will be reduced to low
levels in the years to come. It has been the international experience that, when the level of mortality is not too low or high, substantial increments in the expectation of life at birth of up to one year is normal, but once reasonably high levels are reached, only reduced increments of about half a year per year can be expected. With this in mind it is assumed that, during 1956-1961, 1961-1966, 1966-1971 and 1971-1976, the expectations of life at birth will be respectively $40,45,50$ and 52.5 years, using these levels of mortality from the model life tables.

## Projection

12. By the well-known component method the populations by quinary age and sex groups have been obtained for 1961, 1966, 1971 and 1976 and are given in table 2.

## Implications of the projection

13. Because of this high growth, the density of population also about doubled in the 20 years. With an area of $1,648,000$ square kilometers, the population does not look at all big. As a matter of fact, the density of less than 25 even in 1976 is quite low, but of course this has to be considered in conjunction with the availability of atable land and also with the investments in men and materials needed to train the manpower, to educate the ever-increasing number of children, to cater to the health needs of the growing population, to create jobs for the manpower potential of the country and so on (table 3 ).

Table 2

| $\underset{\text { group }}{\text { Age }}$ |  | 1956 | 1961 | 1966 | 1971 | 1976 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Projected population (males) 1956-1976 |  |  |  |  |  |  |
| 0-4 |  | 1,766,837 | 2,101,865 | 2,515,855 | 2,991,648 | 3,619,540 |
| 5-9 |  | 1,419,050 | 1,607,468 | 1,952,002 | 2,376,225 | 2,847,450 |
| 10-14. |  | 1,110,061 | 1,380,026 | 1,572,907 | 1,919,599 | 2,342,007 |
| 15-19. |  | 964,408 | 1,079,978 | 1,350,079 | 1,545,499 | 1,890,421 |
| 20-24. |  | 788,241 | 926,989 | 1,045,527 | 1,315,112 | 1,510,262 |
| 25-29. |  | 676,644 | 751,194 | 891,300 | 1,012,906 | 1,278,946 |
| 30-34. |  | 626,165 | 642,406 | 720,545 | 862,154 | 983,734 |
| 35-39. |  | 555,531 | 590,912 | 613,562 | 694,893 | 835,082 |
| 40-44. |  | 484,852 | 518,644 | 559,771 | 587,792 | 669,043 |
| 45-49. |  | 414,965 | 445,094 | 484,517 | 529,935 | 559,754 |
| 50-54. |  | 342,151 | 371,975 | 407,261 | 450,310 | 495,966 |
| 55-59. |  | 280,448 | 296,440 | 330,202 | 368,337 | 410,728 |
| 60-64. |  | 225,042 | 231,342 | 251,618 | 286,549 | 322,921 |
| 65 and over |  | 192,899 | 266,772 | 327,659 | 384,814 | 457,601 |
|  | Total | 9,847,294 | 11,211,105 | 13,022,805 | 15,325,773 | 18,223,455 |
| Projected population (females) 1956-1976 |  |  |  |  |  |  |
| 0-4 |  | 1,745,614 | 2,028,720 | 2,427,610 | 2,885,432 | 3,487,287 |
| 5-9 |  | 1,403,925 | 1,589,382 | 1,887,610 | 2,297,247 | 2,751,836 |
| 10-14. |  | 1,104,777 | 1,362,790 | 1,553,303 | 1,854,258 | 2,263,248 |
| 15-19. |  | 962,117 | 1,071,744 | 1,330,628 | 1,525,188 | 1,825,146 |
| 20-24. |  | 769,077 | 922,382 | 1,036,484 | 1,296,697 | 1,491,329 |
| 25-29. |  | 654,314 | 730,623 | 886,040 | 1,004,767 | 1,262,334 |
| 30-34. |  | 612,211 | 618,719 | 699,718 | 857,155 | 976,432 |
| 35-39. |  | 536,580 | 576,642 | 590,877 | 675,508 | 831,440 |
| 40-44. |  | 445,446 | 502,883 | 548,559 | 568,542 | 653,149 |
| 45-49. |  | 372,902 | 413,819 | 474,671 | 524,203 | 546,141 |
| 50-54. |  | 311,403 | 340,832 | 385,017 | 447,947 | 497,626 |
| 55-59. |  | 256,842 | 277,460 | 309,408 | 356,218 | 417,397 |
| $60-64$ |  | 211,079 | 219,292 | 243,083 | 276,889 | 321,665 |
| 65 and over |  | 207,608 | 275,789 | 335,615 | 402,079 | 476,839 |
|  | Total | 9,593,895 | $\overline{10,931,077}$ | 12,707,723 | 14,972,130 | 17,801,869 |

Table 3. Density of population, 1956-1976
(Per square kilometer)

|  | 1956 | 1961 | 1960 | 1971 | 1976 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Density $\ldots \ldots \ldots \ldots \ldots$ | 12 | 13 | 16 | 18 | 22 |

14. The projections imply the following vital rates:

Table 4. Vital rates

|  |  |  | $1956-1961$ | $1961-1966$ | $1966-1971$ | $1971-1976$ |
| :--- | :--- | :--- | :---: | :---: | :---: | :---: |
| B. R. $\ldots \ldots \ldots \ldots \ldots$ | 50.44 | 50.39 | 49.38 | 49.53 |  |  |
| D. R. $\ldots \ldots \ldots \ldots \ldots$ | 24.46 | 20.41 | 16.77 | 15.03 |  |  |
| G. R. $\ldots \ldots \ldots \ldots \ldots$ | 25.98 | 29.98 | 32.61 | 34.55 |  |  |

15. We see that there is a slight reduction in the crude birth rate whereas the reduction in the dealth rate is drastic, causing increased rates of growth. The slight decrease in crude birth rate is due to changed age/sex structure
of the population, and the drastic fall in the death rates is due to the implied vast improvements in health status brought by the increased expectation of life (table 4).
16. From table 5, we see that there will be a drastic fall in infant mortality and the im-
provements will be among females rather than among males.

Table 5. Infant mortality rates

|  |  | $1956-1961$ | 1961.1960 | $1966-1971$ | $1971-1976$ |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Male $\ldots \ldots \ldots \ldots \ldots$ | 196 | 169 | 144 | 131 |  |
| Female $\ldots \ldots \ldots \ldots \ldots$ | 176 | 149 | 124 | 112 |  |

17. This improvement in infant and early childhood mortality has caused an increase in the child population even in spite of no change in fertility.
18. The percentage of children aged 0-14 has increased from 43.98 to 48.05 . Even in the base period the percentage in this group is
rather high, and in 1976 it is very large. This is due to the continuing high fertility and rapidly falling mortality. Correspondingly the percentage in the young adult age/group 15-64 has declined. The percentage in the old-age group $65+$ has shown a slow but steady increase, as can be noted from table 6 .

Tabie 6. Percentage of population by broad age group, 1956-1976

|  | 1956 | 1961 | 1966 | 1971 | 1976 |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $0-14$ | 43.98 | 45.48 | 46.28 | 47.28 | 48.05 |
| 15-64 | 53.96 | 52.07 | 51.14 | 50.12 | 49.35 |
| $65+$ | 2.06 | 2.45 | 2.58 | 2.60 | 2.60 |
| Dependency ratio | 85.3 | 92.1 | 95.5 | 99.5 | 102.6 |

19. This rapid increase in the child population and slight increase in the old age segment has resulted in quite a large increase in the dependency ratio. Whereas it was 85 in 1956, in 1976 it has become 103. This has been brought about by the constant high fertility and the rapidly declining mortality. This increase in the dependency ratio has implications in terms of labour force, economic development etc.
20. The fast increase in the child population also has social implications like the need for providing facilities for schooling, recreation and so on. Considering that age $7-12$ is the compulsory elementary school age, the population in this age segment can be calculated roughly from the formula:

$$
P_{7-12=0.472} P_{5.9+0.856} P_{10.14-0.128} P_{15-19}
$$

21. The figures are given below:

Table 7. Elementary school-age population, 1956-1976

|  |  | 1956 | 1961 | 1966 | 1971 | 1076 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Males |  | 1,496,560 | 1,801,790 | 2,094,943 | 2,566,931 | 3,106,781 |
| Females |  | 1,485,191 | 1,779,553 | 2,049,834 | 2,476,321 | 3,002,588 |
|  | Torat. | 2,981,751 | 3,581,343 | 4,144,777 | 5,043,252 | 6,109,369 |

22. The school age population has more than doubled in 20 years. This is only to be expected when we consider that the total population itself has almost doubled and that the increase is more in the child population. Participation in school programmes is not very high at
present, but the problems in the future with increased populations and with anticipated improvements in school participation may become more acute. Proper planning for education should be set in motion at once so that bottlenecks can be avoided.

# The use of cost functions in making assumptions for population forecasts 

H. V. Muhsam

1. The device of presenting alternative estimates of future population, instead of a single forecast, is probably older ${ }^{1}$ than most modern techniques of population projection. Nowadays, this has become such a generally accepted practice among demographers, that nobody questions its soundness. But it seems that the ways and means of selecting data, methods and assumptions which uitimately lead to such alternative projections, have never been the subject of a theoretical discussion or even of a thorough comparative investigation. The authors of the most comprehensive and detailed text in the field of population projections seem to be satisfied by stating ${ }^{2}$ (given in para. 8) that " $\ldots$ the purpose of any estimate would be defeated, if it were attempted to make the alternatives embrace the entire range of possible future events ... it is desirable to choose the upper and lower limits in such a way that the future trend will more probably lie between these limits than outside them ...". Not only are these advices of little practical help, but the procedure recommended in the latter (cited) sentence definitely embraces the rejected procedure of the former (cited) sentence as a particular, though extreme, case.
2. Two main reasons for the presentation of alternative projections are given by various authors who adopted this procedure: "The range between the 'most pessimistic' and the 'most optimistic' results is in some way a measure of the margin of indeterminateness ..." ${ }^{3}$ and " [a single projection] ... is less useful, as a guide in formulating ... policies and programmes ..." ${ }^{2}$ (given in para. 295). In the present communication, an attempt will be made to cast some light on this last mentioned aspect, namely, that of the utility of alternative projections for practical planning purposes. It will, however, not be possible to indicate here

[^23]more than a sequence of thoughts-a kind of model-which leads to principles which might guide the demographer in selecting assumptions for alternative projections, and to illustrate this model by a schematic example. But in the course of this discussion, the importance of the former aspect will also emerge in a new light.
3. The first step in this sequence of thoughts consists in asking the question: how could a planner take advantage of alternative projections? This will lead to the further question: how should these alternatives be prepared and presented, in order to enable the planner to take such advantage? And finally, we may try to deduce the conditions under which the advantage will be maximal.
4. Let us consider a simple, almost trivial example. Imagine that a projection is performed in order to plan elementary schooling for the prospective school age population of a town. If a single forecast of the school age population were presented, the planner could easily determine the capacity of the planned building, equipment, etc., required for this forecast population. But no sensible planner puts unrestricted confidence in a forecast. submitted to him; he always wishes to leave some margin of safety, in this case by providing for a slightly larger school age population than forecast. This is well established practice and not only with population forecasts. But how large a margin of safety would appear most advisable? This depends on three factors: the degree of confidence which may be placed in the forecast, the additional cost of providing immediately for a larger population, and the ultimate consequences of having planned and provided the required service for too small or too large a population. The demographer obviously cannot express any view regarding the two latter points, whereas the first one should be his exclusive concern. But in order to get the necessary guidance as to how he should formulate his views on this aspect, the demographer should understand the ways and means of assessing the two other points, as well as the methods of combining all the information into a single plan. In our present discussion, we will disregard matters of prestige, public rela-
tions and similar consideration. Now it is easily seen that both the above-mentioned immediate cost and "ultimate consequences" can be measured by a single amount of loss depending, in a first approximation, only on the difference between the assumed number of persons being actually provided for by the plan, and the true number, which obviously will become known only much later. This "loss" is the difference between the cost of providing immediately for the true number of persons and the cost of providing immediately for the assumed number of persons and that of providing later for any excess of the true number over the assumed number. The former cost is practically always smaller than the latter-otherwise planning would not be worth-while. Indeed, if the true population is smaller than the assumed population, it is obviously cheaper to provide for the true population; and if it is larger it is, in general, also cheaper to provide immediately for the true population, than to provide first for a certain smaller number and later for the excess. In the case of schooling the latter circumstances may, for example, involve the construction of two small buildings instead of one larger one. It is obviously often possible to plan in a flexible fashion; but to take this into consideration would render this discussion only more complicated, without changing our main lines of thought or our conclusions.
5. Thus, the loss of function has a minimum for a zero difference between the true and the assumed population figures, and increases in both directions from this minimum; its shape depends, in the present case, on engineering problems, administrative and educational practices, the rate of interest, the price of land, etc. But this is not the aspect which is of interest to the demographer. For him, it is important to know that the loss function is a continuous function, increasing monotonously-at least for a certain range-from its minimum value for a zero error (not in the "best" forecast, but in the figure assumed by the planner) to both sides, i.e., for positive and negative errors, but in general not in a symmetric fashion.
6. Thus, the planner is in a very common situation, where he has to take a decision (to assume a population figure) when he is faced with uncertain information (a set of high, medium and low projections), and hence the risk of losses in case of any decision. Under the circumstances, it is customary, though not necessary, ${ }^{4}$ to attempt to take the decision in such a way that the "expected loss" is minim-

[^24]ized. In other words, the assumed population figure should be determined by minimizing the sum over all the products of possible losses (varying according to the difference between the assumed and all the possible true figures), multiplied by the probability of the respective loss being suffered.
7. This reveals the task of the demographer: he should supply the probabilities of the true population figures to reach all possible numbers. Now it is well known that "... it is impossible to calculate the probability that any given assumption.. will be realized" ${ }^{2}$ (given in para. 296). But two circumstances alleviate the situation:
(a) It is not necessary to calculate the probabilities of various alternative projections, or, more exactly, the likelihood that the true population figure will lie within the ranges delimited by these projections. Guesses as to these probabilities suffice for computing the expected loss and for determining the assumed figure which minimizes this loss. It is true that errors in those guesses render the estimate of the best assumed figure less reliable. But this is by no means a shortcoming peculiar to this procedure; misjudgement at any stage of planning is liable to divert a plan from its most desirable form. But in the absence of, at least, guessed probabilities, it appears utterly impossible to plan at all rationally while in the case of errors in these guesses, like any other errors, the plan may just not be optimal;
(b) These guessed probabilities need not to be expressed in precise, quantitative terms. It has, in fact, been shown ${ }^{5}$ that it does not make any appreciable difference, in the estimate of the best assumed population figure, whether the probability of all the figures within a given range is considered to be equally probable and all values outside this range are considered definitely impossible, or whether the probability is assumed to have a maximum value somewhere within this range, to taper off, gradually, at both sides of this maximum and to become zero just a little beyond the limits mentioned before. Thus, in practice, a rectangular probability function will yield almost the same result as a triangular distribution over a corresponding range. In view of this, the demographer may satisfy all requirements by expressing his views on the likelihood of his different alternative projections in a very vague manner.

[^25]8. Let us return to the example presented above and assume that the demographer has prepared a projection of the school-age population and presented a low projection of $a$, a high projection of $b$ and a medium projection of $\frac{a+b}{2}$. We shall also assume that the planner found that if he plans for a school-age population of $x_{0}$ persons, and the true figure turns out to be $x$, the loss to the town will be $c\left(x-x_{o}\right)$ if $x>x_{g}$ and $d\left(x_{g}-x\right)$ if $x_{o}>x$. Often $c>d$, but this needs not to be assumed, here. What should the planner do in this situation with the demographer's figures, if they are presented as they often are with the only qualification that the true figures should be expected to lie between $a$ and $b$. Should the planner plan for the medium assumption, which will be recommended as the most acceptable by the demographer? Should he try to avoid the danger of unnecessary expenses and plan for the smaller number of $a$ persons, or would it be more advisable to try to avoid the danger of larger losses and plan for the larger number of $b$ persons, or perhaps for even more than $b$ persons?
9. The planner's difficulty stems obviously from the lack of specification of the likelihood of various outcomes. In order to specify these likelihoods, we shall try to follow through the ideas which lead, in the opinion of the United Nations ${ }^{2}$ (given in para. 294), often to alter-
native assumptions: ". . . several rather diverse possibilities ... appear to be almost equally probable . . ." This may perhaps be interpreted, and more strictly formulated, to mean that low, medium and high projections are of equal likelihood, or, in quantitative terms:
All outcomes within the range delimited by the low and the high projections are equally probable.
10. In order to complete the distribution, and to keep mathematics simple, we shall assume that for a short range beyond the low and the high projection, probabilities are still at the same level and then they fall off abruptly, in such a way that the following condition is fulfilled:
It is as likely that the true figure lies within as outside the range delimited by low and high projections.
11. Finally, for the sake of symmetry, we shall assume that:
Outcomes below $a$ are as likely as outcomes above $b$.
These three sentences suffice to determine the likelihood of all possible true figures. Indeed, we have introduced a rectangular probability distribution over a range from $a-\frac{b-a}{2}$ to $b+\frac{b-a}{2}$. The probability $p(x)$ of any population figure $x$ is, thus
\[

p(x)=\left\{$$
\begin{array}{l}
0, x<a-\frac{b-a}{2} \\
\frac{1}{2(b-a)}, a-\frac{b-a}{2} \leqslant x \leqslant b+\frac{b-a}{2} \\
0, x>b+\frac{b-a}{2}
\end{array}
$$\right.
\]

The expected loss is, then

$$
L=\int_{a-\frac{b-a}{2}}^{x_{0}} \begin{aligned}
& \left.x_{0}-x\right) \\
& 2\left(x_{0}-a\right) \\
&
\end{aligned} d x+\int_{x_{0}}^{b+\frac{b-a}{2}} d\left(x-x_{0}\right) \frac{1}{2(b-a)} d x
$$

and the minimal loss is obtained for the value of $x_{0}$ which fulfils the condition $\frac{\partial L}{\partial x_{0}}=0$. This value $\hat{x}_{n}$ is easily seen to be

$$
\hat{x}_{s}=\frac{c a+d b}{c+d}+\frac{1}{2} \frac{(b-a)(d-c)}{c+d}
$$

12. As a first approximation considering only the first term of the right hand side, the most profitable assumption is a weighted average of $a$ and $b$, i.e., a figure somewhere between the low and the high projection, but nearer to
the one which would involve the larger loss if an unweighted mean was used. The correction term, to this approximation, is, first of all, proportional to the range $(b-a)$ of $a$ to $b$; the larger this range, the less the first approxi-
mation, which is, intuitively, highly acceptable, will be reliable. It is also proportional to the lack of symmetry $(d-c)$ of the loss function.
13. In order to gain further insight into the implications of the choice of assumptions, leading to low and high projections, we shall now loosen some of the above, strict conditions. Let us replace the condition in paragraph 10 by the assumption that the likelihood of the true figure to lie within the range of $a$ to $b$ is $p$ and that of lying outside this range: $q=1-p$. At the same time, let us assume that the probability of it being below $a$ is estimated to be $r$ times that of being above $b$. Thus, our probability distribution is still rectangular, but now over the range from
$a-\frac{r}{1+r} \frac{q}{p}(b-a)$ to $b+\frac{1}{1+r} \frac{q}{p}(b-a)$
and the optimal assumption is

$$
\hat{x}_{a}^{\prime}=\frac{c a+d b}{c+d}+\frac{q}{p}(b-a) \frac{d-c r}{1+r}
$$

14. The position of the optimal assumed population figure is still mainly determined as the weighted average of low and high projections. The correction term, to be applied to this weighted average, depends now in a slightly peculiar, implicit manner on the lack of symmetry of the loss function and of the probability distribution. But it may be noted that the demographer might be able to choose his low and high assumptions in such a way that the correction term disappears. This will be so if $r=\frac{d}{c}$, i.e., if the ratio ( $r$ ) of the likelihood of the true population figure to lie below the low projection to that of this figure to lie above the high projection is inversely proportional to the rate of increase of the loss for increasing errors in the corresponding directions. If this could be achieved, at least approximately, the
correction term could be neglected, and the problem of the planner considerably simplified.
15. Another, more important conclusion, which can be drawn from the expression for the optimal assumed population figure under the more flexible assumptions, emerges if it be assumed that the range within which the true population figure is assumed to lie is approximately known to the demographer, and his main problem consists in determining, where, within the limits of this range, he should place his low and high projections. Under these circumstances the range $(b-a)$ is proportional to the probability $p$, i.e., the wider the gap between the low and the high projection, the higher the likelihood of the true figure to fall inside this gap. This is obviously always true, but in the case of a rectangular probability distribution, the ratio of $p$ to $(b-a)$ is a constant. The correction term is, then, proportional to the probability $q$ of the true figure to fall outside the range of the low and high projection. It would therefore appear advisable to select the low and high assumptions in such a way that they embrace nearly all plausible outcomes; this would permit the planner to follow his intuition and to select a weighted average of the low and high projections, as the assumed population figure which he introduces in his plans.
16. It should be stressed that even these few results could be obtained only under slightly unrealistic assumptions. But on the one hand, was it our main purpose to show that as soon as some assumptions are made, they lead to results which may be useful to the demographer in selecting his low and high assumptions. And on the other hand, we are sure that even if our conclusions are affected by the type of assumptions we made, this effect is quantitative rather than qualitative, i.e., even if we had made different assumptions, we should not have arrived at widely divergent conclusions.

# The degree of success achieved in the population protections for Latin America made since 1950. Sources of error. Data and studies needed in order to improve the basis for calculating projections 

César A. Peláez

## I. Introduction

1. This paper is an attempt to evaluate the degree of success achieved in the population projections for Latin America made since 1950 in the light of the results of recent censuses, to investigate the relative importance of the sources of error and to suggest ways of improving the accuracy and reliability of projections in the future.
2. Differing views have appeared in print concerning the most suitable criterion for evaluating the degree of success of a projection. ${ }^{1}$ This paper attempts to analyse the differences between the census results and the projections without going into the implications of these errors for the formulation and implementation of economic and social development plans.
3. The study is confined to an evaluation of the projections prepared by the United Nations in 1954 and $1955 .{ }^{2}$ No account has been taken of other projections based on more recent information. It was considered more important to explore the possibility of obtaining good estimates of the future population as soon as further census results are available. This is not meant to imply that projections made at any given time should be taken as final and should not be revised periodically. ${ }^{3}$
[^26]
## II. Sources of information and method

4. Owing to the fact that the relevant information varies greatly from country to country in both quality and quantity, it was not possible to apply a uniform method for evaluating the degree of success of the projections. The results obtained cannot, therefore, be considered strictly comparable. In attempting to evaluate the accuracy of the results of the projections, taking the census results as the point of reference, it must be borne in mind that census results never represent an exact count of the population. Evaluation of the projections was based largely on the results of studies carried out by fellows and teaching staff of the Latin American Demographic Centre. In order to arrive at the results presented below, the theoretical analysis model set out in the following paragraph was applied so far as possible.
5. Let us assume that we have the adjusted population figures for the date on which the projection begins and for the date of the census, and an adjusted estimate of births during the period between those two dates. Let us also assume that the effect of international migration on the size and structure of the population was nil during the period in question. In order to simplify the reasoning, let us consider only the case where the difference in years between the starting point and the date of the census with which the results of the projection are being compared is a multiple of five. Let $P_{x}^{n}$ represent the population between the ages of $x$ and $x+5$ years estimated in the projection for the moment $n$; let ( $P A)_{w_{0}^{n}}^{n}$ represent the adjusted population of the same age group; let $a_{\Delta}=\frac{(P A)_{x}^{o}}{P_{s}^{o}}$ represent the correction factor for the population between the ages of $x$ and $x+5$, as estimated in the projection for the starting point; let $B_{c-x-5}$ represent the births assumed in the projection for the five-year period beginning at $c-x-5$; let $(B A)_{o \sim x-s}$ represent the same births adjusted; let $b_{x}=\frac{(B A)_{c-x-5}}{B_{c-x-5}}$
represent the correction factor for the error in births, as estimated in the projection for the five-year period beginning at $c-x-5$. When these magnitudes are known, the error in the
estimation of the total population can be expressed as the algebraic sum of the errors attributable to each of the assumptions in the projection by means of the following formula:

$$
\begin{gathered}
E=\sum_{x=0,5, \ldots}\left[P_{x+c}^{c}\left(1-a_{x}\right)\right]+\sum\left[P_{x}^{x}\left(1-b_{x}\right)\right]+\sum\left[a_{x} \cdot p_{x+c}^{c}-(P A)_{x+c}^{c}\right]+\sum\left[b_{x} \cdot P_{x}^{c}-(P A)_{x}^{c}\right] \\
x \leqslant c-5 \leqslant c-5
\end{gathered}
$$

in which the first sum represents the error due to the initial structure of the population, the second represents the error due to the assumption of fertility, and the third plus the fourth represents the error due to the assumption of mortality. Any reference to the effect of a factor should be understood to mean only the direct effect. For instance, if the female population of reproductive age is over-estimated, this results in an over-estimation of births. In the above model, this secondary effect is attributed to the assumption of fertility and not to the error in the age structure.

## III. The 1954 and 1955 projections in the light of the census experience of 1960-1964

6. The table shows the census results and the results of the projections for fifteen countries of Latin America. The high projection underestimated the population of the fifteen countries as a whole by 3.35 per cent. The underestimate is 4.5 per cent in the case of the medium estimate and about 7 per cent in the low estimate. Despite the fact that the reports in which the projections are presented caution the reader against the natural tendency to consider the medium projection the most plausible, ${ }^{4}$ it is very likely that most users adopted that projection. However, even if the high projection had been adopted for the countries of Central America and Mexico and Tropical South America and the medium projection for the countries of Temperate South America-a choice which would also have concorded with the views of the authors - the population of the fifteen countries would have been underestimated by about 3.75 per cent. The underestimate in the high projection was 4.71 per cent for Central America and Mexico and about 4.5 per cent for Tropical South America. The medium projection underestimated the population of Temperate South America very slightly ( 0.20 per cent).
7. An analysis of the results for each country shows a much more varied situation. The fact that the census result falls (or does not

[^27]fall) between the high and the low estimate may be considered an indication of the success or failure of the projections. Applying this criterion, it could be said that, generally speaking, the projections were definitely not a success. In only four of the fifteen countries in question (Honduras, Nicaragua, Panama and Argentina) was the population covered by the census larger than the low estimate and smaller than the high estimate.
8. It might also have been thought that the medium projection was the most plausible for Temperate South America and the high projection for the other two sub-regions. Again, the discrepancies between the population enumerated and the population estimated according to those criteria are sizable in many of the countries. The populations of six of the fifteen countries (Costa Rica, Guatemala, Mexico, Brazil, Venezuela and Chile) were underestimated by more than 5 per cent. The populations of three other countries (Peru, Paraguay and Uruguay) were over-estimated by more than 5 per cent. The error was much greater than 5 per cent for some of those countries: Costa Rica ( -8.53 per cent), Venezuela ( -9.58 per cent), Peru ( 12.04 per cent) and Paraguay ( 10.01 per cent).

## IV. Sources of error in the projections

9. The fact that the figure for the total population enumerated may tally with the estimated total does not necessarily mean that development actually occurred as forecast in the projections, since the errors due to the assumptions may have cancelled each other out. Consequently, in order to evaluate properly the degree of success of the projections, a detailed analysis must be made of the different sources of error.
10. The high projection for Costa Rica underestimated the population by more than 8.5 per cent. The birth rate appears to have remained at a level of about 50 per thousand, which is far above the rate of 44 per thousand assumed in the projection. This error probably resulted in an underestimate of the total population of about 5 per cent. The assumption concerning mortality also contributed to the underestimation of the population, probably by between 2 and 3 per cent. There are signs that

Census results (1960-1964) and results of the projections prepared in 1954 and 1955 for fifteen countries of Latin America (in thousands of persons)

| Country | Censw | Projections* |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | High |  | Medium |  | Low |  |
| Fifteen countries of Latin America | 174,557 | 168,704 | (-3.35) | 166,708 | (-4.50) | 162,669 | (-6.81) |
| Six countries of Central America and Mexico ............. | 48,555 | 46,267 | (-4.71) | 45,030 | $(-7.26)$ | 43,849 | (-9.69) |
| Costa Rica | 1,333 ${ }^{6}$ | 1,220 | (-8.53) | 1,175 | (-11.90) | 1,133 | (-15.05) |
| El Salvador | 2,557e | 2,528 | (-1.12) | 2,458 | (-3.84) | 2,392 | (-6.43) |
| Guatemala | 4,278* | 4,058 | $(-5.16)$ | 3,886 | (-9.18) | 3,725 | (-12.93) |
| Honduras | 1,885 | 1,891 | (0.35) | 1,842 | (-2.28) | 1,194 | (-4.80) |
| Mexico | 35,953d | 33,952 | (-5.57) | 33,139 | (-7.83) | 32,356 | (-10.01) |
| Nicaragua | 1,536 ${ }^{\text {b }}$ | 1,600 | (4.18) | 1,538 | (0.09) | 1,480 | (-3.65) |
| Panama | 1,013e | 1,018 | (0.48) | 993 | (-2.02) | 969 | (-4.42) |
|  |  |  |  |  |  |  |  |
|  | 93,392 | 89,200 | (-4.49) | 89,133 | (-4.56) | 86,919 | (-6.93) |
| Brazil | 70,967e | 66,371 | (-6.48) | 66,353 | (-6.50) | 64,765 | (-8.74) |
| Ecuador | 4,581*e | 4,464 | (-2.56) | 4,445 | $(-2.97)$ | 4,309 | (-5.95) |
| Peru | 10,320ef | 11,562 | (12.04) | 11,540 | (11.83) | 11,224 | (8.76) |
| Venezuela | 7,524 | 6,803 | $(-9.58)$ | 6,795 | (-9.69) | 6,621 | (-12.01) |
| Four countries of TemperateSouth America $\ldots . . . . . . .$. |  |  |  |  |  |  |  |
|  | 32,609 | 33,237 | (1.93) | 32,545 | $(-0.20)$ | 31,901 | (-2.17) |
| Argentina | 20,759 | 21,273 ${ }^{3}$ | (2.47) | 20,823i | (0.31) | 20,374i | (-1.85) |
| Chile | 7,374 | 7,014 | (-4.88) | 6,918 | (-6.19) | 6,866 | (-6.89) |
| Paraguay | 1,817* | 2,072 | , (14.03) | 1,999 | (10.01) | 1,931 | (6.26) |
| Uruguay | 2,659k | 2,878 | (8.24) | 2,805 | (5.50) | 2,731 | (2.73) |

* Provisional results.
a Figures for the dates of the censuses interpolated between the results of the projections mentioned in foot-note 3. The dates of the censuses were as follows: Costa Rica (1 April 1963), El Salvador (2 May 1961), Guatemala (18 April 1964), Honduras (17 April 1961), Mexico (2 May 1960), Nicaragua (25 April 1963), Panama ( 11 December 1960), Brazil (1 September 1960), Ecuador (25 November 1962), Peru (2 July 1961), Venezuela ( 26 February 1961), Argentina ( 30 September 1960), Chile ( 29 November 1960), Paraguay (14 October 1962), Uruguay (16 October 1963). The figures in parentheses are the corresponding errors in the projections.
${ }^{6}$ Provisional results by sampling.
e Adjusted census result. See: Alex A. Alens, República de El Salvador: proyección de la población por sexo y grupos de edad, 1961-1981, Latin American Demographic Centre, series C, E/CN.CELADE/C.25, Santiago, Chile, 1964.
a Adjusted census result. See: Zulma L. Recchini, Proyección de la población total de México por sexo $y$ grupos de cdades: 1960-1980, Latin American Demographic Centre, series C, E/CN.CELADE/C. 33 , Santiago, Chile, 1965.
e Does not include indigenous jungle population.
${ }^{\text {* Adjusted census result. See: Julia Salazar H., "Cálculo de la población total por sexo, grupos quin- }}$ quenales y edades individuales en 1961, cifras corregidas". Boletín de Análisis Demográfico, National Directorate of Statistics and Censuses, Year 1, No. 1, Lima, July 1964.
$\xi$ Census result excluding adjustment for omission estimated at 5.8 per cent and indigenous jungle population estimated at 31,800 in 1961 .
${ }^{h}$ Adjusted census result. See: Zulma C. Camisa, Republica Argentina, Evoluación y ajuste del censo de población de 1960 por sexo y edad y tabla abreviada de mortalidad 1959-1961, Latin American Demographic Centre, E/CN.CELADE/C.32, Santiago, Chile, 1964.
i Including the net effect of migration recorded since 1950 , calculated in accordance with the model used in The Population of South America 1950-1980.

Population covered by the census, excluding adjustment for omission estimated at 5.4 per cent.
k Provisional adjustment of the census result provided by A. Cataldi, United Nations Technical Assistance expert.
migration had a positive influence on population growth, which might account for at least a small part of the total underestimate.
11. The high projection for El Salvador underestimated the total population by a little more than 1 per cent. This error was the net result of larger errors due to the assumptions concerning fertility and mortality and, perhaps
to a lesser degree, migration. The difference between the assumed birth rate (42.7 per thousand) and that estimated by A. A. Alens (about 48 per thousand) probably resulted in an underestimation of the total population amounting to about 3 per cent. The projection assumed a life expectancy for both sexes of 52.6 years in 1950-1955 and 55 years in 1955-
1960. Alens has estimated that this indicator hardly rose above 46 years in the period $1950-$ 1961. This error is probably the main cause of the difference between the total underestimation and that attributable to the assumption concerning fertility. There are also some indications that emigration to Honduras may have been sizable.
12. In the case of Guatemala, only a provisional figure for the total population was available from the 1964 census. It was therefore impossible to determine clearly the effect of the different sources of error in the projections. The birth rate was probably not substantially different from the 49.4 per thousand assumed in the high projection. However, the assumption concerning mortality (life expectancy of 39.50 and 41.75 years in 1950-1955 and 1955-1960 respectively) certainly contributed to the underestimation of the population, since this indicator was above 43 years in 1950 (United Nations Demographic Yearbook, 1957). One significant source of error was the estimation of the population for 1950 ; the population for that year as estimated by B. Barrios and H. Ruiz was nearly 8.5 per cent higher than the figure used in the projection.
13. The high projection for Honduras overestimated the population by less than 0.5 per cent. This apparent success was due to the fact that the errors resulting from different causes largely cancelled each other out. The assumed birth rate ( 40.3 per thousand) probably underestimated the true rate by about 20 per cent, resulting in an underestimate of the total population of about 5 per cent. The estimate of the total poptuation for 1950 according to the projection was approximately 3 per cent higher than the total population as adjusted by G. Avila. The assumed mortality (life expectancies of 52.6 years in 1950-1955 and 54.76 years in 1955-1960) contributed to the over-estimation of the population, probably by a little more than 2 per cent. Avila estimated that life expectancy was only 45 years in 1950-1955 and 47 in 1955-1960. It is also possible that migration from El Salvador to Honduras affected population growth in both countries.
14. The high projection for Mexico underestimated the total population (adjusted result) by about 5.3 per cent. On the assumption that the effect of migration had been nil, the conclusion was reached that all the sources of error had contributed to the underestimation of the population. The projection assumed a life expectancy of about 51 years in 1950-1955 and 53 years in 1955-1960, whereas Recchini estimated that this indicator was above 53 years
in 1950-1955 and neariy 58 years in 19551960. The underestimation of the population due to this error was probably about 2.5 per cent, concentrated especially in the highest and lowest age groups. The projection assumed a birth rate of 44.1 per thousand. Recchini estimated the birth rate at about 45.5 per thousand. This error contributed to an underestimation of the total population of about 1.5 per cent and of the population under ten years of age of more than 4 per cent. A comparison of the estimate of the structure by sex and age for 1950 used in the projection with the corrected result of the 1950 census showed estimated errors which probably contributed to the underestimation of the 1960 population by a little more than 1.5 per cent.
15. The high projection underestimated the population of Nicaragua (provisional result) by a little more than 4 per cent. It is not possible, with the information available, to estimate the magnitude of the errors due to each of the assumptions. Two factors may have contributed to the underestimation of the population - the assumed birth rate (47.1), which was possibly a little lower than the true rate, and the estimated population for 1950 , which was not corrected for census omission. The assumption that life expectancy would reach the level of 52.6 years in 1950-1955 and 55 years in 1955-1960 and the assumption that migration would be nil may have contributed to the underestimation of the population; mortality appears to have been higher, and there are signs that emigration to Costa Rica may have been considerable.
16. In the case of Panama, the high projection over-estimated the population enumerated (final result, unadjusted) by less than 0.5 per cent. According to the estimates made by H. Araica, the assumed birth rate underestimated the true rate by about 10 per cent. The estimated population for 1950 also contributed to the underestimation of the population, since it did not take into account the omission from the census of children under 5 years of age, estimated by Araica at about 4.5 per cent. Life expectancy ( 62.3 years in 1950-1955 and 64 years in 1955-1960) contributed to the overestimation of the population. Life expectancy for the period 1950-1960 was estimated by V. Médica at a little less than 57 years.
17. The high projection underestimated the population of Brazil by about 6.5 per cent. It was assumed that life expectancy would be 44 years in 1950-1955 and 46.5 years in 19551960. However, C. Arretx has estimated that life expectancy for the inter-censal period reached a level of 52.5 years. This error may
have contributed to an underestimation of the population of 7 or 8 per cent. The projection assumed that international migration would be nil. However, the positive net effect of this factor during the inter-censal period was estimated at about 600,000 persons, or a little more than 1 per cent of the population enumerated. The estimated population for 1950 also contributed to an underestimation of the 1960 population, probably by a little less than 0.5 per cent, being the net result of the underestimation of the population between ten and twenty years of age and the overestimation of the population over twenty years of age. The assumed birth rate ( 46.6 per thousand) contributed to an underestimation of the total population of about 2 per cent; it has been estimated that the rate for the inter-censal period was not more than 43 per thousand.
18. In the case of Ecuador, it was not possible to determine clearly from the information available why the high projection had underestimated the population enumerated (preliminary result) by more than 2.5 per cent. Once the final results of the census are known, it will be possible to estimate the development of the different components of population growth during the inter-censal period and to compare it with the development assumed in the projection.
19. The population of Peru (adjusted census result) was over-estimated in the high projection by 12 per cent. As a result of research by A. Cataldi and J. Salazar for the intercensal period 1940-1961, the effect of the errors in the assumptions can be estimated. The most significant cause of error was the over-estimation of the 1950 population by more than 7.5 per cent, which contributed to an over-estimation of the 1961 population of about 6.5 per cent. The assumed life expectancy ( 52.6 years in 1950-1955 and 54.7 in 1955-1960) contributed to an over-estimation of the population of about 4.5 per cent. A. Cataldi estimated this indicator at 34.2 years for 1940-1950 and 46.8 years for 1950-1960. The birth rate used in the projection ( 46.3 per thousand) was slightly higher than that estimated by Cataldi (45.2 per thousand) and contributed to an over-estimation of the population of 1 per cent.
20. The high projection for Venezuela underestimated the population enumerated by more than 9.5 per cent. It was not possible, with the information available, to estimate the effect of the errors in each of the assumptions used in the projection. The estimated population for 1950 did not take into account omissions in the census of that year; this certainly contributed to the underestimation of the 1961
population. The over-estimation of mortality was probably a major source of error. A life expectancy of 52.8 years in 1950-1955 and of 55 in 1955-1960 was assumed. However, life expectancy was estimated at about 54 years in 1950 by Páez Celis and about 65 years in 1961 by Michalup. It is possible that the birth rate assumed in the projection ( 46.5 per thousand) was not a significant source of error and that migration had an appreciable positive effect on population growth.
21. If an estimate of the net effect of migration during the period 1950-1960 is added to the estimated population for Argentina in 1960 according to the medium projection, there is very little difference between the result and the adjusted census result. However, the estimate of the net effect of migration is subject to a considerable margin of error. The projection assumed a life expectancy of about 63 years in 1950-1955 and of a little over 64 years in 1955-1960, and this may have contributed to a slight underestimation of the population. Camisa estimated that this indicator was about 61 years in 1947 and 66 in 1960. The birth rate (25.1 per thousand) probably underestimated births in the first five-year period and overestimated them in the second. The effect of these errors was certainly very minor, since they themselves were not large and tended to offset each other.
22. The medium projection for Chile underestimated the population enumerated by more than 6 per cent. According to J. L. Sadie's calculations, the estimate of the population for 1950 used as the starting point for the projection underestimated the population in that year by more than 6 per cent. The life expectancy assumed in the projection ( 50.6 years in 1950-1955 and about 53 years in 1955-1960) over-estimated the level of mortality. J. M. Pujol and O. Tacla estimated life expectancy at about 55 years for 1952-1953 and a little over 57 years for $1960-1961$. The birth rate ( 33.3 per thousand) underestimated births in the period $1950-1960$ by more than 8 per cent. Sadie calculated that the rate was more than 36 per thousand.
23. In the case of Paraguay, the high projection overestimated the population covered by the census (provisional result) by more than 14 per cent. It was not possible, with the information available, to make a precise estimate of the errors due to each assumption. It was assumed that life expectancy would be 57.5 years in 1950-1955 and a little over 59 in 1955-1960. However, A. Silvero estimated life expectancy in the period 1950-1962 at about 53 years. The estimate of the 1950 popu-
lation used as a basis for the projection was nearly 5 per cent higher than the corrected estimate calculated by R. Mellon. There are signs that emigration to neighbouring countries, particularly Argentina, may have been sizable. The assumed birth rate ( 47.1 per thousand) does not appear to have been a major source of error.
24. The medium projection underestimated the population of Uruguay (provisional result of the 1963 census) by 5.5 per cent. The assumptions concerning mortality and fertility coincide with the recent estimates by A. Cataldi and do not therefore appear to have been causes of appreciable errors. According to the same writer, the estimate of the 1950 population which was used as the starting point for the projection was higher than the true population at that date, possibly by more than 10 per cent. It appears that migration had a positive effect on population growth, but it is difficult to determine the error due to that factor, since the statistics of migratory movement are of doubtful quality.

## V. Data and studies required in order to improve the basis for porulation proJECTIONS

25. The subject of this section is a corollary of the preceding one, since the evaluation of projections made in the past is an operation which, while indicating the need for further projections, also makes it easier to avoid the same errors in the future. The errors brought to light in the course of evaluation may be due to the methodology employed or to the estimates made of the levels and trends of demographic variables in the past. These depend both on the basic information available and on the evaluation and adjustments effected. The possibility of applying a given methodology also depends on the basic information available.
26. Censuses are the source of basic information for the preparation of studies on the growth and structure of the population, the components of growth and factors influencing these components. ${ }^{5}$ Following the success achieved by the 1950 census programme for the Americas, the development of censuses in Latin America appears to have suffered a setback with the censuses taken since 1960. This setback was both quantitative and qualitative. ${ }^{6}$
[^28]The 1970 World Census Programme will place great emphasis on the collection and tabulation of information needed for demographic research and for formulating economic and social development plans. It will also stress the importance of evaluating census results, of considering the use of sampling methods in census-taking and of adopting modern methods of data processing to speed up the release of the results. ${ }^{7}$
27. According to a recent publication, ${ }^{8}$ the register of births and deaths is incomplete in fourteen of the twenty republics of Latin America. The degree of incompleteness of the registers is not known, however, even though attempts have been made to gauge it directly in some countries. The accuracy of the information contained in the statistical reports on the vital events registered is also not known.
28. The development of vital statistics in the countries of Latin America has been slow. ${ }^{9}$ The improvement of this situation raises more complex problems than the improvement of censuses. The magnitude and continuity of the administrative operations required, the fact that the registers are used for legal as well as statistical purposes, the need for collaboration between different governmental bodies and departments, and the fact that the registration of vital events requires the active participation of the public are some of the factors which contribute to the delay in developing this source of information in Latin America.
29. These problems have been raised, and solutions have been suggested, at a number of international seminars. ${ }^{10}$ The report on the Second Inter-American Seminar on Civil Registration discussed the bases for a regional civil registration improvement programme during the period 1964-1960. ${ }^{11}$ The implementation of this programme depends largely on two subjective factors. The first is recognition

[^29]by Governments and their various agencies of the need to have good vital statistics as part of the over-all administrative information required for economic and social development planning. The other is the co-operation of the public, which appears to be proportionate to the degree of economic and social development attained in a given country. It is believed, however, that an active publicity and educational campaign may be a very useful way of enlisting such co-operation.
30. Another source of information which may help to improve the basis for population projections in the future is sample surveys. The organization of an efficient national system of vital statistics will require a considerable period of time in some countries of the region. In the meantime, sample population surveys can provide the information which is essential for the preparation of population projections. However, the most significant contribution of surveys would be the possibility of estimating differential fertility, mortality and migration and the attitudes and motivations connected with them. Studies of this kind are very useful, especially as a basis for assumptions concerning the future development of the components of population growth. Owing to its complexity and the large number of ques-
tions which must be asked, such research cannot be carried out with the information currently obtainable from censuses and from registers of vital statistics. The Latin American Demographic Centre, in collaboration with other institutions and the Governments of some countries in the region, is doing very important work in this field.
31. Lastly, a few words concerning international migration. Despite the fact that it is very difficult to provide bases for the assumptions relating to this component in the projections, and despite the further fact that its relative significance to most of the countries will probably wane in the future, the importance of studying international migration trends should not be underrated. As was seen in section IV, international migratory movements appear to have been a major cause of the error in the projections for some countries of Latin America. The fact that their effect could not be fully verified indicates the need to improve international migration statistics. The possibility that international migration from overseas countries may be replaced in the future by migration between the different countries of the region, especially those belonging to economic groupings, should also be borne in mind.

# The use of electronic computers for population projections 

A. F. Pobedina

1. The purpose of population projections is to estimate the future size and structure of the population on the basis of certain assumptions.
2. It is impossible to organize social production or public services on a sound basis without data on the size and structure of the future population. Plans for the building and siting of industrial enterprises, power stations, railways, municipal services, shops, schools, hospitals, children's institutions, housing and so on must be related to the size of the total population and of the working population, the number of children of school and pre-school age and the size of other age groups.
3. The most accurate of the various methods of making population projections is the aging technique, which yields sufficiently reliable estimates of the future size of the population by age and sex.
4. This method has been in use in the Soviet Union for a long time. It was used, for example, to make population projections for the first five-year economic development plan (1928-1932).
5. The method is very labour-consuming. For example, to estimate the population of a particular territorial unit twenty years ahead under such headings as urban and rural population, male and female population, and so on, taking migration into account, it is necessary, with 2,000 items of basic data, to perform over 100,000 calculations.
6. Soviet economic planning requires population forecasts for Union Republics and economic and administrative regions as well as for the country as a whole. As the amount of calculation work therefore runs into millions of operations, population projections made with conventional calculating machines would, of course, require a great deal of time and labour. Today, problems of this kind are being solved through the use of electronic computers.
7. The use of electronic computing equipment is worth while when a calculation consists of a large number of cycles each of which
can be performed within a single programme. Population projections in which a large number of calculations for many regions are carried out within a single programme meet these requirements.
8. Electronic computers can perform calculations in a small fraction of the time required by conventional electric calculating machines. Whereas with the latter a great deal of time and labour is required to calculate even one alternative, the former can quickly produce several alternative projections based on different assumptions about reproduction rates.
9. Soviet statisticians have worked out models for calculating the reproduction rate on the basis of natural population movement both with and without migration.
10. These models are based on the aging technique.
11. The programmes for population projections are drawn up on the basis of various assumptions about the reproduction rate. One alternative, for instance, was based on the assumption that the reproduction rate would remain constant during the whole period, while other alternatives made various assumptions about changes in the reproduction rate.
12. In making population projections with a model allowing only for natural movement, with the reproduction rate constant, the following basic data were used:
(a) Population at the beginning of the period by sex and one-year age groups (from 0 to 100 years), broken down into rural and urban population;
(b) Aging factors by sex and one-year age groups, for rural and urban population, and aging factors for infants born during the year;
(c) Fertility rates for one-year age groups (from fifteen to forty-nine years) of women, for rural and urban population;
(d) Birth timing for males and females.
13. The technique of aging is as follows. The population of each territorial unit at the beginning of the period (for example, on 1

January 1964) is converted, by one-year age groups of each sex, from the base year $t$ to the beginning of the following year $t+1$, each such group being multiplied by the corresponding aging factor, i.e., the population at $i$ is converted to age $i+1$. This gives the next year's population in each age group, except for the group aged less than one year ( $i=0$ ).
14. The number of children aged less than one year is obtained as follows:
(a) The mean population of women aged fifteen to forty-nine years, inclusive, during the year in question is calculated. By multiplying the mean population of women in each age group $i$ by the fertility rate for that age group and summing the products, we get the total number of children born in year $t$;
(b) The total number of births for the year is apportioned between males and females in accordance with the male-to-female ratio for newborn infants;
(c) The figures thus obtained for the number of male and female births are multiplied by the aging factor for infants born during the calendar year, and this gives the number of children of zero age at the beginning of year $t+1$.
15. All these calculations are then repeated to obtain the population at the beginning of each subsequent year in the period.
16. The components of the model which takes into account only natural reproduction factors with constant rates, are as follows:

$$
\begin{equation*}
K_{i}^{a \beta} \chi_{i}^{a \beta t}=\chi_{i+1}^{a \beta(t+1)} \tag{1}
\end{equation*}
$$

Aging for ages 0 to 99 years inclusive

$$
\begin{equation*}
K_{99}^{\alpha \beta} x_{99}^{\alpha \beta t}+K_{\Omega}^{\alpha \beta} \chi_{\Omega}^{a \beta t}=\chi_{\Omega}^{\alpha \beta(t+1)} \tag{2}
\end{equation*}
$$

Aging to obtain population aged 100 years and over

$$
\left.\begin{array}{c}
K_{-1}^{\alpha \beta} \xi^{a \beta} \sum_{i=15}^{i=4 \theta} \phi_{i}^{a} \frac{1}{2}\left(x_{i}^{\alpha} \text { women } t\right. \\
+x_{i-1}^{a} \text { women } t \tag{3}
\end{array} K_{i-1}^{a \text { women }}\right)=x_{o}^{a \beta(t+1)} .
$$

Calculation of number of births in year $t$ and number surviving at beginning of year $t+1$
where $t=$ calendar year;
$i=$ age (0, 1, 2 . . 98, 99) ;
$\Omega=$ age 100 years and over;
$a=$ urban or rural ;
$\beta=$ male or female;
$\chi_{i}^{\alpha \beta t}=$ population by age, sex and rural/ urban distribution at the beginning of the period (year $t$ );
$K_{i}^{\alpha \beta}=$ aging factor by sex and one-year age groups from 0 to 99 years for rural and urban population;
$K_{\Omega}^{\alpha \beta}=$ aging factor by sex for rural and urban population aged 100 years and over;
$K_{-1}^{\alpha \beta}=$ aging factor for infants born during the calendar year;
$\phi_{i}^{\alpha}=$ fertility rate for women aged 15 to 49 years, inclusive, with rural/ urban distribution;
$\xi^{\alpha \beta}=$ percentage of males and females among newborn infants ( $\xi$ males $+\xi$ females $=100$ per cent $)$.
17. In addition, the number of deaths in year $t$ is calculated in this model according to the following formula:
$\mathrm{M}^{a \beta t}=\sum_{i=0}^{n} x_{i}^{a \beta t}\left(1-K_{i}^{\alpha \beta}\right)+N^{a \beta t}\left(1-K_{-1}^{\alpha \beta}\right)$
where $\mathrm{M}^{\alpha \beta t}=$ number of deaths classified by sex and by rural/urban distribution in year $t$;
$\mathrm{N}^{\alpha \beta t}=$ number of births classified by sex and by rural/urban distribution in year $t$.
18. Comparison of the figures for estimated population derived by means of electronic computers with those calculated from statistical data (census data plus births minus deaths) showed that there was very little difference between the two ( $\pm 0.1$ per cent).
19. This, however, was true only for the total population. The model as a whole was still incomplete because it did not take movements from rural to urban areas into account, i.e., it did not allow for migration.
20. The high rate of industrial development in the USSR is accompanied by the movement of large numbers of people from the country to the towns. The proportion of urban population is constantly rising while that of the rural population decreases. As a result of migration, the sex and age structure of the urban and rural population is changing, this being one of the major factors determining natural increase and therefore the future size of the population.
21. As there was no doubt about the need to take migration into account in making population projections, further work was done to improve the mathematical formulation and programme for demographic projections in such a way as to include migration.
22. The new model for population projections provided for different assumptions about changes in the rate of reproduction and for the following types of migration:
(a) Intra-republic (intra-regional) migration, i.e., the movement of population from rural to urban areas within a republic (region);
(b) Inter-republic (inter-regional) migration, i.e., the movement of population from the urban and rural areas of one republic (region) to the urban and rural areas of another republic (region) ;
(c) Increase in urban population and decline in rural population due to the transformation of rural communities into urban ones as a result of industrial development.
23. The extent and direction of migration are strongly influenced by widely differing factors. As migration trends depend much less on past conditions than on future developments, estimates of future migration cannot be derived solely from statistical data for past years.
24. The reproduction model allowing for migration was constructed in such a way that the total extent and direction of migration were determined when the basic data were prepared, and this information was fed into the machine for each year together with the basic data on the size of the population and other factors.
25. Accordingly, in order to allow for migratory movements of population in making population projections, it is necessary first to determine the likely volume of migration, on the basis of the plans for the economic development of the administrative units in question, and then, since population projections are made by one-year age groups and by sex, to determine the ratios for distributing the migrants by age and sex.
26. This distribution is determined differently in the model for the different kinds of migration. In the case of the net intra-republic and inter-republic migration (the balance of migration), the ratios for the distribution of migrants by age and sex are determined at the stage when the basic data are prepared; this is done by using the previous years' statistics on movements of population in the USSR as a whole, in the union republics and in economic regions and by taking into account the characteristics of the future age-sex structure of the population.
27. The basis for the calculations was as follows: in the case of net intra-republic migration, the percentages of males and females and the distribution of migrants by age were determined from the data for each territorial unit; in the case of inter-republic migration, uniform figures were adopted for all territorial units on the basis of the data for the USSR as a whole, since it was necessary to avoid double counting
of persons leaving one republic or region and arriving in another.
28. Net intra-republic and inter-republic migration was calculated on the electronic computer in accordance with the following formula:

$$
e^{\alpha} \mathrm{B}^{\beta t} \gamma^{t} \rho_{i}^{\beta t}+d^{\beta t} \gamma^{\alpha t} P_{i}^{\beta t}
$$

where $p_{i}^{s t}=$ percentage distribution of migrants by age within a territorial unit ( $\Sigma_{p_{i}^{\beta t}}=100$ );
$P_{i}^{\beta t}=$ percentage distribution of migrants by age in inter-republic migration ( $\Sigma P_{i}^{\beta i}=100$ );
$\mathrm{B}^{\beta t}=$ percentage of males and females in intra-republic migration;
$d^{\beta t}=$ percentage of males and females in inter-republic migration;

$$
\left.\begin{array}{rl}
\gamma^{t} & =\text { net intra-republic migration for } \\
\text { vear } t ; \\
\gamma^{a t} & =\text { inter-republic migration for year } \\
t ;
\end{array}\right\} \begin{aligned}
& \epsilon^{\alpha}=+1 \text { for urban area ( } \alpha=\text { urban } \\
& \text { area) ; } \\
& \epsilon^{\alpha}=\frac{-1 \text { for rural area }(\alpha=\text { rural }}{\text { area }) .}
\end{aligned}
$$

29. The sex-age distribution of the population passing from the category of rural to the category of urban population as a result of rural areas becoming urban areas was carried out on the electronic computer in accordance with the sex-age distribution of the total population of each republic or region in the year in question. The idea behind this was that in their economic development and way of life, and hence in their sex-age structure, such communities occupy an intermediate position between long-established urban areas and purely rural areas and that the sex-age distribution of their population is halfway between that of urban and rural populations.
30. The mathematical formula for such changes in status is as follows:

$$
\epsilon^{\alpha}\left(\frac{x_{i}^{\text {town } \beta t}+x_{i}^{\text {country } \beta t}}{x^{t}}\right) r^{t}
$$

where $\quad r^{t}=$ total number of persons changing category in the year in question ( $t=1964$, 1965, etc.) ;

$$
\begin{aligned}
x_{i}^{\text {town }} \beta t & =\text { urban population by age } \\
& \text { and sex; }
\end{aligned}
$$

## $x^{t}=$ total population of the territorial unit at the beginning of year $t$.

31. The assumptions about future changes in the reproduction rate are based on a study of such changes in the past and on various suppositions about future economic and social changes.
32. In particular, a decline in infant mortality, a decline in the mortality of other age groups and a rise in age-specific birth rates in certain republics are assumed in making alternative population projections.
33. In accordance with these assumptions about changes in the future reproduction rate, functions of the changes in fertility rates and in aging factors were introduced into the model.
34. In calculating the number of births with allowance for a rise in the birth rate, the average annual rate of change in the fertility rate for the years in question is used ( $\mu_{i}^{\alpha t}$ ).
35. The annual rate of change in the fertility rate is calculated by the electronic computer in accordance with the formula:

$$
\mu_{i}^{\alpha t}=\sqrt[n]{M_{i}^{\alpha}}
$$

where $M_{i}^{\text {к }}=$ expected increase in fertility rate from the base year to the end of the period in question (broken down by female age groups and by urban and rural population) :
$n=$ number of years in the period in question.
36. For the purposes of the aging technique, the average annual rate of change in the aging factor is determined for each age group, broken down by urban and rural areas and by sex ( $\lambda_{i}^{\alpha \beta t}$ ).
37. In order to obtain the annual rate of change in the aging factor, it is necessary first to calculate new aging factors for the period which take into account the expected decline in mortality. The basic parameters used for this
purpose are the values for the probability of death ( $q_{i}^{\alpha \beta}$ ), from which the basic aging factors are calculated, as well as the expected rates of change in the probability of death for the entire period ( $\eta_{i}^{\alpha \beta}$ ).
38. The average annual rate of change in the aging factor is calculated for each subprogramme in accordance with the following formulas:
(a) $K_{i}^{1 \alpha \beta}=\frac{\left(1-q_{i}^{\alpha \beta} \eta_{i}^{\alpha \beta}\right)\left(2-q_{i+1}^{\alpha \beta} \eta_{i+1}^{\alpha \beta}\right)}{2-q_{i}^{\alpha \beta} \eta_{i}^{\alpha \beta}}$

Calculation of aging factor with allowance for expected decline in mortality by the end of the period

$$
\text { (b) } \quad \lambda_{i}^{\alpha \beta t}=\frac{\sqrt[42]{K_{i}^{1 \alpha \beta}}}{K_{i}^{\alpha \beta}}
$$

Calculation of the average annual rate of change in aging factor
where $K_{i}^{\alpha \beta}=$ aging factor at the beginning of the period;

$$
K_{i}^{L_{\alpha \beta}}=\text { aging factor with allowance for }
$$ decline in mortality by the end of the period;

$q_{i}^{\alpha \beta}=\underset{\text { next year of life for age group }}{\text { probality }}$ $i$, sub-population $\alpha \beta$;
$\eta_{i}^{\alpha \beta}=$ rate of change in $q_{i}^{\alpha \beta}$ for period in question;
$n=$ number of years considered;
$\lambda_{i}^{\alpha \beta t}=$ rate of change in aging factor during one year of the period considered.
39. The rate of change in the aging factor ( $\lambda_{i}^{\alpha \beta t}$ ) obtained in this way is used in the basic programme for aging.
40. In its complete form, the model, taking into account the migration factor and future changes in the reproduction rate, is as follows:

$$
\begin{gather*}
\frac{\chi_{i}^{\alpha \beta t} K_{i}^{\alpha \beta} \chi_{i}^{\alpha \beta t}}{\text { Aging }}+\frac{\left[\epsilon^{\alpha} \beta^{\beta t} \gamma_{\rho}^{t} \rho_{i}^{\beta t}+d^{\beta t} \gamma^{\alpha t} t_{i}^{\beta t}\right]}{\text { Rural-urban population movement }} \begin{array}{c}
\text { (balance of migration) }
\end{array}+\frac{\epsilon^{\alpha}\left(\frac{\chi_{i}^{\text {town } \beta t}+\chi_{i}^{\text {country } \beta^{t}}}{\chi^{t}}\right) r^{t}=\chi_{i+1}^{\alpha \beta(i+1)}}{\begin{array}{c}
\text { Rural-urban population movement } \\
\text { due to change of category }
\end{array}} \\
\frac{\lambda_{99}^{\alpha \beta t} K_{99}^{\alpha \beta} \cdot \chi_{99}^{\alpha \beta t}+\lambda_{\Omega}^{\alpha \beta t} K_{\Omega}^{\alpha \beta} \chi_{\Omega}^{\alpha \beta t}=\chi_{\Omega}^{\alpha \beta(t+1)}}{\text { Aging to obtain population aged } 100 \text { years and over }}
\end{gather*}
$$

Calculation of number of births in year $t$ and number surviving at beginning of year $t+1$

$$
M^{\alpha \beta t}=\sum_{i=0}^{n} \chi_{i}^{\alpha \beta t}\left(1-K_{i}^{\alpha \beta} \lambda_{i}^{\alpha \beta t}\right)+N^{\alpha \beta t}\left(1-K_{-1}^{\alpha \beta} \lambda_{-1}^{\alpha \beta t}\right.
$$

Calculation of number of deaths during year $t$
41. The procedure for population projections, inclusive of migration, covering one year in one territorial unit is basically as follows.
42. First, all those operations are carried out which relate to aging and to the determination of the number of births, i.e., the same procedure is followed as in the programme which excludes migration.
43. Then, from the planned figures for movements of population within and between republics, the final figure for the urban and rural population at the beginning of the year in question is calculated.
44. It is assumed in the calculations that when a community moves from the rural to the urban category its reproduction rate changes at the same time from rural to urban.
45. These newly obtained population figures are taken as the basis for the calculations from the beginning of the next year, and so on.
46. The basic data and the programme must, before being fed into the computer, be transferred to punched cards, perforated tape or some other recording medium.
47. After the programme and basic information have been fed into the computer, it automatically solves the problem in sequence on the instructions of the programmer (see block diagram on page 39).
48. The results are then delivered to the printer.
49. The block diagram of the basic programme consists of the following blocks, the sequence of which is dictated by the calculation techniques (see diagram).
50. The various blocks in this diagram represent complete parts of the programme.
51. The first block (I) represents the input of the basic data from the punched cards, verification of the accuracy of the punched cards and of the accuracy of the input.
52. The second block (II) represents the verification of the completed steps with the aid of the expression $\Gamma_{p b}-\Gamma_{1}$. The cell $\Gamma_{1}$ stores the number of steps executed and the cell $\Gamma_{w}$ contains the number of steps required.
53. The third block (III) represents the operation of carrying the figures forward to the beginning of the following year and of taking from the magnetic drum the coefficients needed for the calculation.
54. The fourth block (IV) represents the actual calculation of the population and consists in its turn of five blocks, (a), (b), (c), (d) and (e), representing this calculation in accordance with the appropriate formulas and in the prescribed sequence.
55. The fifth block (V) represents the verification of the conditions justifying the delivery of the results for the year in question to the printer. This is done in accordance with a scale which is a combination of zeros and ones, where " 1 " stands for "a step which must be delivered to the printer" and " 0 " stands for "a step which does not require delivery of results to the printer".
56. The sixth block (VI) represents the delivery of the results to the printer.
57. The output information for the beginning of each year for each territorial unit is printed in nine groups as follows:
Urban population (male, female, both sexes) ; Rural population (male, female, both sexes); Total population (male, female, both sexes).
58. For each group the computer delivers the following data: number of births and deaths, total population, population by one-year age groups, by five-year age groups and by other age groups necessary for economic development planning and the planning of public-health, cultural and other facilities and services.
59. In addition, from the absolute popalation figures the computer calculates and prints a number of relative indices: number of births, deaths and natural increase per 1,000 population; proportion of different age groups in the total population in each category; proportion of urban and rural population in the total population; and so on.
60. All the above data are delivered by the computer in the form of decoded tables.
61. When calculations with the computer have been completed, a comprehensive economic analysis of the data obtained is made, and the optimum alternative is selected.
1.

II.


$$
\text { if. } \Gamma_{w}-\Gamma_{1}>0
$$

III. Preparation for beginning of computation
IV. Execution of one step in model, i.e.; calculation of population for one year:
(a) Calculation of population at beginning of next year aged 0 to 99 years

(b) Calculation of population at beginning of next year aged 100 years and over $\lambda_{99}^{\lambda_{99}^{\alpha \beta t} K_{99}^{\alpha \beta}} \chi_{\Omega}^{a \beta t}+\lambda_{\Omega}^{a \beta t}{\underset{\Omega}{\alpha \beta}}_{\alpha}^{\alpha \beta t}=\chi_{\Omega}^{\alpha \beta(t+1)}$
(c)

Calculation of male and female births in year $t$
$\mathrm{N}^{a \beta t}=\xi^{a \beta} \sum_{i=15}^{49} \mu_{i}^{a t} \phi_{i}^{\alpha} 1 / 2\left(x_{i}^{a \text { women }{ }_{+}+} \chi_{i-1}^{a \text { women } t} \lambda_{i-1} K_{i-1}^{a \text { women }}\right)$
(d) Calculation of number of infants aged 0 year at beginning of year $t+1$ $x_{0}^{\alpha \beta(t+1)}=N^{\alpha \beta t} K_{-1}^{\alpha \beta} \lambda_{-1}^{\alpha \beta t}$
$x^{\alpha}$

1
(e)

Calculation of number of deaths during year $M^{a \beta t}=\sum_{i=0}^{\Omega} x_{i}^{a \beta t}\left(1-K_{i}^{a \beta} \lambda_{i}^{a \beta t}\right)+N^{a \beta t}\left(1-K_{-1}^{\alpha \beta} \lambda_{-1}^{a \beta t}\right)$
V.

Verification of need to print results for year in question

If scale $=0$

$$
\text { if scale }=1
$$

VI.

Delivery of résults to printer

# Projection basis for populations of Tropical Africa: a general discussion 

## A. Romaniuk

1. The purpose of this paper is to examine the basis which can be used to make projections by age for the population of Tropical Africa. In the first three sections, we discuss the basic data on the age distribution, the fertility and the mortality as given by the censuses carried out in recent years. The last section presents some qualitative considerations concerning the future trend of fertility and mortality. Lack of space compels us to omit from the discussion related topics such as the size of population and the growth rate derived from the population based on consecutive censuses.

## I. Age distribution

2. Censuses carried out in Africa in recent years generally give the age distributions in quinquennial or decennial groups. In addition to numerous irregularities (caused by accidental errors, age differential omissions and, perhaps, some past fluctuations in vital rates), these distributions show deviations of an obviously systematic nature. These deviations are so similar among the different African populations considered, that one can actually speak of a specific African pattern of age misreporting. When compared to a stable age distribution based on the estimated or observed current vital rates, the reported age distribution shows, above all, an apparent deficit among the young adults (ten to twenty), in some cases up to 50 per cent of the expected proportion, and an apparent excess among the adults from twenty to forty-five years of age, especially for females. It also shows, for many of the populations studied, a deficit less pronounced yet typical enough, in the proportion of old persons. In contrast to this, the reporting with respect to children under ten, and especially for those under five years of age, is generally much more satisfactory.
3. The problem which one faces in setting up the projection is how to adjust the age distribution at base date. The choice of method depends on the main cause of the distortion. In this respect, there are some differences of opinion among demographers working in Africa. The authors of the projection made recent-
ly for French-speaking Africa, for example, content themselves with an averaging of the age distribution of individual countries, thus eliminating some accidental errors, but leaving intact the main shape of the age distribution as reported. They think that the deviations in reported age distribution are in fact, to an important extent, due to the past fluctuations in the vital rates. ${ }^{1}$ A similar view is held by the authors of the projection of population for the Democratic Republic of the Congo. ${ }^{2}$ It is quite possible that some fluctuations in vital rates have taken place in the past. It is doubtful, however, whether these would be really noticeable in an age distribution which is clearly biased.
4. The only practical solution would be to fit to the reported age distribution a stable age distribution based on the observed or estimated current vital rates. It is true that not all African populations are of the stable or quasistable type. Yet, even for those which underwent a declining fertility trend, a stable age distribution, based on the current mortality and fertility rates, would be preferable to a dubious empirical smoothing,

## II. Mortality

5. In addition to the conventional information by age groups on deaths occurring during a twelve-month period, for certain countries censuses provide data on the proportion of deceased children among all the children born, by age groups of mothers. This proportion can be converted into probability of death from birth to age ( ${ }_{n} q_{0}$ ) by means of a special technique perfected by W. Brass. ${ }^{3}$ It is generally agreed, however, that neither one nor the other set of data are reliable enough to be used directly for the construction of a survival table needed for the projection. Therefore, it is now cus-

[^30]tomary to resort to a survival table selected among the existing models (United Nations, Princeton) which fits, as much as possible, the presumed actual mortality schedule of the projected population.
6. Under these circumstances, the practical problem one faces is that of finding, through the analysis of the available data on mortality, a basis on which the selection of a proper model can be made. It is reasonable to assume, indeed, that not all data are erroneous to the same degree. A carefully detailed analysis may disclose some parts reliable enough to provide some indication about the level of mortality and, eventually, its age pattern, so that a suitable model could be selected. The comparison of two largely independent sets of mortality data may help to assess their respective value. A further consistency test may be carried out through an internal analysis of the age sequences of mortality rates of each set of data. In either case, we must be able to convert different mortality indices into a common expression so as to make them comparable (for example into ${ }_{1} q_{s}$ or ${ }_{5} q_{o}$ ). This can be done with the help of the United Nations or the Coale-Demeny life tables models. The latter models have the advantage of being subdivided according to four different typical age patterns of mortality, labelled West, East, South and North. ${ }^{4}$
7. The age pattern of mortality, while of relatively little significance for the projection itself (the latter being only approximate), is of great importance for the analysis of the data in the way outlined above. Thus, the infant mortality rate derived from a given post-infant death rate is significantly higher when one uses the "East" model than when one uses the "North" model. Unfortunately, in view of heavy differential age misreporting affecting both living and dead persons, it is extremely difficult to assess with any certainty the true age pattern of mortality of African populations. Better evidence exists regarding the relationship between infant mortality and child mortality. Indeed, the analysis of basic information seems to suggest that among African populations, a relatively low infant mortality is associated with a given level of child mortality. This shows a relationship similar to that implied in the Coale-Demeny "North" model based on life tables for Scandinavian countries.

[^31]8. The table in the appendix compares, for a few African countries, the reported quotient and the quotients derived by means of the "North" model. The most interesting feature of this comparison is the conspicuous understatement of the infant mortality rate (col. 1) based on infant deaths reported for the twelvemonth period. The implication of this finding is that the post-infant death rate ( col .2 ), as reported, provides a better basis for selecting. a model than does the crude death rate and is, indeed, much better than the infant death rate. It is not easy to decide which is the more adequate measurement of actual mortality, the post-infant death rate, as based on the deaths for a twelve-month period, or the indices derived from children who have died among all the children born (cols. 3, 4). Both types of measurement have their merits and their faults. The reader is referred to Frank Lorimer's paper, ${ }^{5}$ which discusses their respective merits more thoroughly. One should, however, note that both are subject to under-reporting. In addition, the post-infant mortality supposedly reported for a twelve-month period may be affected by the errors connected with indetermination of the period reference. On the other hand, the indices based on proportion of deceased children might express the past rather than the present mortality conditions, even when the sequence of $n q_{o}$ values is restricted only to age five (i.e., children born to women thirty to thirty-four years of age).

## III. Fertility

9. Statistics on fertility are not only more thorough and diverse, but also appear to be more reliable. Thus, along with information on births occurring during a twelve-month period, used to calculate conventional fertility rates, censuses for many African countries give, by age groups of mothers, data relevant to the average number of children born. The latter can be converted into the conventional fertility rates or can be used as the basis for adjustment of the reported birth rate in the manner shown in the appendix. Although age distribution is generally strongly distorted, it is nevertheless true that the reporting on young children is relatively correct for countries where a house-to-house census was taken and where the registration of births has reached a fairly high percentage, thus providing the exact date of birth for many children. A fairly reasonable birth rate can be derived in this case by means of

[^32]the stable population model, combining an assumption of the mortality with the reported population of children under five years of age. Finally, though not directly related, the proportions of sterile women which are available for many countries, give an idea of the reproductive capabilities of those populations.
10. The table in the appendix (cols. 5, 6, 7) compares, for a few countries, the estimates of birth rates based on the three different procedures outlines above. It is encouraging to find that for certain countries (the Central African Republic, the Democratic Republic of the Congo, Dahomey, Upper Volta, etc.) all three estimates, in spite of their being largely independent of one another, lead to a very similar fertility level. For other countries (Guinea, Niger), the margin of indetermination is unfortunately larger.
11. For a more refined projection, one needs fertility rates by age group. Unfortunately, these rates as reported are strongly affected by age misrepotting of women. On the average, they are depressed, approximately to the extent to which the reported proportion of women within fifteen to forty-four years of age is in excess over the true (stable) proportion (see paragraph 2). (For some countries, the general fertility rate as reported is ten to twenty per cent lower than the stable general fertility rate.) Certain projections are based on the reported age pattern of fertility and the latter is adjusted only for the general level. We do not know, and there is no way of finding out, how the rates are affected for each individual age group. It would probably be less erroneous to use simply the general fertility rate instead of age-specific fertility rate (even if the latter is adjusted for its general level). Since the reported general fertility rate is deflated, a "correct" one can be calculated simply by dividing the best available estimate of birth rate by the stable proportion of females in the fifteen to forty-four age group in the total population.

## IV. Future trends of fertility and morTALITY

12. What course are fertility and mortality likely to take for a medium range projection of about twenty-five years?

## A. Fertility

13. The most current assumption for a medium range projection for Tropical Africa is that fertility will remain at its present level. Other assumptions of low and high trends are also made, but without any serious attempt
to justify them. As far as the present high fertility populations of Tropical Africa are concerned (i.e., those with a birth rate of 50 per 1,000 or higher, and a sterility rate less than 10 per cent), we would think that the assumption implying an unchanged fertility trend is the only one consistent with the amalysis of underlying factors. Perhaps the most convincing argument in favour of this assumption is the observation one can make with respect to urban fertility in Africa. Indeed, in spite of the fact that urbanization entails an important change in living conditions, the traditional atitude towards procreation has not, as yet, changed among African urbanites. The demographic surveys undertaken in recent years do not reveal any significant lowering of urban fertility. This does not mean, however, that there is no change at present or that we cannot expect any change in factors of fertility in the near future among African populations. For example, the rise in the marriage age, due to a greater education and the state's enforcement of a minimum age for marriage, is already noticeable. The decline in the practice of polygamy in many parts of Africa may also produce some depressing effects on nuptiality: delay in the marriage age and increase in the proportion of tumarried women. While these changes may affect to some extent the age pattern of fertility, however, their lowering effect on the birth rate may be more or less offset by factors operating in the opposite direction. In particular, we would like to mention a weakening of certain customs such as avoidance of sexual intercourse during nursing, and hence, reduction of the intervals between births. The development and use of maternity hospitals in the cities and some rural areas may result in a reduction of death in childbirth and delivery accident rates.
14. The problem is more complex when one considers populations that exhibit a relatively low birth rate and high sterility (see appendix). Although the majority of African populations are extremely prolific, there are nevertheless important regions where sterility reaches an abnormally high rate (central regions of the Democratic Republic of the Congo, Gabon, the southern part of the Sudan, and other regions). Different explanations are advanced for this high sterility. Our own study of fertility factors for the Democratic Republic of the Congo, as well as other research done in other countries, ${ }^{6}$

[^33]have convinced us that venereal diseases constitute the main, if not be only reason, for infertility. If this is true, then the future trend of fertility in present low fertility regions will depend mainly upon the success of a medical programme directed towards the suppressing of venereal diseases. In contrast to the social factors of fertility which are slow to change, the sanitary factors may produce quite a rapid impact on fertility. At any rate, the sanitary aspect of fertility in Africa deserves closer scrutiny than it receives in the current analysis.

## B. Mortality

15. Most of the projections made for Tropical Africa which we have thus far consulted imply an assumption of a rise in expectation of life at birth, by half a year per year during approximately the next twenty years. However, little, if any, analysis of underlying factors is made in order to justify such an assumption. This simply rests on confidence in further medical and technological progress in Africa and on recent experience in such countries as Ceylon and Mauritits. The increase
of expectation of life in these countries was approximately one year per year during the period 1950-1960. This increase amounts to about 0.6 years per year for the coloured (nonBantu) inhabitants of South Africa. It should be recognized that the examples cited benefit from particularly favourable conditions, hardly duplicated elsewhere in Tropical Africa on a significant scale. The past reduction in mortality has probably been achieved primarily through pacification and the control of epidemics, especially tryponosoma. The eradication of paludism and intestinal worms, two main causes of morbidity in Tropical Africa, will require tremendous effort and much time. The next stage of medical improvement, curative medicine, will for many years benefit only privileged classes of African society and selective areas since the low income of the population does not yet make possible the implementation of curative medicine on a popular basis. Considering also the economic and political difficulties which accompany the process of decolonization in some countries, the outlook for a substantial reduction of mortality does not now seem very promising for Tropical Africa, as a whole.

## APPENDIX

Infant mortality rate ( ${ }_{1} q_{0}$ ), birth-rate and proportion of childless women for a few African countries
(The purpose of these estimates is essentially illustrative)

| Country | $\begin{gathered} \text { Infant martality } \\ \text { per } 1,000 \end{gathered}\left(1 q_{0}\right)$ |  |  |  | $\begin{gathered} \text { Birth-rate } \\ \text { (BR) } \\ \text { per } 1,000 \end{gathered}$ |  |  | $\begin{gathered} \text { Childless } \\ \text { roomen } \\ \text { per } 100 \\ 8 \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 |  |
| Central African Republic (1959-1960) | 190 | 154 | 194 | 207 | 48 | 46 | 47 | 16 |
| Congo (Leopoldville) (1958-1959) | 104 | 154 | 153 | 177 | 43 | 45 | 43 | 20 |
| Dahomey (1961) | 110 | 207 | - | - | 54 | 56 | - | - |
| Gabon (1960-1961) | 129 | 230 | $\square$ | - | 36 | 35 | 30 | - |
| Guinea | 216 | 280 | 227 | 228 | 62 | 53 | 50 | 6 |
| Konkoure (Guinea) (1957) | 114 | 164 | 165 | 182 | 40 | 46 | 57 | 10 |
| Niger (1960) | - | - | 210 | 184 | 60 | 55 | 53 | 6 |
| North Cameroun (1960) | 180 | 180 | 225 | 228 | 42 | 41 | 41 | 12 |
| Upper Volta (1960-1961). | 174 | 219 | - | - | 49 | 50 | 48 | 6 |

1: ${ }_{1} q_{0}$ as based on the infant deaths reported by the survey for a 12 -month period.
2: Infant mortality as derived from the post-infant mortality rate (over age 1) based on the reported 12 month period deaths.
3: ${ }_{1} q_{o}$ as derived from the proportion of children deceased among the children born to women aged 15 to 19 years (Brass Method).
4: ${ }_{1} q_{o}$ as translated from the ${ }_{i 0} q_{0}$ by means of the Coale-Demeny "North" model. The ${ }_{5} q_{0}$ is based on the children deceased among the children born to women aged 30 to 34 years (Brass Method).
5: $B R$ as based on the reported births for a 12 -month period.
6: BR as derived from the proportion of children under 5 years of age, by the Coale-Demeny "North" model ; the mortality assumption: ${ }_{1} q_{a}$ (col. 3), and col. 2 if ${ }_{1} q_{0}$ (col. 3) not available.
7: BR as adjusted by reference to the average number of children born to women aged 20 to 24 years (observed $B R$ is multiplied by the ratio of parity at age 22.5 to cumulative fertility up to age 22.5).
8: Percentage of women over 45 years of age who never gave birth to a live child, to the total number of women of that age group.

## The post-war population development of Finland compared with predictions made after the war

## Leo Törnqvist

1. As a result of the war, and of post-war developments, all earlier Finnish population forecasts became clearly misleading. Therefore in 1947 a new series of predictions was made under the direction of the author. In these predictions extending to the year 2000 the future development was calculated by means of graphically predicted survival rates for each sex and five-year age group, and corresponding birth-rates for women. About each of them three different predictions were made called "high", "low", and "medium". The two firstmentioned were aimed at giving an 80 per cent confidence interval for the actual development. The names of those predictions tell if a change from "medium" to "high" or "low" will cause an increase resp. a decrease in the population. Because migration was not believed to have any notable effects on the results of the calculations, and the effects of new antibiotics were not yet predictable, these factors were not taken into account.
2. When predicting the future development of the age specific fertility rates of Finnish females the observed high numbers for the year 1947 were supposed to descend rapidly to the level prevailing before the war. The number of births for the period 1946-1950 was, however, badly underestimated. The total 24 per cent decrease in the number of births from the maximum level to a "normal" level almost agrees with the "high" prediction according to which the corresponding decrease was supposed to be 24.7 per cent. But as a matter of fact this "normalization" of the birth-rates, which was expected to be completed by the beginning of the 1950's, did not end before the second half of the decade. This was due to a remarkable increase in the proportional number of marriages in all fertile age groups. This increase has been especially striking in the female age group of $20-25$, in which the population of married women has increased from 27.6 per cent to 45.4 per cent during the period 1940-1960. As a result of the underestimation of the birth-rate the actual number of births during the period 1946-1960 was 9.8 per cent higher than the "high" prediction.
3. New antibiotics like penicillin, streptomycin and aureomycin were already known in the 1940's, but because their demographic effects could not then be determined the steady increase in the survival rates taking place in the 1930's was supposed to continue. In reality, however, the development in this respect has been so much stronger that the level, which according to the forecast could not be reached until the year 2,000 , was approximately reached at the end of the 1950's. During the period 1936-1940 new-born boys were expected to live 54.3 years and new-born girls 59.5 years. During 1956-1960 the same figures were 64.9 and 71.6 years, while the corresponding "high" predictions were about eight years lower. For comparison it may be mentioned that according to the "high" prediction the expected length of life in the year 2000 was supposed to be 64.0 years for new-born boys and 73.9 years for new-born girls.
4. The exceptionally rapid increase in the expected length of life is, I think, mainly due to new antibiotics, but also the increase in the number of marriages may have caused a slight decrease in mortality
5. Curves describing the post-war development of total population, number of births, deaths and the total deductions including the number of deaths, net emigration and statistical corrections are presented in figure I. Actual and predicted population growth are illustrated by the shadowed areas between the curves describing the number of births and deductions.
6. The actual state of the Finnish population in 1960 and the three predictions are presented by the age pyramid in figure II. In the scale used, the part of the pyramid describing the actual and the predicted population aged over 55 years agree with each other very well. In the age group of $20-54$ years, on the contrary, the actual number of persons is 0.8 per cent smaller than what was expected according to the "low" prediction. This is due to the fact that migration has caused an un-


Figure I
Post-war population development of Finland
expectedly great decrease in this age group, overcompensating the error caused by the underestimation of the increase in survival rates. The number of persons born before 1945 aged over 15 years in the year 1960, however, practically agrees with the corresponding number of the "low" prediction. The effect of migration has been relatively small on the population aged $15-19$ years. The underestimation of the decrease in mortality explains why the actual number of persons in this age group is 4.4 per cent higher than the "high" prediction. Taken altogether, the population in the year 1960 was 5.9 per cent higher than "high", 7.6 per cent higher than "medium" and 11.3 per cent higher than "low".
7. In the years 1950 and 1960 complete censuses of population were made in Finland. The information collected from them forms the basis of our new population projections that were made under the direction of Tor Hartman in
the year 1963. These projections for the years 1970,1980 and 1990 are described in the publication "Regional projections of population and households to the year $1990^{\prime \prime}$. The projections are based on the following assumptions:
(a) The net emigration remains at the level registered in the 1950 's, namely, 7,000 per year;
(b) The migration from one region to another or from rural communes to urban communes or vice versa will, regarding direction and intensity, remain as calculated in the later half of the 1950's;
(c) The life tables remain invariable during the period of projection as calculated on the basis of the mortality for the year 1961 ;
(d) The birth rates and their differences between different parts of the country decrease.

8. Results of these projections until the year 1990 are also described in figures I and II, comparing them graphically with the "high". or the "medium" prediction of our first postwar forecast. It is seen from the figures that according to the calculations the number of births will remain continuously at a higher level than expected according to the "medium" prediction though, contrary to the "medium" prediction, any clear repetition of the post-war "baby boom" is not envisaged in this projection. As to the part of the population aged over 45 years in 1990, who had already been born in 1945, the number of persons in this age group will be practically the same according to both the calculations. So the larger number of our "medium" prediction in the female age group is fully compensated by the smaller number of males, and the decrease in mortality by the assumptions made in the later projections about migration.
9. If the welfare of the Finnish people continues to increase without disturbances until 1990, Hartman's projected number for 1990 of 5.25 million could, I think, be considered as a "low" prediction. The latest 1964 projections directed by A. Strömmer, "Calculations concerning the population development in communes of Finland during 1960-1990" (publ. The National Planning Offices, series A:16) result in the corresponding number 5.19 million, according to the calculations taking migration into account, while the higher number, 5.48 million, is obtained according to calculations taking no account of migration. If besides migration we also take into account the further increase in the expected length of life during the period 1960-1990, and the fact that all earlier plausible predictions and projections made have been surpassed by the actual developments, it would not surprise me at all if the actual number for 1990 were above 5.5 million.

# Population projections for countries of Middle South Asia during the 1950's 

## Pravin M. Visaria

1. This paper attempts to examine the population projections made during the 1950's for four countries of Middle South Asia in order to evaluate: (a) the degree of success in estimating population trends; (b) the probable sources of errors; and (c) the directions in which further research is required to improve the basis for future projections. It covers India (including Sikkim), Pakistan, Ceylon and Nepal, which have each taken two censuses between 1950 and mid-1964.
2. Populations enumerated by the latest censuses in these countries were as follows: India -439.2 million on 1 March 1961 ; Pakistan93.8 million on 1 February 1961 ; Ceylon- 10.6 million on 8 July 1963 ; and Nepal- 9.4 million (provisional figure) on 22 June 1961. The table in the annex shows the percentage differences between these census counts and the population projections made by various authors and the method and year of projection. Differences between the census dates and the reference dates of projections have generally been allowed for by interpolating between the average growth rates of successive quinquennia. Since the base populations of most projections for India excluded areas for which censuses were not taken in 1951, the projected populations are compared with the 1961 count for areas covered by the 1951 census. Further, since almost all the projections for India and Pakistan have fallen short of the recent census counts, except in one case, only the upper limit of the various projections by an author or agency has been shown for these two countries.
3. The main features of the table may be summarized as follows:
(a) While a majority of projections for Ceylon overestimated the population, for the other three countries all projections (except one) fell short of the counts;
(b) If one projection by Sarkar is excluded, the range of difference between the projected and censused populations varies from -7.5 per cent in the case of the Planning Commission's projection for India to +7.1 per cent in the case of Selvaratnam's "high" projection for Ceylon. The most successful projections have
been: (i) the low projections by Ceylon's Census and Statistics Department; and (ii) the one by the United Nations for Pakistan, based on medium assumptions. Several of the projections made in the late 1950's have come within 3 per cent of the census counts;
(c) All projections, except one based on the mathematical method, have either used the component method or have extrapolated the growth rate over some period in the past, sometimes with adjustment. Projections based on the component method have fared better than those extrapolating the past growth rates.
4. In a broad discussion of the probable sources of errors in various projections, the quality of the data on the base populations may be considered first. While Nepal had no synchronous country-wide census until 1961, the other three countries have a fairly long tradition of periodical censuses. And yet, nearly 3.6 per cent of Pakistan's 1961 population was either enumerated on special tribal schedules or was merely estimated. The low density of population in Nepal and some apparently socio-cultural factors in Pakistan also raise questions about the completeness of census coverage. The situation is no doubt improving. But differentials in the completeness of enumeration in successive censuses could partly explain the discrepancies between the projected and enumerated populations. In 1951, conditions in India and Pakistan were comparatively unsettled and 1961 census conditions were better than those of 1951. India's sample checks on census coverage have shown a net undercount of 1.1 per cent and 0.68 per cent in 1951 and 1961, respectively. ${ }^{1}$ According to these estimates, better census coverage in 1961 can explain a discrepancy of about 1.8 million between the projected and enumerated populations of India. The point is relevant also to
[^34]Pakistan where an under-enumeration of 5 per cent of the urban population in 1951 is officially acknowledged.
5. Except perhaps in Ceylon, a major problem in preparing population projections has been the paucity of information on levels of fertility and mortality. In Ceylon, the registration of vital events is approaching completeness. But in India and Pakistan the official vital registration is grossly deficient and it is virtually nonexistent in Nepal. While India had, even in the early 1950 's, a few ad hoc special studies which provided generally reliable estimates of vital rates in the local areas, Nepal and Pakis$\tan$ did not enjoy that advantage. The stable and quasi-stable population models do provide reasonably good estimates of birth and death rates; but then the age data in these countries have also been deficient and with the possibility of under-enumeration, the age distributions of Pakistan present a serious puzzle.
6. However, despite the non-availability and various limitations of data, the projections of the 1950's based on the component method have generally come closer to the census counts than others. The main reason for the relatively poor performance of projections based on an extrapolation of the past experience is the rapid decline in mortality in Ceylon from 1946 1954 and in India and Pakistan from 19511961, which has resulted in what seem to be unprecedentedly high growth rates for these countries. In fact, demographers were slow to learn the lesson from Ceylon and elsewhere. They held that larger countries like India and Pakistan could not expect a similar achievement. ${ }^{2}$ Coale and Hoover were the first to point out the implications of various public health programmes undertaken in India's Fiveyear Plans for her rate of population growth, in the light of the experience of Ceylon and a few other low-income countries. ${ }^{3}$ Their penetrating analysis has had an impact on all subsequent projections in the region; and it was corroborated by the estimates of vital rates during 1957-1958 by the Indian National Sample Survey. Subsequently an official expert committee on Vital and Health Statistics prepared a new projection - apparently the first official projection of the 1950 's to be based on the component method-for use in the for-

[^35]mulation of India's Third Plan, which missed the census count, two years later, only by 1.8 per cent. The official Indian life-tables prepared after the 1961 census have estimated an expectation of life of 41.2 years during the years 1951-1960, indicating the actual decline in mortality to be even higher than that envisaged by Coale and Hoover. ${ }^{4}$ For Pakistan, there is suggestive evidence that besides some underestimation of mortality decline, the level of fertility was perhaps underestimated in the projections based on the component method. ${ }^{5}$ However, Selvaratnam's projections for Ceylon which exceed the census count by 7 per cent seem to have overestimated mortality decline. Selvaratnam had assumed a life expectancy of 65.9 years for Ceylon from 1961-1966 as against the United Nations assumption of an expectancy of 65.6 years from 1975-1980.
7. An aspect of population change taken into account only in projections for Pakistan is international migration. True migration statistics are notoriously deficient and the stimuli and magnitudes of migration cannot be foreseen. Moreover, while important in Nepal and Ceylon, migration is relatively unimportant in large populations of India and Pakistan. However, in a retrospective analysis, the subject deserves due consideration. The available data for Ceylon indicate an estimated net emigration of about 130,000 persons between the two censuses, which can explain 65 to 80 per cent of the difference between the United Nations projections and the 1963 count. ${ }^{6}$ Elsewhere, a net immigration of 0.8 million persons during 1951-1961 is reported by Pakistan. ${ }^{7}$ And India's census data on religion suggest an immigration of over 2 million Hindus and about 1 million Muslims from East Pakistan. ${ }^{8}$ Further, this coincides with the fact that, except in one case, projections for East Pakis-

[^36]$\tan$ have either exceeded the census count or have fallen short of the latter by a smaller percentage than projections for West Pakistan. The subject of international migration needs careful investigation in these countries in the context of observed differences between projections and census counts.
8. The preceding analysis brings out the need for intensive research to improve and evaluate the data on the base population and to obtain reliable information on fertility, mortality and migration. During the past decade or so, the availability of data and demographic skills in the region have improved both quantitatively and qualitatively. A few specific points for research may be mentioned here:
(a) The usefulness of sample post-enumeration checks on the coverage and the content of censuses needs more recognition. The limitations of such checks notwithstanding, they can, if properly conducted and analysed, prove valuable supplements to indirect tests on subjects like the alleged census undercounts of (i) infants and young children, perhaps with sex-
selection and (ii)) females in particular agegroups or marital status categories;
(b) As was mentioned at the Asian Population Conference in 1963, the applicability of the United Nations model life-tables to countries like India, Ceylon and Pakistan is somewhat questionable. Contrary to the recorded experience of developed countries including Japan and Taiwan, females in these countries have a lower expectation of life at birth than males. An identification of factors contributing to this phenomenon will help to project accurately the future course of sex-age-specific mortality;
(c) Special studies and periodical surveys are necessary to verify and detect the possible rise of reportedly non-existent socio-economic differentials in fertility in the initial stages of change;
(d) The collection and analysis of information on the demographic characteristics of international migrants is vitally necessary for Ceylon and Nepal and desirable also for India and Pakistan.

## ANNEX <br> The salient characteristics of population projections made for India, Pakistan, Ceylon and Nepal during the 1950's

| Country/ author (s) of projection <br> (1) |  | Method of projection (3) | Projected population millions) (4) | Percentage <br> difference from the latest census count |
| :---: | :---: | :---: | :---: | :---: |
| India ${ }^{\text {a }}$ |  |  |  |  |
| 1. Kingsley Davis | 1951 | Extrapolation of the 1921-1941 growth rate | 402.5 | -7.27 |
| 2. R. A. Gopalaswami | 1953 | Extrapolation of the 1941-1951 growth rate | 407.1 | $-6.22$ |
| 3. A. Das Gupta and M. Majumdar | 1952 | Component method | 409.0 | -5.78 |
| 4. Planning Commission | 1956 | Extrapolation of the percentage change during 1941-1951 | 401.5 | -7.51 |
| 5. A. J. Coale and E. M. Hoover ${ }^{\text {b }}$. | 1956 | Component method | 425.0 | -2.10 |
| 6. T. Chellaswami | 1957 | Component method | 423.7 | -2.40 |
| 7. United Nations | 1958 | Component method | 417.0 | -3.94 |
| 8. S. N. A.garwala | 1959 | Component method | 423.0 | -2.56 |
| 9. Expert committee on vital and health statistics | 1959 | Component method | 426.4 | -1.77 |
| 10. Ministry of Labour and Employment. . | 1959 | N.A. | 417.0 | -3.94 |
| Pakistan |  |  |  |  |
| 1. Census office ${ }^{\text {c }}$ | N.A. | N.A. | 89.0 | -5.15 |
| 2. National Planning Board. | 1957 | Extrapolation of the 1951 growth rate | 89.1 | -5.00 |
| 3. Inam-ul Haq | 1957 | Mathematical method | 89.3 | -4.83 |
| 4. Habibur Rehman | 1959 | Extrapolation of the 1951 growth rate with adjustment | 89.8 | -4.32 |
| 5. W. Parker Mauldin and S. S. Hashmi c | 1959 | Component method | 91.4 | -2.54 |
| 6. United Nations ${ }^{\text {c }}$ | 1959 | Component method (conservative assumption) | 92.5 | -1.41 |
| 7. United Nations ${ }^{\text {c }}$ | 1959 | Component method (medium assumption) | 94.5 | +0.71 |

The salient characteristics of population projections made for India, Pakistan, Ceylon and Nepal during the 1950 's (continued)

| Country/ author(s) prof projectios (I) | Year when projection reows made (2) | Method of projection (3) | Projected population millioses) (4) | Percentage difference from the latest census cosint (5) |
| :---: | :---: | :---: | :---: | :---: |
| Ceylon |  |  |  |  |
| 1. N. K. Sarkar | 1957 | Extrapolation of the 1921-1946 growth rate | 8.79 | -17.29 |
| 2. N. K. Sarkar | 1957 | Component method | 10.16 | -4.34 |
| 3. Department of census and statistics. | 1957 | Component method (high) | 10.95 | $+3.09$ |
| 4. Department of census and statistics. | 1957 | Component method (low) | 10.68 | $+0.50$ |
| 5. United Nations. | 1958 | Component method (high) | 10.82 | +1.81 |
| 6. United Nations. | 1958 | Component method (medium) | 10.80 | +1.63 |
| 7. United Nations. | 1958 | Component method (low) | 10.78 | +1.42 |
| 8. S. Selvaratnam. | 1958 | Component method (high) | 11.38 | $+7.12$ |
| 9. S. Selvaratnam. | 1958 | Component method (medium) | 11.37 | +7.02 |
| 10. S. Selvaratnam. | 1958 | Component method (low) | 11.36 | $+6.93$ |
| Nepal |  |  |  |  |
| 1. United Nations. | 1959 | Assumption about percentage increase in population | 9.26 | -1.35 |

[^37]
## Under-enumeration of the initial population and under-registration of the births as sources of errors in population projections

## J. Tohr Yamaguchi

1. A number of studies on the quality of the census enumerations and birth registration of the United States have shown, among other things, varying degrees of deficiency in the coverage completeness. ${ }^{1}$ However, a lack of conclusive information makes it difficult, if not impossible, to account for the deficiency in projecting population size and sex-age structure even though if unadjusted, it would also be projected and result in errors in the projected estimates. Moreover, the general purpose of population projections is to approximate, rather than predict, future population trends a priori under assumed trends of fertility, mortality, and net migration, within a plausible range of variations into which the approximation is likely to converge. Considerations of relatively insignificant errors arising from the undercount of the initial population and also the under-registration of the vital events may not be too relevant.
2. Nevertheless, this paper is an attempt to visualize the extent to which the projected estimates can be affected by such errors. Illustrations are based, for the most part, on the projections to 1985 of the United States population, by age and sex, according to the U.S. Bureau of the Census ${ }^{2}$ and on the estimates of enumeration and registration completeness according to Coale-Zeinik, Yamaguchi, and the U.S. National Office of Vital Statistics. ${ }^{3}$
[^38]Under-enumeration as a source of errors
3. To illustrate how the enumeration errors affect the projected estimates, a component projection is considered for a "closed" population, i.e., subject to no migration, by age and sex, over an arbitrarily chosen time interval of $n$-years. Let $p(x, t)$ denote females of the population, aged $x$-years at the beginning of the interval in a given year $t$, and $u_{x}(x, x+1)$ a survival probability of $p(x, t)$ successively from age $x$ to $x+1$. The number of survivors from $p(i, t)$ at the end of the interval then becomes,

$$
\begin{equation*}
p(i+n, t+n)=p(i, t) \underset{\substack{n+i-1}}{u_{i}(x, x+1)} \tag{1}
\end{equation*}
$$

where $i$ represents any member of a set of positive integers and zero and its upper limit equals to the higest age observed among the females living at the beginning of the interval. The total number of survivors aged $n$ years and above at the end of the interval will then equal,
4. As evident in these equations, the estimated number of survivors aged $n$-years and above reflect errors inherent in the enumeration (or estimation) of the initial population in two ways: (1) numerical values given for $p(i, t)$ 's and (2) for $u_{i}(x, x+1)$ 's. If the former is 10 per cent under-enumerated, then the estimated number of survivors will have an under-estimation by 10 per cent provided that the survival function is free from the underenumeration errors. Very often the survival function, derived from relevant life-table values which are based on the age-specific death rates, ${ }_{n} m_{s}$-values, in a stationary population, is subject to the influence of under-enumeration but

[^39]if there is a positive correlation between the omissions of population from the census count and of deaths from the registration, ${ }_{n} m_{m}$-values are not seriously affected.
5. A method devised by Drs. C. Chandra Sekar and Edward W. Deming ${ }^{4}$ can be applied to approximate the unbiased estimate of deaths and subsequently to determine the degree of variability in the survival function due to the unregistered and unenumerated events at the beginning of the interval, but when the mortality level expressed in terms of $e_{0}$ is in the order of 65 years and more, deviations in the survival functions from one level to the other would be extremely small. For this reason, the influence of under-enumeration on the survival function is excluded from the discussion.
6. Estimates and projections shown in
${ }^{4}$ C. Chandra Sekar and Edward W. Deming, "On a method of estimating birth and death rates and the extent of registration," Journal of the American Stanistical Association, vol. 44, No. 245 (March, 1949), pp. 101-115.
table 1, based on a set of the four projections by age and sex to 1985 of the United States population according to the U.S. Bureau of the Census, ${ }^{5}$ are those of the population under 25 years of age in 1960. Projections are obtained under the assumption of a slightly declining mortality trend which would vary from $e_{o}$ of 66.6 years in 1960 to 68.0 years in 19841985 for males and of 73.1 years in 1960 to 74.5 years in 1984-1985 for females. The population is assumed to have no migrational movements (international). These estimates and projections are different from any figures shown by the Bureau because the beginning of the projection period refers to 1 July 1960, rather than 1 July 1963. This is necessary because the measures of under-enumeration and under-registration refer to the former date. Survival rates are calculated by appropriately interpolating those given by the Bureau. ${ }^{6}$
${ }^{5}$ U.S. Bureau of the Census, op. cit.
${ }^{6}$ Ibid., appendix A, table A-3.

Table 1. Estimates and projections of the population of the United States, by age and sex: 1960-1985 (in thousands; figures relate to 1 July and include armed forces abroad)

|  | $\begin{gathered} 1960 \\ (1) \end{gathered}$ | $\underset{(2)}{1965}$ | $\begin{gathered} 1970 \\ (3) \end{gathered}$ | $\begin{gathered} 1975 \\ (4) \end{gathered}$ |  | 1985 $(6)$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Mals |  |  |  |  |  |  |
| Under 5. | 10,352 | - | - | - | - | - |
| 5-9 | 9,572 | 10,305 | - | - | - | - |
| 10-14 | 8,595 | 9,547 | 10,278 | - | - | - |
| 15-19 | 6,814 | 8,557 | 9,505 | 10,233 | - | - |
| 20-24 | 5,558 | 6,761 | 8,490 | 9,431 | 10,153 | - |
| 25-29 | - | 5,509 | 6,701 | 8,415 | 9,348 | 10,064 |
| 30-34 | - | - | 5,459 | 6,641 | 8,341 | 9,267 |
| 35-39 | - | $\cdots$ | - | 5,397 | 6,568 | 8,251 |
| 40-44 | - | - | - | - | 5,306 | 6,459 |
| 45-49 | - | - | - | - | - | 5,163 |
| Female |  |  |  |  |  |  |
| Under 5. | 10,013 | $\cdots$ | - | - | - | - |
| 5-9 | 9,254 | 9,977 | - | - | - | - |
| 10-14 | 8,314 | 9,238 | 9,960 | - | - | - |
| 15-19 | 6,651 | 8,297 | 9,219 | 9,939 | - | - |
| 20-24 | 5,554 | 6,630 | 8,271 | 9,191 | 9,909 | - |
| 25-29 | - | 5,532 | 6,605 | 8,240 | 9,157 | 9,872 |
| 30-34 | - | - | 5,504 | 6,572 | 8,200 | 9,113 |
| 35-39 | - | - | - | 5,466 | 6,527 | 8,145 |
| 40-44 | - | - | - | - | 5,409 | 6,461 |
| 45-49 | - | - | - | - | - | 5,325 |

7. The figures in column 1 of the table are to be adjusted for under-enumeration and then projected to 1985 under the same assumption on mortality and migration. Adjustment factors can be directly calculated from per cent completeness of the enumerations in 1960 shown in table 2. These figures actually refer to the natives of continental United States as
of 1 April 1960 but are assumed to apply also to the foreign-born as well as the population of Alaska, Hawaii, and other island-areas since the former accounted for only 5.4 per cent and the latter less than 1 per cent of the total $d e$ facto population of the United States including military personnel abroad in 1960.

Table 2. Per cent enumeration completeness of the native populations of the United States, by colour, sex, and age up to 25 years (figures relate to 1 April 1960, and include military personnel abroad) a

|  | Total |  | White |  | Non-white |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Male | Female | Mate | Female | Male | Female |
| Under | 96.9 | 97.8 | 98.0 | 98.6 | 90.8 | 93.3 |
| 5-9 | 96.9 | 98.1 | 97.5 | 98.7 | 93.6 | 95.2 |
| 10-14 | 96.8 | 98.2 | 97.1 | 98.7 | 94.4 | 95.0 |
| 15-19 | 95.5 | 96.5 | 96.7 | 97.6 | 88.2 | 89.8 |
| 20-24 | 92.9 | 96.2 | 94.8 | 97.5 | 80.0 | 87.9 |


#### Abstract

a Yamaguchi, op. cit. Figures are obtained on the basis of intercomparison of the enumerated natives, by state of birth, colour, sex and age, in 1960 with the corresponding population expected in the same year. The latter is estimated by projecting a cohort of births registered in a given state during a five-year time interval which starts, consecutively, from 1 April 1935. The registered births are adjusted for under-registration and depleted by life-table survival rates to allow for mortality. The 1940 and 1950 birth registration tests and also state life-tables are used for such adjustments. Later, figures for each state are combined to derive corresponding percentages for each region and finally for the United States.


8. Revised estimates and projections are shown in table 3. Although per cent errors prevalent in the 1960 estimates are brought forward with the surviving cohorts, the deviations in terms of the absolute magnitude amount to as much as $2,486,000$ among males
and females aged 25-49 years in 1985. Such a magnitude of error measures more than 68 per cent of the estimated contribution of $3,647,000$ by net migration to the same population. ${ }^{?}$
7 U.S. Bureau of the Census, op. cit., table B-2, pp. 69-70.

Table 3. Adjusted estimates and projections of the population of the United States, by age and sex: 1960-1985 (in thousands; figures relate to 1 July and include armed forces abroad)

|  | ${ }_{(1)}^{1960}$ | ${ }_{\text {c }}^{1965}$ | ${ }_{(3)}^{197}$ | ${ }_{(4)}^{1975}$ | ${ }_{(5)}^{1980}$ | ${ }_{\text {(6) }}^{1985}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Male |  |  |  |  |  |  |
| Under | 10,673 | - | - | - | - | - |
| 5-9 | 9,869 | 10,624 | - | - | - | - |
| 10-14 | 8,870 | 9,843 | 10,597 | - | - | - |
| 15-19 | 7,121 | 8,831 | 9,800 | 10,550 | - | - |
| 20-24 | 5,953 | 7,065 | 8,762 | 9,723 | 10,468 | - |
| 25-29 | - | 5,900 | 7,003 | 8,684 | 9,638 | 10,376 |
| 30-34 | - | - | 5,847 | 6,940 | 8,608 | 9,554 |
| 35-39 | - | -- | - | 5,780 | 6,864 | 8,515 |
| 40-44 | - | - | - | - | 5,683 | 6,750 |
| 45-49 | - | - | - | - | - | 5,530 |
| Female |  |  |  |  |  |  |
| Under | 10,233 | - | - | - | - | - |
| 5-9 | 9,430 | 10,196 |  | - | - |  |
| 10-14 | 8,464 | 9,414 | 10,179 | - | - | - |
| 15-19 | 6,884 | 8,446 | 9,394 | 10,158 | 12 | - |
| 20.24 | 5,765 | 6,862 | 8,420 | 9,366 | 10,127 | - |
| 25-29 | - | 5,742 | 6,836 | 8,388 | 9,331 | 10,089 |
| 30-34 | - | - | 5,713 | 6,802 | 8,348 | 9,286 |
| 35-39 | - | - | - | 5,674 | 6,755 | 8,292 |
| 40-44 | - | - | - | - | 5,615 | 6,687 |
| 45-49 | - | - | - | - |  | 5,527 |

9. The completeness of census count is known, empirically at least, to fluctuate by age and sex. ${ }^{8}$ Such a sex-age selectivity of the under-enumeration then implies that the sexage composition of the projected population would be affected by the undercount of the initial population by sex and age. However, to

[^40]measure the impact of such a selectivity would require taking into account also the survivors of children to be born during the projection interval and presenting, therefore, a difficult problem since the latter is further influenced by the under-enumeration as well as the underregistration of births in connexion with the fertility projection.

Under-registration of the births as a SOURCE OF ERRORS
10. To illustrate how the registration errors affect the projected estimates, a fertility projection is considered over a time interval of $n$ years. Notations are identical to those defined previously except: $B(t+m)$ denotes the number of female children to be born in year $(t+m)$ where $0 m n-1 ; f(i, t+m)$ refers to the age-specific fertility rate per 1,000 women aged $i$ years in $(t+m)$ where once again $0 m n-1$; and $k$ represents a reciprocal of the sex ratio at birth (approximately $0.4878)$. Then,

$$
\begin{equation*}
B(t+m)=K \int_{i=0}^{\infty} p(i, t+m+1 / 2) f(i, t+m+1 / 2) d i \tag{3}
\end{equation*}
$$

In terms of a single fertility indicator such as sex-age adjusted birth rate, it becomes,

$$
\begin{aligned}
B(t+m)= & K\left[\begin{array}{c}
\text { Weighted female population aged } \\
15-44 \text { years in year }(t+m+1 / 2)
\end{array}\right] \\
& \times\left[\begin{array}{c}
\text { Sex-age adjusted birth } \\
\text { rate in year }(t+m+1 / 2)
\end{array}\right]^{9}
\end{aligned}
$$

11. As previously shown, the first entry on the right side of the equation is affected by the deficiency in the enumeration of the initial population in year $t$ which is projected to year $(t+m+1 / 2)$. The second entry is influenced not only by the same factor but also by the deficiency in the registration of births in year $t$ which, in terms of sex-age adjusted birth rate, is projected to year $(t+m+1 / 2)$.
12. An example of how the second entry is so affected is shown in a fertility projection over the interval of 1960-1975, which is analogous, approximately, to the fertility projection of the Series B projection prepared by the Bureau of the Census. ${ }^{10}$ In such a projection, the fertility level is assumed to decline from the 1960 level by 4.6 per cent in $1960-$ 1965, 11.2 per cent in 1965-1970, and 13.1 per cent in 1970-1975. Expressed in sex-age adjusted birth rate, uncorrected for underenumeration and under-registration, the level is measured 27.99 per 1,000 of a weighted

[^41]aggregate of number of women in the various quinquennial age groups 15 to 44 .
13. In order to adjust this rate, estimates of female population by age are corrected upward for under-enumeration. Per cent census enumeration errors cited by Coale and Zelnik ${ }^{11}$ for the native whites in the United States aged 15-44 years as of 1 April 1960, are used in conjunction with the author's own estimates for the whites and nonwhites ${ }^{12}$ to calculate an adjustment factor to be applied to all age-groups $15-44$. It is assumed that the same completeness by age and sex applied to the natives and foreign-born and that the completeness ratio of the whites to the nonwhites at ages 15-24 applied to all other age-groups 25-44. An upward adjustment coefficient so calculated is 1.013513 .
14. On the basis of the 1950 test of birth registration by type of attendance ${ }^{13}$ and births recorded in 1960 according to the corresponding attendance type, it is possible to estimate the completeness of birth registration in the same year. According to such a procedure, the completeness is estimated to be 98.9 per cent which is assumed to apply to births by all ages of mothers. A sex-age adjusted birth rate, taking into consideration the adjusted population estimates and registered births, then becomes 27.96.
15. The difference between the corrected and uncorrected rates is thus extremely small and the variance of only .03 may very well be due to some other factors. Nevertheless, if it represents causes due to the under-enumeration and under-registration, errors in the projected population estimates would be only in the order of 10,000 in each of the years 1965, 1970, and 1975.
16. In conclusion, examples illustrated in the United States population projections indicate that the under-enumeration of the initial population can affect the projected estimates more significantly than the deficiency in the birth registration. However, these bias factors are, no doubt, more acute in their roles where the quality of census and vital statistics data is below the standard of the United States, and consequently, population projections based on such demographic data will have more significant errors due to the under-enumeration and under-registration.

[^42]
## SUMMARY OF PAPER

# Methods of analysing interrelationships between demographic phenomena and social and economic phenomena 

## Vittorio Castellano

The author observes that the failures of the leading policies find their real justification in the weaknesses of a descriptive social science which might permit reliable forecasts. In particular, in the field of the relationships between demographic and socio-economical phenomena, data are insufficient to give scientific dignity to the numerous forecasts of future population, to which the whole world is devoting close attention. The author exposes a programme of work, financed by the Italian National Research

Council and to be carried out by a group of Italian University Institutes, for the systematic analysis of these relationships in Italy. He exposes the general methodology of this analysis, which consists in tracing the relevant variations of demographic phenomena and in cutting down in space and time the field of research, in order to single out all the possible situations as in an experimental plan in which to dispose artificially the variations of the factors, so as to test their importance.

As a first contribution to this study, for the period 1878-1962, the author applies a system to find out the years for which it is almost certain that the variations ascertained in demographic phenomena result from general factors which it is hoped to determine.

# PROJECTIONS OF URBAN AND RURAL POPULATION, ECONOMICALLY aCTIVE POPULATION, HOUSEHOLDS AND FAMILIES 

## PAPERS

## Some factors limiting the study and calculation of households in Latin America

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## I. Introduction

1. In order to clarify the meaning of the following paragraphs, it should be noted that:
(a) The term "household", as used in this document, has the meaning recommended in the programme for the Census of the Americas (COTA-1960). The household is thus considered to consist of a group of individuals sharing the same private dwelling, whether related or not. This definition includes the person living alone, who constitutes a oneperson household;
(b) In view of the fact that a family - a group of persons related by marriage or blood - is always a household, or part of one, implicit and very brief references to this basic social institution are unavoidable. Such references, which occur from time to time in the following pages, may also be explained by the fact that information concerning the family often emerges during the processing of the results of an inquiry when the structure of the household is analysed according to the relationship of its members;
(c) Although this paper does not go into the problems involved in analysing households, its title implies that, in principle, all demographic projections should be accompanied by a brief study of the situation.

## II. Importance of the study of households

2. The study of the characteristics and growth of households is important from two points of view: the economic and the social. With regard to the first, it should be realized that in many communities these groups constitute units of production and that, given the
nature of certain goods, they replace the individual as the basic unit of consumption. A classic example of this latter aspect is the dwelling unit. In fact, much of the growing interest in the study and calculation of households in Latin America is attributable to the difficult housing situation. From the sociological point of view, it should be noted that the processes of reproduction, allocation of status, socialization and upkeep take place within the household; hence the importance of studying the household in official surveys of the component families, the reproductive capacity and the cultural, economic and health levels of the population. In Latin America, as in other developing regions, another important factor in the analysis of the structure and growth of households is the need to know the extent of the changeover from joint (extended) families to biological (nuclear) families. This trend, resulting from the intensive urbanization of Latin America, may influence housing needs, which are already acute owing to the shortage of capital and the pressure of accelerated demographic growth.

## III. Approach to the calculation of HOUSEHOLDS

3. Ideally, a household projection should consist of an analysis of the "existing" situation, a description of the hypotheses and methods of work, the projection itself and comments on the meaning of the results. In addition to giving a picture of the main characteristics (size and geographical distribution of households and demographic, economic, social and cultural attributes of heads and members of households), the analysis should include an evalua-
tion of the data which serve as a basis for calculating the number of households. The hypotheses and procedures to be applied in projections are based on such analysis.
4. Various methods have been developed for projecting the number of households. Their degree of refinement depends on the quantity and quality of the statistical information available, but however rough or elaborate the method applied, a projection of the total population will always be necessary, except in the case of a simple extrapolation of the number of households. A number of calculation methods are outlined below:
(a) Where the proportion of the population forming households and the average household size are known, the projection is obtained by dividing the estimate of the population forming households by the average number of inhabitants per household. Of course, the proportions and ratios used may be constant or variable, depending on the amount of data available and the hypotheses implicit in the method;
(b) Another simple method is based on the distribution of population by marital status and on assumptions concerning groups of persons of a specific marital status who constitute households. ${ }^{1}$ Once the ratios of such groups to the base population have been projected, estimates of the number of households are obtained by adding the products of those ratios to the projected population. This type of calculation is a working alternative at the stage where housing needs are estimated and desirable standards of housing which take demographic growth into account are applied;
(c) Similary, the (fixed or variable) percentages of heads of households by age and sex in relation to the population of the same sex and age may be applied to a projection of the population classified by the same attributes. This method of calculation, which is similar to that often used in estimating the school-age population and the labour force, gives not only the number of households but also distributions of heads of household by sex and age, which may be useful for various purposes;
(d) The procedure described in (c) may be refined by using the marital status variable. This does not complicate the calculations, but a projection of the population by sex, age, and marital status is necessary;

[^43](e) When the methods of collecting and processing census data permit, estimates may be made of specific family groups, such as total nuclear families constituting households or parts of households, total families headed by men or by women, etc. ${ }^{2}$ For this it is necessary to have projections of the population by age and sex, to formulate hypotheses concerning the proportion of the population forming households and to know or estimate the proportion of unmarried and married persons and other related data.
5. The field of application becomes more limited as methods become more elaborate, owing to the basic information required. When it is difficult to obtain population projections, it would be over-optimistic to hope to obtain estimates of the number of households by size, for example, and broken down according to the sex, age and marital status of the head. Calculations distinguishing between households, families in the generic sense mentioned above, nuclear families, married couples, etc. are even less feasible. These observations hold good for most Latin American countries where, as indicated below, there are many difficulties to overcome.

## IV. Difficulties in estimating the number of gouseholds in Latin America

6. The factors which have created and boosted demand for adequate and up-to-date statistics include the rapid population increase, the expansion of public services and the need to rationalize the use of national resources through planning. Nevertheless, "In spite of the considerable importance of information on the number and characteristics of households for various planning purposes, the data on families and households available for the countries of Latin America are quite limited. ${ }^{33}$
7. The main factors which make it difficult to calculate the number of households in Latin America may be summed up as follows: shortage of personnel and equipment, ignorance of the usefulness of demographic statistics and inadequacy or absence of basic statistical information.

[^44](a) Shortage of personnel and equipment. There has been a shortage of skilled personnel to prepare and carry out plans for analysing the information. Data processing equipment has often been in short supply and inadequate, so that the benefit derived from analysing the data collected has borne no relation to the resources invested;
(b). Ignorance of the usefulness of demographic statistics. The statistical information obtained from population censuses, vital statistics and demographic surveys has not been put to the best advantage, largely owing to ignorance of the way in which it may be used in the formulation, implementation and evaluation of policy and action plans. In short, the problem might be described as unawareness of the uses to which the data may be put, a situation which has led to a waste of scanty resources;
(c) Inadequacy or absence of basic statistical information. The main sources of information for the study and calculation of households and families are population censuses, vital statistics and demographic surveys, which provide data on fertility, mortality, nuptiality, divorce and widowhood rates, the age structure of the population and the tendency of families to share the same dwelling; in other words, data on the factors which determine the growth of households. These sources also provide the information needed for demographic projections, which are necessary for calculating purposes in household projections. Some of the difficulties inherent in each of the tools referred to and which affect the analysis and calculation of households, are mentioned below.
8. The attempts to estimate net omissions from enumerations in Latin America are of recent date and the countries which have studied the matter have not made proposals to remedy the situation, so that the population and household projections are not adjusted for census omissions and are therefor of limited value.
9. The age-specific distributions of population derived from Latin American censuses clearly show mistakes in the reporting of ages in the enumeration. Such errors make it essential to apply data-adjustment techniques, or to form appropriate compensatory age-groups before making demographic projections.
10. In some Latin American countries, environmental, cultural and economic conditions explain the high rate of consensual or free unions, which are true substitutes for marriage. Data on the marital status of persons who live
together as man and wife without being legally married are usually very defective. Even when the census instructions are designed to ascertain the de facto or de jure situation of such persons, the pressure of social conventions may cause them to declare a different marital status. This is the cause of the striking differences between the sexes to be noted in the distribution by marital status of the population of some Latin American countries.
11. With a few exceptions, recent (i.e., about 1960) census information on households is lacking, and the information obtained during the 1950 Census of the Americas (COTA1950) is scanty. At the end of 1964, only one country (Panama) had published data on households and families obtained during the 1960 census. Fourteen countries provided information for 1950 on the number of households by size; only eleven countries published data on the relationship between the head and the members of the household; no publication contained data on the household structure groups and only a few countries gave figures on the sex and age of heads of households.
12. Legislation establishing civil registers has existed since the middle of the nineteenth century. Theoretically, the vital statistics provided by the registers should exist for a very long series of years, but in fact this is not the case. The statistical information in the civil registers does not go back to the time when the respective acts were promulgated. Furthermore, there is one country, Honduras, which does not have civil registers. With the exception of a few countries, the data are defective and there is no telling to what extent the registers are complete. There is clear evidence of omissions in the registers of births and deaths. This under-registration can noticeably affect demographic projections if correction factors are not applied to the rates which serve as a basis for those projections. It should be noted that in some countries it is not enough to analyse marriages and divorces in order to study the formation and dissolution of families, for a high proportion of the families are organized not on the basis of legal marriage but of de facto unions.
13. The third source of information which can be of use in studying the formation and growth of families and household structure is field surveys. Despite the fact that many countries make periodic surveys, which could be designed to include the study of households, there is no record of this source having been utilized.

## V. An example

14. By way of illustration, and subject to all necessary reservations, some alternative
calculations based on two of the methods described in this document are given below for three Latin American countries.

Calculation of the number of households in Brazil, Cuba and Panama
(In thousands)

| Country | Method* | Year |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 1965 | 1978 | 1975 | 1980 |
| Brazil | (a) | 14,409 | 16,191 | 18,166 | 20,409 |
|  | (c) | 14,686 | 16,670 | 19,026 | 22,668 |
| Cuba | (a) | 1,536 | 1,697 | 1,868 | - |
|  | (c) | 1,567 | 1,750 | 1,958 | - |
| Panama | (a) | 247 | 287 | 334 | 388 |
|  | (c) | 238 | 275 | 321 | 374 |

* Methods (a) and (c) described in paragraph 4.


## VI. Conclustons

15. Since the recommendations that might be made are conditioned by the difficulties outlined above, one need only stress the need to modify procedures-for the purpose of studying dependency, for example-so that the category of head of household is given a more precise meaning and is not merely an honorary title, as is often the case because the
person considered the head is the one recognized as such by the other members of the household. Lastly, it would seem advisable to adopt the definition of the household that identifies it with the private housing unit, and to defer until the data processing stage the formation of whatever groups of persons related by blood, marriage, or adoption are best adapted to the concept of the family prevailing in each country.

# Conceptual aspects of urban projections in developing countries 

## Kingsley Davis

1. Projections have most frequently been made for political units such as nations, provinces, cities. They have often sought to foretell numbers in age-sex, marital-status, and labourforce categories, who would be using various public services. Such short-run forecasts are obviously required for official planning and are now made on an almost routine basis, various techniques being utilized. ${ }^{1}$
2. Our task is to discuss a whole class of projections called urban, and to discuss the conceptual and analytical aspects rather than the accounting procedures. What kinds of projections fall within this "urban" class? The types may be ottlined as follows:
I. Individual-city projections:
(a) For the whole city;
(b) For constituent areas.
II. Urbanization projections:
(a) Of the urban population;
(b) Of the urban proportion of the total population;
(c) Of rural-urban migration.
III. Inter-city projections:
(a) Of the rank-size distribution;
(b) Of the geographical distribution:
3. Of the urban population;
4. Of the urban places, by size.
IV. City-structure projections:
(a) Of concentration or deconcentration;
(b) Of settlement patterns.
5. This list refers to analytically separable features of urban phenomena. Although not exhaustive, it suggests that up to now the interest in urban projections has been onesided. A preoccupation with individual-city projections has led either to ignorance of the possibility of other types or to a failure to develop them. This overemphasis is paralleled by a preoccupation, in planning circles, with planning for individual cities as against national or regional urban planning. The assumption

[^45]has been unconsciously made that "cityplanning" is the planning of the individual city; yet it is increasingly apparent that the development of individual cities is far more influenced by national changes and policies than by the particular city plans.

## Individual-city projections

4. Popular as city projections are, they raise some of the knottiest problems of prediction. One difficulty is that, other things being equal, the smaller the unit the greater is the relative variability in the determining factors. Although some cities are larger than some nations, the fact remains that on the average their populations are smaller and less stable than those of nations or provinces. In particular, especially in developing countries, a big factor in local city growth is migration. Since migration is chiefly determined by social and economic factors, it is more unpredictable than fertility and mortality, which have some biological restraints. Within nations there is normally either no regulation of movement at all or only poorly enforced regulation, with the consequence that net movement into or out of a city is hard to estimate in advance. If the migratory factor is uncertain with respect to whole cities, it is even more uncertain with respect to sectors or neighbourhoods within cities. For these reasons alone, individual-city forecasts are hazardous and have no practical value except for very short-run periods, say ten years or less. In a survey of ninety-nine United States forecasts for local areas (most of which related to cities, counties, and metropolitan areas), Siegel found that "the average error was 8.4 per cent, and more than a quarter of the errors were 10 per cent or more [although] the forecast period was under ten years in all but a few instances and quite commonly under five years." ${ }^{2}$
5. A more profound problem-affecting hypothetical projections as well as practical

[^46]forecasts - is the question of the areal unit of analysis. Normally, the forecasters are thinking in terms of political units (e.g., cities, counties, municipios, wards) with fixed boundaries, and the task then becomes the prediction of population growth within the particular unit. However, for purposes of understanding the actual growth and change of urban aggregates, we cannot be confined by the legal boundaries. Populations spill over political limits.
6. Efforts have long been made to designate more realistic units for analysis-units variously called "urbanized areas," "metropolitan areas", "greater towns," "conglomerations," etc. ${ }^{3}$ But these units change in their geographical boundaries from one time to another. It follows that any model of growth which is to be used for prediction and as a basis for planning should be a two-variable model - that is, should predict the growth in both population and territory. ${ }^{4}$
7. This requirement may seem obvious, but it is seldom met. The usual way of analyzing "city" or "metropolitan" growth is to "hold boundaries constant." To fail to hold boundaries constant has been regarded as an error, whereas this is necessary if we are to represent reality.
8. In the case of urban subunits, one can argue that the governments within those areas need to know exactly what populations in the future they will be dealing with and therefore want the calculations made with fixed boundaries. True, and there is no reason why projections cannot be made on that basis. However, if this alone is done, the result will likely be false. It is not reasonable to make projections for a particular area within a metropolitan complex without reference to the relation of that unit to others in the complex. The best idea of a given area's future may come from trends in areas contiguous to it. Blighted areas, for example, move outward from central parts of an urban agglomeration; a particular area's future may be governed by transport plans developed by some larger unit. Therefore, local governments within urban complexes need future estimates that are connected with estimates for the other units and for the entire urban complex.

[^47]9. If the components of metropolitan areas are defined in ecological terms - e.g., "central city", "rings," and "urban fringe" - the distortion that comes from holding their boundaries constant is great. As the total urban agglomeration grows, what was once a part of the ring becomes a part of the centre, and what was in the fringe becomes a part of the intermediate rings.
10. The change in territory of urban communities is a fundamental aspect of the future of such communities. Growth in territory permits a growth in population without a corresponding rise in population density. From this observation comes a definition of urban concentration and deconcentration. Deconcentration is occurring when the territory covered by the urban settlement is growing faster than the population; concentration is occurring when the reverse is true. In the case of the San Francisco Bay Area, for example, the population rose from 364,000 in 1890 to $3,217,000$ in 1960, but the over-all density declined from 5,643 to 2,501 per square mile, because the territory expanded at a faster pace than the population.
11. Territorial expansion has restraints that differ in character and timing from those affecting population growth. It must normally be outward rather than inward. It thus often runs into other urban units undergoing similar expansion. The big urban community "eats" the smaller nearby ones, although the latter may be large when compared to the nation's cities generally. In short, estimating models must be two-variable models, embracing territory as well as population.
12. The moving boundary of a growing urban community is hard to determine, especially if censuses have not been directed to this purpose. However, the true boundary at different times can be approximated by taking the smallest territorial political units (e.g., barrios) and, on the basis of specified criteria, separating those which belong to the urban complex from those belonging to the rural sector. Among the criteria are the following: (a) contiguity to the main city. Does the civil division share part of its boundary with either the central city or some division already included in the urbanized area?; (b) employment primarily in non-agricultural pursuits. Does the unit have most of its labour force in pursuits outside of farming or forestry?; (c) commutation to the main city. Does a fourth or more of the labour force commute inward to places of work more centrally located?; (d) density of settlement. Is the density in the unit
more similar to the established urban areas than to the outlying rural areas?; (e) transportation to the central city. Do good transport facilities provide the residents with ready access to the central city?
13. Data for applying all of these criteria will not normally be available. Further, a unit may qualify as urbanized on one count but not on another. For these reasons the criteria cannot be applied automatically but always require judgement and knowledge of the local situation.
14. The urbanized area, with its moving boundary, almost always grows faster in population than will a city or a metropolis with fixed boundaries. This faster population growth affects the future economy of the urban complex. Merchants in the central city feel the demand for goods coming from the new areas absorbed into the urban aggregate; urban utilities have to cope with the needs of the expanding population at the fringe; transportation facilities throughout the urbanized area have to handle the traffic of fringe-area residents as they make trips to other parts of the ecological city. Serviceable projections for individual cities must therefore be made with reference to both territory and population.

## Projections of national urbanization

15. One could forecast the total urban population and the total rural population by summing the projections for local units. But seldom are projections available for all such units in a nation. Other, less cumbersome, methods of estimating the future process of urbanization must thus be found.
16. One such method is to project rural and urban populations as wholes. In so far as this is done by estimating future birth, death, and net migratory rates for each population - the relevent data are difficult to find in underdeveloped regions. Births and deaths should be allocated according to the residence of the parents, and internal migration should be measured with reasonable accuracy. ${ }^{5}$ Since such information is almost never available in adequate detail (e.g., on an age-sex basis), the technique is so dependent on assumptions and "corrections" that it is hazardous as a guide to the future. Perhaps its main value is not the projections it produces but the data-inadequacies it exposes.

[^48]17. A third approach is to project the change in the rural-urban ratio itself, which describes a typical attenuated "S" curve. Fitting a logistic curve to the past points and projecting it is a good method for judging the short-run future course of urbanization, and it is probably superior for judging the long-run course. Alternatively, one can take as a model the course of urbanization in the past history of some now developed nation. For this purpose there should be a rough correspondence between the urbanization curves of the two countries, ignoring difference in dates. Since urbanization in India has followed the Frencli more closely than the Japanese or United States curve, France therefore serves as a better projection model, although other features of the demography of India and France are not similar.
18. Great interest attaches to estimates of future rural-urban migration; yet internal movement is more poorly documented than virtually any other demographic phenomenon. It therefore tends to be calculated as a net residual, either by subtracting natural increase from population growth or by analyzing age structure. Given a knowledge of past internal migration, its future can be estimated by whatever assumptions we care to make. By projecting the future urban ratio, we can add estimates of rural-urban differences in naturai increase and thus compute the rural-urban migration required to attain the projected change in the urban population. Two corrections must be made because many rural people become urban, not by moving to a city, but by staying at home (the place where they live grows from the status of "rural" into the status of "urban") and because, between any two dates, some of the natural increase in cities is contributed by migrants. ${ }^{6}$

## Inter-city projections

19. A fundamental aspect of urban demography is the size-distribution of a nation's cities and towns. It is generally assumed to be more variable than it actually is. If the populations of the urban places of a nation (especially a large nation) are plotted on double-log paper, they will be found to fall rather closely along a straight line, approximately described by the formula $R S=C$, where $R$ is rank, $S$ is size, and $C$ is a constant. ${ }^{7}$ By

[^49]a least-squares solution one can derive a variant of the formula for a particular country; ${ }^{8}$ it seems to remain much the same over time.
20. Sometimes a country is called "topheavy" or "unbalanced" in its urban structure. But what is the standard adopted? Grauman, writing about Latin America (op. cit.) says: "Latin American urban population is 'topheavy'. If about equal numbers in four size groups, like in Canada, is a standard, Turkey's urban population is 'regressive' while that of Argentina, and most countries in Latin America, is markedly 'progressive'." Canada is a purely arbitrary standard. Also, the application of fixed-size classes to urban populations of varying magnitudes has a distorting effect.
21. Over the short run a country's urban structure tends to be constant. ${ }^{9}$ It can vary in the long-run, but hardly enough to affect planning. Increased urbanization seldom pro-

[^50]duces a change in the rank-size system. The latter refers to size relations simply among cities themselves, regardless of degree of urbanization. As urbanization occurs, maintenance of the same structure among size classes requires that the larger cities grow faster than the smaller ones, because the bottom class is bounded whereas the top class is unbounded. In Argentina between 1947 and 1960, the proportion of the total population living in cities of 100,000 or more increased from 39.2 to 49.1 per cent, a substantial rise in urbanization. When growth by fixed size classes is analysed, the largest class shows most gain:

| $\begin{gathered} \text { City } \\ \text { size } \\ \left(000^{\prime} s\right) \end{gathered}$ | Per cent gain 1960 |
| :---: | :---: |
| 100-199. | 15.6 |
| 200-499. | -19.2 |
| $500+$ | 79.5 |

Such a procedure is deceptive, because the number of cities in the system, the identity of those in each class, and the relation of the classification to the total city population all change. The result makes it look as if the city population was concentrating in the bigger cities. The fault can be seen by examining the distribution at the two dates:

| $\underset{(000 \text { 's) }}{\text { Size }}$ |  | Number of cities |  | $\begin{gathered} \text { Per cent } \\ \text { of } \\ \text { city population } \end{gathered}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 1947 | 1960 | 1947 | 1960 |
| 100-199. |  | 4 | 5 | 9.5 | 6.9 |
| 200-499. |  | 3 | 3 | 16.7 | 8.9 |
| $500+$ |  | 1 | 3 | 73.8 | 84.1 |
|  | Total | 8 | 11 | 100.0 | 99.9 |

The top class rose as a proportion of the total because it could gain new members but could not lose any. If the total system is altered in size, the use of the same class boundaries will vitiate the comparison of its rank-size structure.
22. To maintain comparability, one must use proportionate classes. When this is done, one finds virtually no change in the rank-size system in Argentina in 1947-1960.

## City-structure projections

23. With a rise in the level of living, urban deconcentration tends to occur, despite increased urbanization and population growth. ${ }^{10}$
[^51]Consequently, an extrapolation of past trends will often lead to the prediction of sparser urban settlement. However, there is a limit to urban deconcentration; it is the point at which one expanding urban aggregate begins to run into another. With the fantastically fast growth of human populations plus further urbanization, the collision of cities is gaining in frequency. Within three to four decades, at rates of growth exhibited in the past, the San FranciscoOakland urban aggregate will merge, with cities whose centres are still seventy miles away. Along the Eastern seaboard of the United States the cities have already coalesced for a distance of some 500 miles. ${ }^{11}$ In such cases, the population in the area of the collision can no longer grow without incurring greater density. As

[^52]more and more collisions occur, deconcentration will no longer become possible.
24. Within a country the pattern of concentration or deconcentration is apt to characterize all cities more or less similarly. Consequently, for national policy, projections of future concentration or deconcentration do not have to be made for every city.

## Conclusion

25. Space does not allow discussion of every kind of urban projection in our outline. Re-
flection on types considered indicates that urban projections have little value if the person making them does not understand what he is doing. There is no automatic routine technique to obtain satisfactory future estimates. With understanding of urban phenomena, projections become quantitative statements of contingent possibilities rather than presumed predictions. It is the contingent possibilities rather than stark predictions that make planning intelligent.

# Projections of the economically active population 

Erland von Hofsten

1. As is well known, a population projection of the usual type for one or several future points of time and for a certain geographical area, gives the total population, with breakdowns by sex and age, and possibly also by marital status. ${ }^{1}$ The projection is founded on assumptions with regard to fertility, mortality and outer migration. These assumptions may be more or less realistic. If they are considered realistic, when the projection is made, it is called a forecast. ${ }^{2}$
2. The future growth of a population may be influenced to some extent by policy decisions. In order to moderate a population growth which is considered too rapid, it may thus be possible to stimulate birth control, sterilizations, abortions and emigration. If, on the other hand, growth is considered too slow, fertility and immigration may be stimulated, or birth control and abortions may be checked.
3. A population forecast may have, as a consequence, decisions which aim at making the future population deviate from what looked most probable when the forecast was made. The forecast may thus "kill itself," so to speak. In order to avoid this, the forecast may take future policy decisions into account; this implies that the forecast includes elements of programme or planning, and that we are dealing no more with a forecast, in the proper sense of the word.
4. However, in so far as we are dealing with the total population of a country for which outer migration can be considered unimportant, the scope for planning is relatively limited, and it can be maintained that we are still dealing with a forecast, in the proper sense of the word.
5. That this is so, is fully realized if the purposes of a forecast are considered. Data for the projected population, with breakdowns by

[^53]sex and age, are used for planning the building of schools, the training of school teachers, the building of hospitals or old people's homes and for making cost estimates for old age pensions, etc. In such cases, a relatively clear distinction can be made between the forecast itself and the plans, which take the expected population changes into account. The plans referred to can be assumed not to have any influence on the future population.
6. However, if the purpose is to make a forecast for a smaller area for which outer migration is important, or if the aim is to make a forecast for a certain segment of the population, the element of planning is so important that we may, in fact, be dealing with a plan, rather than with a forecast. This is especially obvious if the aim is to make a forecast for the economically active population. Such a forecast will be used primarily for the formulation of long-term economic policy, especially in regard to employment and unemployment. There is, therefore, a direct relation between planning and the forecast. If policy decisions are being based on the forecast, without its being remembered that the forecast is already based on certain assumptions regarding policy, the situation will be confused.
7. In order to become statistically measurable, the concept "economically active" must be more closely defined. In the post-war period, the "labour force" concept has become increasingly popular for this purpose. According to the definitions given by the Eighth International Conference of Labour Statisticians (1954), the total labour force is the sum of the civilian labour force and the armed forces. The former includes both the employed and the unemployed. Among the employed, the most important category is persons at work, i.e., "persons who performed some work for pay or profit during a specified brief period, either one week or one day". Persons who are temporatily absent (on account of illness, injury, vacation, etc.) are also included among the employed, as are workers on their own account and unpaid family workers who are occupied
for at least one third of the normal working time. ${ }^{3}$
8. In many countries, statistical data about the labour force are collected through smallscale "labour force sample surveys." Sweden is one of many countries which regularly undertake such surveys, based upon a probability sample of approximately 12,000 persons, and with the data collected by trained interviewers. The Swedish surveys refer to one calendar week of each quarter of the year, and the international definition for the labour force is used. Thus, part-time workers having

[^54]worked for at least one hour during the survey week are included in the labour force.
9. The surveys give age-specific labour force participation rates (LFPR's), i.e., the number of persons in the labour force as a percentage of the total number of persons in corresponding age groups. Figures for Sweden for May, 1964, are given below. Corresponding figures for other countries and areas show that the position may vary considerably. This can be explained by a number of factors which cannot be analysed here. ${ }^{4}$

[^55]Table 1

| Age, years | Men | Unmarried women | Married women |
| :---: | :---: | :---: | :---: |
| 14-17. | 36.4 | 28.2 |  |
| 18-24 | 77.3 | 72.7 | 50.2 |
| 25-29 | 95.5 | 87.0 | 43.5 |
| 30-34. | 96.1 | 77.4 | 48.3 |
| 35-39. | 97.9 | 78.5 | 50.0 |
| 40-44 | 96.8 | 87.0 | 54.3 |
| 45-49. | 97.7 | 82.0 | 56.2 |
| 50-54. | 96.8 | 75.4 | 51.1 |
| 55-59. | 94.7 | 64.2 | 39.5 |
| 60-64. | 81.4 | 49.0 | 26.9 |
| 65-69. | 51.6 | 16.2 | 8.0 |
| 70-74. | 24.6 | 3.9 | 7.3 |
| 75. | 10.2 | 2.3 | 1.3 |

10. The natural method for arriving at the future labour force is to apply expected LFPR's to the projected total population by age and sex. ${ }^{3}$ But how can we arrive at LFPR's for the future? To assume that they will remain constant in the future would almost certainly imply a heavy bias. It is necessary to take into account a number of factors which may influence the LFPR's in the future.

[^56]11. Seasonal variations. For most purposes, it is important to know the size of the economically active population over a whole year. As a labour force sample survey relates only to the conditions during one week (or an alternative short period), seasonal changes may be obscured. In Sweden, seasonal variation is, on the whole, without great significance, except for the younger age groups, where LFPR's for four consecutive quarters are shown below.

Table 2

|  | Men |  | Unmarried women |  |
| :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & 14-17 \\ & y \text { years } \end{aligned}$ | $\begin{aligned} & 18.24 \\ & \text { years } \end{aligned}$ | $\begin{aligned} & 14-17 \\ & \text { years } \end{aligned}$ | $\begin{aligned} & 18-24 \\ & \text { years } \end{aligned}$ |
| November 1963 | 40.7 | 75.4 | 31.2 | 72.1 |
| February 1964. | 38.7 | 73.9 | 27.3 | 72.4 |
| May 1964. | 36.4 | 77.3 | 28.2 | 72.7 |
| August 1964 | 56.4 | 80.3 | 41.3 | 80.6 |

It can be seen in the above data that the higher figures for August are clearly due to the fact that many school children and students take temporary jobs during their holiday.
12. Ages below 25 years. For these ages, a higher school-leaving age, as well as enhanced high school and university enrolment, may influence the LFPR's considerably. It is necessary to know something about the plans for developing the educational system if reliable forecasts for these ages are to be possible. This is a good example of how planning must and can - be taken into account for the formulation of a forecast.
13. Ages above 65 years. From the figures quoted above, it can be seen that in Sweden the LFPR's for the highest age groups - at least in regard to men - are so high as to make it essential to take into account the labour force in these age groups. Several factors may influence future development. On one hand, many old people may now work from sheer necessity; gradual improvement in pensions may cause them to stop working. On the other hand, improved health conditions in the higher age groups may influence more and more people to continue working after the normal retirement age. As regards women, for whom the rates in the higher age groups are now quite low, it should be remembered that these rates refer to women, only a few of whom had paid jobs when they were younger. It is gradually becoming more common in the lower age groups that women - more especially the married ones - have paid jobs, and that an increased proportion will continue to work while growing older. (It should be noted that widows are included among the unmarried women.) The rules for direct taxation may also have an influence on LFPR's in the higher age groups. It is very hard to tell what the predominant tendency will be. On the whole, the present author believes that for Sweden, the LFPR's in the higher age groups will increase.
14. Men and unmarried women between 25 and 64 years. For men in these ages, the Swedish LFPR's quoted above are so near 100 per cent that no substantial increase can occur. For the unmarried women, a certain increase can take place. In both categories, changes of the number of hours worked can occur without their being visible in the LFPR's (see paragraph 18).
15. Married women between 25 and 64 years. This is a difficult category, composed of two groups: one with small children, and the other without. That the presence of children plays an important part in the size of the

LFPR's can be seen from the following figures (May, 1964):

Table 3

| Number of children 7 years | $\begin{gathered} \text { LFPR's } \\ \text { in } \\ \text { tert } \\ \text { cent } \end{gathered}$ |
| :---: | :---: |
| 0. | 46.9 |
| 1. | 38.0 |
| 2. | 24.1 |
| 3. | 21.4 |
| 4 and | 15.5 |

16. Changes in regard to fertility, as well as changes in the proportion of married women in the child-bearing ages, may thus have an important influence on the LFPR's. This is also a case, however, in which planning may influence the LFPR's considerably. An increasing number of day nurseries, as well as other measures being taken in order to make it possible for women with children to have paid jobs, may result in increases (see paragraph 19). (When considering the economic effect of the increase, one must, of course, take into account that part of the women added to the labour force are required as personnel at the day nurseries.)
17. Many married women with older children are not prevented from having paid jobs by the necessity of caring for small children, but the LFPR's are much lower for these women than for those who are unmarried. As the married women in the age groups above approximately 40 years are gradually replaced by younger married women who have become more accustomed to paid jobs, the LFPR's will presumably increase. ${ }^{6}$
18. For the married women in the labour force, the amount of work performed for pay is, on the whole, rather lower than for other categories. This can be seen from the following table, which shows a percentage distribution of the number of hours worked (May, 1964). It can also be seen that a rather high proportion of men worked many hours during the week, perhaps because they had an extra job in addition to their normal occupation. This factor is also of importance.
19. From the 1960 census, it is known that the LFPR's for married women vary considerably from place to place. This is primarily a
[^57]Table 4

| Hours worked |  | Men | Unmarried women | Married women |
| :---: | :---: | :---: | :---: | :---: |
| 0-14 |  | 2.1 | 4.7 | 12.7 |
| 15-29 |  | 4.4 | 9.1 | 29.4 |
| 30-39. |  | 9.1 | 19.5 | 22.1 |
| 40-44 |  | 24.7 | 25.8 | 15.9 |
| 45-50. |  | 43.3 | 32.8 | 14.7 |
| 51 - |  | 16.4 | 8.1 | 5.2 |
|  | Total | 100 | 100 | 100 |
| Median |  | 45.8 | 42.7 | 33.7 |

consequence of the varying demand for female labour; in the rural areas and in many smaller places where there is only a limited demand for female labour, the rates are low. The varying number of places for children in day nurseries also has an influence. Day nurseries are, on the whole, not very common in Sweden, and there are many places where there is no such institution available. ${ }^{7}$
20. Unemployment and underemployment. From the statistical-technical point of view, the unemployed are (as mentioned above) included in the labour force, and are, consequently, considered as part of the economically active population. Unemployment is related to underemployment, which sometimes takes two forms: visible underemployment, which is characteristic of persons involuntarily working part-time; and invisible (or "disguised") underemployment, which is characteristic of persons working at a very low productivity level. ${ }^{8}$ Population groups characterized by visible underemployment will be included in the labour force. Invisible underemployment, which in

[^58]most countries is common among women, and which also plays an important part in the agriculture of underdeveloped economies, will, in the first instance, be found among persons not in the labour force.
21. In some areas of Sweden, there has been a certain amount of structural unemployment during the post-war period, and the comparatively low LFPR's for women may be interpreted as underemployment. In general, however, the amount of unemployment and underemployment has been small during the post-war period; for long periods, and in many areas and occupations, there has been a marked lack of manpower. When projections of the economically active population are made, it is assumed that the labour market in the future will also be characterized by full employment. The problems are: how big the future manpower deficit will be, and how it will be met.
22. With regard to many other countries, and especially with regard to underdeveloped nations, the problem is the opposite : how much can and must be done in order to prevent the increase of unemployment and underemployment. This may provide an entirely different interpretation of labour force projections. ${ }^{9}$

[^59]
# Anticipating city growth and population projections for urban development planning 

John Stuart MacDonald

1. This paper reviews experience accumulated in making and revising successive population projections, parallel to continuing economic projections, for a particular urban agglomeration, Since Neopolis, the anonymous city under discussion, has moved far toward continual comprehensive planning, the evolution of its population projections should illuminate similar problems to be found by city planners following the same course, particularly where economic and population projections are calculated in unison.
2. Neopolis is not unique, being one of several rapidly growing industrial agglomerations found in the sparsely-populated tracts of the underdeveloped world. The traditional market town, villages and homesteads which antedated Neopolis held some 4,000 inhabitants at the census of 1950. At that time, the entire region was devoted to extensive livestockraising and shifting agriculture, with the exception of the small beginnings of the extractive operations which have since gathered great momentum. Shortly after the 1950 census, a regional transportation and administrative centre was established outside the old market town. A residential area for senior employees was constructed nearby. This company suburb housed a variety of nationalities and, later, a growing number of indigenous white-collar workers from other parts of the country. Almost at once, clusters of huts formed between the old and new towns, quickly congealing into a shanty town. By the mid-1950's, heavy industry was set up. Subsequently the area has received a remarkable volume of investment. The census of 1961 revealed a population of some 42,000 . In the following year, the old and new towns, the intervening shanties, and the immediate countryside were incorporated as a single city. Up to the present, some agriculture, grazing and traditional trading persist within the city limits. But the economy is already dominated by manufacturing and extractive operations, around which have formed modern forms of commerce, transportation, government and other services.
3. Since the national government is openly committed to developing Neopolis, economically and socially, it is an attractive place in the eyes of the great proportions of unemployed and underemployed in the rest of the country, who have already shown that they have no aversion to internal migration. The assumption of these responsibilities necessarily poses the question of anticipating population growth which, on the one hand, spells manpower while, on the other hand, it spells social development requirements, including the costs of the unemployed. This situation presents a problem for economic and social development theory: how much will localized development effort on the production front be cancelled out by the arrival of the persistently unemployed? A number of tentative population projections have been made for Neopolis in order to whittle this problem down to more manageable proportions, and further research has been designed to put the next, more definitive population projections on a firmer footing. The provisional population projections already made are of two types: economy-based projections and strictly demographic projections.
4. The on-going planning process of Neopolis involves consideration of the costs of prospective population under its consumption aspect and under its human resources investment aspect, as well as in terms of industry's manpower requirements. Successive balances have been calculated by Neopolis' economists and manpower analysts in order to project economic growth and the investments required thereby, including the associated allocations to human resources and social welfare. These economic and manpower balances imply certain trajectories of population growth. Although natural increase in Neopolis is in the order of 3.5 per cent per annum, even the most pessimistic economic prognostications imply continuing large-scale in-migration to provide manpower. Projections of the city's economic growth, and associated increases in infrastructure and services, imply a corresponding amount of employment. This derived employ-
ment figure implies a corresponding amount of unemployment, since the country as a whole is unlikely to approach full employment over the next 10 years. The total labour force in turn implies a certain number of dependents. Adding together employment, unemployment and dependents should give the total population, granted that each of the preceding steps is correct. Another way of arriving at the same result is to calculate the total population figure from the labour force participation rate.
5. Column 1 of the table shows the results of a recent exploratory exercise in the eco-nomy-based population projection method. Rough employment estimates for each establishment and for each branch of activity were the first steps in the calculations. These estimates were drawn from direct and indirect sources. As is usual with local government areas in even the most statistically sophisticated countries, there was no single source of data, and the data which were most to the point were incornplete. The direct sources were the last census, a labour force and employment survey, two non-household establishment surveys of employment, and a survey of employment in construction. These direct sources do not cover the entire gamut of economic activity in Neopolis simultaneously, and are, to some extent, uncertain or contradictory. Therefore, extended inferences and indirect data from comparable populations were drawn upon, in addition to some casual observations and plain guesses. For example, the particular volume of employment in a projected factory with no existing comnterparts in Neopolis had to be predicted on the basis of employment observed in similar establishments in other parts of the country or abroad. It was assumed that there would be an unchanging mix of traditional labour-intensive commerce and distributive activities with more modern capital-intensive commercial and service organizations, as observed in the country's other industrial centre. Increasing labour productivity was allowed for on an arbitrary basis. The census labour force participation rate of 35 per cent was used to calculate the entire population from the estimated employment, allowing for a sliding scale of unemployment beginning at 25 per cent in 1961, the census year, and falling to 10 per cent in 1975. The labour force survey in 1962 indicated a labour force participation rate of 25 per cent; although the difference between this and the census figure can be partly explained in terms of different definitions and coverage, the labour force survey rate is still suspect until it is checked against the next survey in 1965.
6. The economy-based population figures in column 1 of the table could be calculated in another way with the same result, by assuming that each household would continue having 5.8 members, among whom 1.5 would be employed. The latter figure is from a multi-purpose survey of the country's only other highly industrialized city. Household size was measured by the 1961 census.
7. A set of economic and demographic projections was calculated to see what might happen if the population grew independently of economic development in the 1960's but gradually reached a critical point discouraging further massive in-migration because of the slowness of economic growth. Thus unsuccessful economic development was assumed, on the one hand, and heavy in-migration lured by false economic expectations, on the other hand; there would be a time-lag of several years before the former would effectively inhibit the latter. Population growth in the 1960 's was supposed to continue as the result of 1,000 in-migrants per month, the volume suggested by the length-ofresidence data from the 1962 labour survey. These in-migrants were ascribed the same rate of natural increase as the inhabitants born or long resident in Neopolis, estimated at 3.5 per cent. The trend of gainful employment was set pessimistically low. The proportion of unemployment would increase because all in-migrants after 1970 were given the poor employment record found by the 1962 labour survey among Neopolis' shanty-town dwellers. The average size of family was kept at 5.8 persons. Gainful employment trends were derived from much simpler calculations than in the economy-based population projection. Heavy industry employment is typically easier to project than other categories of employment. The total econom-ically-active population was reached by assuming, first, light industry and crafts would be only half that expected by the medium-level economic development programme being prepared. Then it was assumed that manufacturing would constitute 30 per cent of the total eco-nomically-active population. Labour force growth was linked to population growth in the 1970's by assuming that the labour force participation rate would move from the 25 per cent reported by the 1962 labour survey to the 35 per cent found by the 1961 census.
8. Four strictly demographic population projections were also calculated. Age- and sexspecific projections of in-migration and outmigration, or of net migration balances, could not be made for lack of any plausible data. Therefore the demographic projections do not
use the component method but simply trace one or another plausible trajectory for population growth as a whole. Column 3 in the table shows the population of Neopolis if it grew at 13.3 per cent per annum. This percentage represents the difference between the population counted at the 1961 census and the population estimated from the 1962 sample survey. Column 4 of the table shows the results if population grew by 23 per cent per annum, the rate of intercensal growth from 1950 to 1951. The base population is set at 44,000 , instead of 42,000 , to allow for 5 per cent underenumeration, the margin of error calculated for the country's total population. The population at the census of 1950 was raised by 10 per cent to allow for the undoubtedly greater undercounting at that time. Column 5 of the table gives population growth as if there were a constant increment from natural increase and in-migration combined; the constant increment of 5,200 being the estimated difference between the population at the 1961 census and the 1962 labour survey, converted into annual terms. These very simple projections have no other purpose than showing the upper and lower limits of Neopolis if conditions in the future continue as in the past. The difficulty here is to identify past conditions, as reflected in past population growth; the evidence is ambiguous. Which is the better, a rate of 13 or 23 per cent? At present there are no grounds for choosing one against the other, except to say that 23 per cent is impossible year after year. So Neopolis' planners need not prepare for a population of more than half a million in the 1970's. This is not a particularly useful conclusion.
9. The most intellectually satisfying, if not most realistic demographic projection, is in column 6 of the table. This limits Neopolis' future growth in accordance with the experience of the country's only other rapidly growing industrial town. The population there increased at nearly 10 per cent yearly at the peak of its economic growth, when it possessed 173,000 inhabitants. This projection holds that, the closer Neopolis' population approached 173,000 , the closer its initial growth rate of 23 per cent would fall toward its industrial predecessor's peak rate of 10 per cent. Thus Neo polis' growth rate decelerates until 1970, and thereafter remains at 10 per cent. This projection shows what would happen if Neopolis recapitulated its industrial predecessor's success. Although this would be a very remarkable achievement in itself, the development of Neopolis should be considerably faster if the draft economic and social programmes were
put into effect. This brings us back to economybased projections.
10. Although Neopolis' economy-based population projections are only exercises at this stage, they are in principle superior to narrow demographic projections in the case of an open population such as a city. Undoubtedly the coefficients used in deriving total population from employment-and employment from economic growth-are quite debatable. Greater confidence in these coefficients requires a set of theories about these relationships, as well as more data from Neopolis and elsewhere. There is a great need, particularly, for a compendium of coefficients showing the relationships between employment and economic expansion in each category of economic activity under various broad conditions. The 1965 labour survey will put these coefficients on a firmer basis, but will not solve the problem that manpower analysts do not have a comprehensive set of international figures to use as a ready reckoner. Such comparative information is obviously indispensable in the case of prospective economic activity of a type which does not yet exist there.
11. Better coefficients for converting economic growth into employment will not directly answer the problem of accounting for in-migration which may go into unemployment rather than employment. Therefore a special study will be made contrasting in-migrants, out-migrants and residents-since-birth, not only with respect to their different age and sex pyramids during regular periods, but also their motivations. Improved information about economic activity in Neopolis and other parts of the country will soon provide migration-economic growth coefficients which can be related to the sample survey of migrants' and non-migrants' motivations. At the same time, a special study of development prospects in the country's other regions and cities will show the shifting field of opportunities in which the potential migrant will make his calculations about the relative advantages of moving to Neopolis, moving elsewhere, or staying at home. On this basis, the component method of population projections can be used, for the present and prospective incidence of mortality and fertility by age and sex is already fairly well known.
12. Another avenue of investigation is the relations among the number of economicallyactive persons per household, the principal branch of activity of the main breadwinner, and the number of dependents. Probable changes in mortality and fertility do not figure in the economy-based projections on the grounds that
the population required by the city's economic growth would be drawn to it, if it were not already living there in sufficient quantities. However, changes in fertility and mortality are
likely to change the ratio of dependents in each household. Also female labour force participa-tion-which is not given a special place in the present projections-should be affected too.

## Illustrative population projections a

(In thousands)

|  | Economybased A. b | $\begin{gathered} \text { Semi. } \\ \text { inde. } \\ \text { pendent a, a } \end{gathered}$ | $\begin{gathered} \text { Com- } \\ \text { pounded } \\ \text { at } \\ 13.3 \\ \text { per } \\ \text { cent } \mathrm{d} \end{gathered}$ | $\begin{gathered} \text { Cam- } \\ \text { pounded } \\ \text { at } \\ 23.0 \\ \text { p.er } \\ \text { cent. } \end{gathered}$ | $\begin{gathered} \text { Increve } \\ \text { uncnts } \\ \text { of } \\ 5,200 \\ \text { per } \\ \text { annum : } \end{gathered}$ | Historic maximum $\boldsymbol{n}$, E |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1961. | 42 | 42 | 42 | 44 | 44 | 44 |
| 1962. |  | 48 | 49 | 54 | 49 | 54 |
| 1963. |  | 64 | 55 | 67 | 54 | 65 |
| 1964. | 76 | 80 | 62 | 82 | 60 | 78 |
| 1965. | 97 | 98 | 67 | 101 | 65 | 92 |
| 1966. | 113 | 115 | 78 | 124 | 70 | 107 |
| 1967. | 141 | 134 | 88 | 152 | 75 | 123 |
| 1968. | 153 | 153 | 98 | 187 | 80 | 139 |
| 1969. | 185 | 172 | 111 | 231 | 86 | 165 |
| 1970. | 236 | 193 | 124 | 284 | 91 | 173 |
| 1971. | 246 | 215 | 139 | 349 | 96 | 190 |
| 1972. | 286 | 235 | 157 | 429 | 101 | 209 |
| 1973. | 309 | 255 | 176 | 528 | 107 | 230 |
| 1974. | 352 | 285 | 197 | 649 | 112 | 253 |
| 1975. | 391 | 315 | 221 | 798 | 117 | 279 |

[^60]
# Some views on the needs and problems of school-age population projections in the developing countries 

Surinder K. Mehta

## I. Introduction

1. Perhaps the only valid rationale for making school-age population projections for developing countries is their relevance to social and economic planning. The conquest of illiteracy and the raising of the level of educational achievement in the general population are accepted goals in any programme of development. Although in developing countries the gap between the facilities needed for universal education, at however modest a level, and those achievable, may be very wide, there is still need of some basis for judging the magnitude of the problem. Knowledge of the probable future number of persons of school age is pertinent not only for the promotion of general education, but also for meeting specific manpower needs for economic development. National planners must have some idea of the number of persons with various skills, training, and education who will be needed for social, economic, and cultural development. Once these needs are determined, strategies of planning, resource allocation, and policy formation with respect to education can be developed.
2. Parnes has succinctly stated the argument that planning for education must be based in considerable measure upon analyses of future manpower requirements. He writes: "The rationale for according manpower forecasts a prominent role in assessing educational needs is perfectly straightforward. It runs something like this: a nation with plans or aspirations for economic development cannot afford to slight the preparation of its human agents of production. The creation of a new steel works, for example, is meaningless unless provision is also made for the scientists, engineers, managers, technicians, skilled workers, clerical staff, etc. necessary to operate it. Since one of the functions of the educational system in a society is to provide its work force with the abilities required for productive activity, it follows that that system must be reasonably well geared to the production requirements of the economy.

Moreover, it is the future pattern of manpower requirements that must guide today's educational decisions. The reason is that the lead time' in producing qualified manpower is exceptionally long. When one considers the time involved in constructing new school facilities, in training new teachers, and in filling up the educational pipeline in order to expand significantly the number of university graduates, it becomes clear that the educational planner must have in mind the prospective patterns of manpower requirements at least a decade or two in advance. Thus the need for long-term forecasts of manpower needs." ${ }^{1}$
3. Future manpower requirement is not the only factor that influences planning for education. Among other things, political pressures and strains within the nation also have to be taken into account. And, of course, the future number of persons for whom primary, secondary, and university level education will have to be provided must be estimated fairly well. This is necessary to determine the investment needed in buildings, equipment, teacher training, and training of school and university administrators.
4. It needs to be recognized that not all education is necessarily conducive to economic development. John Vaizey has argued that education in most countries has not been directed primarily toward the fostering of either new skills or inventiveness. He states that "only tarely, historically speaking, has education been concerned with developing what may very broadly be called a 'scientific' or pragmatic attitude to life. Indeed ... we may truthfully say that in many cases schools and colleges have been deliberately designed to counter the growth of this attitude. This is certainly so, for example, in most educational systems which have been dominated by traditional religious

[^61]forms." ${ }^{2}$ A system of education devoted to perpetuating archaic norms, values, and culture patterns or to maintaining the status quo in poor countries will also retard development. Thus, one may contend that education is a necessary but not a sufficient condition for socioeconomic growth.
5. The importance of education for social, economic, and political development should not be underestimated, however. ${ }^{3}$ Countries, both rich and poor, are development minded, and education is necessary for development. Obviously an education that is calculated to promote the goal of socio-economic progress rather than hinder or retard it is the type that is required.

## II. Problems in making national population projections

6. Before going into the problems involved in projecting school-age populations, some general problems encountered in the preparing of projections of national populations should be mentioned. There are essentially two different methods of making population projections. In the "mathematical method" formulas are used or curves are fitted to past data (usually census data for a number of points in time). Once these formulas or curves have been chosen, future population figures can be readily computed or simply read off the extrapolated curve. The second, the "component method", estimates the three components of population change (births, deaths, and migration) separately. It begins with the age-sex groups (and other subdivisions by race or ethnicity, if needed) of a census population. Each subgroup is "survived" into the future by applying appropriate age-sex survival ratios, usually in steps of 5 -year intervals. Future births by sex are added by applying age-specific birth rates to the female population, and these in turn are successively "survived" by applying survival ratios. If, in addition, some assumptions about

[^62]future change due to migration are needed, the procedure is modified by adding in or subtracting out estimates of net migration for each age-sex cohort. It should be apparent that the component method is in a sense a variant of the mathematical method in that often the assumptions about future birth and death rates are based on some sort of extrapolation of past rates.
7. The earliest mathematical methods employed simple linear projections. Later methods became more complicated, culminating in the "rediscovered" logistic curve of Pearl and Reed. ${ }^{4}$
8. The component method was developed in its detailed form in the United States of America by Thompson and Whelpton in the 1930 's. ${ }^{5}$ This newer method of population projection not only has the advantage over the mathematical method of yielding separate estimates of age-sex groups, but is inherently more flexible in regard to assumptions about the future course of the components of growth.
9. Although the component method has undergone many refinements and improvements, the history of predictions or projections of future populations has been a sad one, studded with failures of varying magnitude. Essentially, the failures have been due to the inability to foresee significant shifts in the patterns of mortality, and, particularly, of fertility. This was notably the fate of many of the population projections (mathematical, component, or other) made in the 1930's and early 1940's. Even the projections of such eminent demographers as Whelpton, Sauvy, and Note-

[^63]stein and his associates ${ }^{0}$ came to grief because of the unforescen and sustained high fertility and the unexpected decline in death rates.
10. In the last two decades considerable improvements in methods have been made. ${ }^{7}$ Methods have even been developed for making population projections for countries with only "scanty and imperfect" demographic statistics. ${ }^{8}$ It needs to be pointed out, however, that many problems of both methodology and prescience still remain. Past experience has shown that more refined and complicated methods have not necessarily given better approximations to future populations than simpler mathematical procedures. ${ }^{8}$ Although Grauman ${ }^{10}$ is "guardedly optimistic" about the success of current population forecasts, the results of the recent "round of censuses in Asian countries have shown how even short-term projections may be wildly wrong". ${ }^{11}$

## III. Some problems in making school-age POPULATION PROJECTIONS ${ }^{12}$

11. In making school-age population projections all the problems involved in making na-

[^64]tional population projections discussed above will be encountered, but the pitfalls will be even greater.
12. The basic requirement for school-age population projections is the availability of one or more reasonably good census counts of the population-by sex and age (preferably by single years). The school-age population is subject to the influences of changing number of births (if projections are made for a period exceeding the school-entering age of children in the given country) and changes in infant and child mortality. Even if the basic data required for projections are available, one has to make assumptions about the future course of fertility and mortality and here one may be "wildly wrong". A very serious problem encountered in most of the underdeveloped countries is that even current levels of fertility and mortality can be estimated only roughly. ${ }^{13}$
13. School-age population projections are inherently subject to greater proportionate error than are projections of total populations since the base population (school-age) that is being projected is much smaller. Furthermore, to be of greatest value school-age projections should preferably be made by single years of age or at least by primary and secondary school-age groups, by sex. ${ }^{14}$ The requirement of this finer detail in the projections will further prejudice the results.
14. Regarding projections of the age-groups from which college and university students come, such projections are necessary in countries such as the United States of America or the USSR where a large proportion of the population graduates from high school and many go on to college, but it is doubtful if such projections are necessary in countries where only a minute proportion of the population gets any higher education. In the developing countries the need is for estimates of the number of secondary school graduates

[^65]and requirements of highly trained and educated personnel. ${ }^{15}$
15. In planning educational facilities, locational considerations must be faced. Very serious problems are encountered when projections of school-age populations are made for regions, states, and communities, rather than for the country as a whole. Not only are current local levels of fertility and mortality in doubt ${ }^{16}$ (because of the highly variable adequacy of local vital statistics) but the future courses of fertility and especially of mortality are subject to greater variability on the local than on the national level. Greater change in fertility and mortality in the local community may occur due to successful public health measures and family planning programmes, for example, whereas the effects of these measures and programmes may be relatively less pronounced in the country as a whole. Furthermore, at the national level migration is not usually a very disturbing factor (barring war or other calamities, international migrants will constitute only a small fraction of the population for most countries and thus will not greatly affect the

[^66]future population), but at the local level, internal migration can and probably will play havoc with the projections. This is because the effect of social, economic, political, and demographic changes on internal migration is extremely difficult to predict for the local scene. ${ }^{17}$ Here it may be suggested that "economic" methods ${ }^{18}$ be used in conjunction with "component" methods for making school-age population projections.
16. In closing, I wish to make two final points. One, the range of error for local area population projections will be great even for total populations, but the errors will be still greater in the case of school-age populations. Two, the longer the period for which the projections are made, the more likely it is that the projected figures will deviate by increasing amounts from actual future populations. ${ }^{19}$

[^67]
# The choice of assumptions in household and family projections 

Robert Parke, Jr.

1. Projections of households and families typically include estimates of the future number and average size of households and families. A few projections of a somewhat experimental nature inclure, in addition, estimates of the future distribution of households and families by number of members, and estimates of the composition of families with respect to the age of members and the number of children. Guides for the preparation of household and family projections have been published by the United Nations, as part of its programme for the study of housing needs. ${ }^{1,2,3}$ The following discussion treats a few issues having to do with the design of household projections prepared by demographic methods, and the selection of assumptions used in the projections.

## I. The demographic method

2. A demographer views the number of households (or the number of births, deaths, persons in the labour force, etc.) as the cumulative effect of the action of a schedule of rates upon a population which may be distributed in various ways with respect to susceptibility to these rates. Accordingly, nearly all schemes for preparing household projections require the classification of the population by age, sex, and marital status. For each class, projections are prepared of (a) the total number of persons in the class; and (b) the ratio of household heads to the total number of persons in the class (headship rate). The projected number of households in the entire population is obtained by summing over all classes the product of these figures calculated separately for each class.

[^68]3. One wishes to incorporate a population characteristic in the projection scheme whereever (a) the headship rate is subject to substantial variation as between classes of the characteristic; and (b) changes in the distribution of the population with respect to the characteristic can be anticipated and can be expressed numerically. Hence, it may be desirable to include urban-rural residence in the projection scheme. ${ }^{4,5}$ However, although residence and the age-sex distribution have an important place in the scheme for projecting households, the assumptions employed in preparing population projections by these characteristics are outside the scope of this paper.

## II. Assumptions about marttal status

4. The simplest and most important classification by marital status is the dichotomy of married persons and persons not married. (For this purpose, persons in consensual unions are probably better classified as married.) Evaluation of the assumptions about marital status is facilitated if the population not married is further dichotomized into single persons (never married) and widowed and divorced persons. The projected proportions of single persons by age may then be studied to see if they imply an acceptable average age at first marriage. Methods for calculating average age at first marriage from proportions single have been described elsewhere. ${ }^{6}$
5. Future distributions of the population by marital status may be estimated by extrapolation of trends for age groups. ${ }^{7}$ For instance,

[^69]curves fitted to past data for females 30 to 34 years old are used to estimate the future proportions in each marital status class for females 30 to 34 years old. Pressat, however, has offered an alternative method in which these trends are extrapolated for cohorts. ${ }^{8}$ For instance, according to Pressat's method, the proportion married five years hence among females 30 to 34 years old is based on (a) the current proportion married among females 25 to 29 years old; and (b) change in the proportion married between ages 25-29 and 30-34 experienced by females who are now 30-34. A method similar to Pressat's has been used by the U.S. Bureau of the Census. ${ }^{9}$ Applied with care to avoid unreasonable proportions ultimately married, methods based on cohorts have much to recommend them. For estimating future proportions single, they are to be preferred because they eliminate the possibility of implying negative marriage rates and reduce the probability of implying unreasonably high marriage rates in certain ages, both of which errors are possible under the conventional method. These methods are useful primarily for ages of the cohort after a substantial proportion of marriages have occurred. For younger ages (under 25 in the U.S.A.), conventional methods are preferable.
6. The method of cohorts may help to resolve a problem that arises when the projected distributions by marital status prepared separately for each sex are considered jointly, that is, the disparity between the number of married males and married females. This disparity is a result of the fact that, in actual populations, marriage rates are distorted by changes in the relative number of males and females of marriageable age. These changes may result from changes in the number of births, because men and women marry at different average ages. Since the numerical relationship between a birth cohort and each other birth cohort is fixed, and the sex ratio at birth changes a little, it should be true that the relative number of marriageable persons of the opposite sex is a fairly stable characteristic of a cohort, except insofar as this number is altered by mortality and migration.
7. Disparities between the projected numbers of married males and females may be ad-

[^70]No. 90 (Washington, D.C., 1958).
justed by making the male number equal to the female number, ${ }^{10}$ and by adjusting to a number midway between the figures. ${ }^{11}$ Where the disparity is large, a less arbitrary adjustment based on analysis of the causes of the disparity may be in order. ${ }^{12,13}$

## III. Assumptions about headship rates

8. The development of assumptions about headship rates depends upon whether the projections are expected to produce estimates of housing needs or estimates of households. For estimating future housing needs, a set of headships is required that reflects the number of married couples, other family nuclei, individuals, and groups of unrelated persons, who are presumed to need separate housing units. ${ }^{14}$ Such rates are intended to yield estimates of the number of persons who would occupy separate housing units assuming no restriction upon their doing so. Rates of this type are commonly held constant throughout the projection period. ${ }^{15,16}$
9. For projecting the number of households, the headship rates express the proportion of the population who are household heads, as distinguished from the proportion who potentially might be. In some studies, rates of this sort have been held constant throughout the

[^71]projection period; ${ }^{17,18}$ elsewhere, the rates have been designed to reflect anticipated changes in living arrangements. ${ }^{19}$ Projections prepared from constant headship rates are offered as measures of future changes in the number of households attributable to population growth and changes in the distribution by age, sex, and marital status, and not as forecasts. When projections based on constant household headship rates are accompanied by projections of potential households, as described in the preceding paragraph, the two series together provide some indication of the range within which the future number of households may actually fall. For instance, recent projections for France include a series based on actual headship rates and a series that includes, in addition, the estimated number of secondary families. ${ }^{20}$ However, the "actual" and the "potential" series may differ so much that they provide the data user with insufficient guidance as to the probable future number of households.
10. In the United States, statistics and projections of households are widely used as a basis for planning by government agencies and by manufacturers and merchandisers who require estimates of future changes in the market for goods and services for which household and family groups are the main consumers. In these circumstances, projections must describe probable (not merely hypothetical) future changes in the number of households. That is to say, the projections must be based on calculations of future changes in household headship rates.
11. At the U.S. Bureau of the Census, these changes are projected by extrapolating past trends. For example, in preparing the household projections for 1960 to 1980, the proportion of married couples by age of husband who were separate households was calculated for 1950 and 1957, and the average annual increase in the proportion was obtained. ${ }^{21}$ For projection series A (the high series), this

[^72]average annual increase was assumed to continue to 1965 . For series B, one-half this increase was assumed to continue to 1965. The projected proportions were multiplied by the projected numbers of married couples by age of head, to obtain estimates of the future number of husband-wife households. Similar calculations were performed for other elements of the population. Only two per cent of the married couples in the United States are now doubled up in the households of others, so that at the present time little further undoubling is to be expected. However, significant changes in other groups, for example the proportion of widows forming separate households, can be expected and must be allowed for in the projections.
12. Calculations of future changes in household headship rates imply assumptions about the trend in the housing market, income, and other factors. This is true whether the basic household concept be of the "household-housing unit" type ${ }^{22}$ such as that used in the U.S.A., which establishes an identity between the number of households and the number of occupied housing units, or whether it be of the "housekeeping unit" type, which permits the enumeration of more than one household per housing unit. Precisely what assumptions are implied is unknown because of the lack of quantitative information about the relationship of housing market conditions and income to the occupancy of separate housing units.
13. In short, for analytical purposes, one may adopt a constant set of headship rates. For projections of housing needs, the headship rate will be designed to reflect the number of family nuclei and the number of non-family members who are presumed to need separate housing. For projections of the number of households which must serve in part as forecasts, the headship rate will reflect anticipated changes in patterns of housing occupancy.

## IV. Household size

14. For the planning of housing programmes, the average household size is insufficient, and it is desirable to prepare projections of the number of households of each size. The principal task in this connexion is the estimation of future distributions of families by size. The complexity of the assumptions that may be required to prepare such estimates is indicated

[^73]by Brown. ${ }^{23}$ Working with a stationary population model distributed by marital status, Brown developed estimates of families by size from information on number of children ever born by marriage duration and age at marriage, and information on families by number of children in the home. The results were used by Glass and Davidson to develop estimates of households by size and composition in a stationary population. ${ }^{24}$ For present purposes, the value of Brown's work is that it gives the reader a lively sense of the processes that underlie the distribution of families by size.
15. Muhsam has proposed a method based on (a) the projected number of families, by age and sex of head; and (b) the assumption that census distributions of families by size, within age and sex groups of family head, will continue unchanged. ${ }^{25}$ It can generally be expected that estimates from this method will be superior to estimates based on the assumption that the size distribution of all families (disregarding age of head) will continue unchanged. There is a more or less typical association of family size with age of head; consequently, the total number of families in each size class depends to a large degree on the distribution of heads by age.
16. The projection of families by size obtained by this method may be checked for agreement with the average size of family calculated from projected to total numbers of families and family members. ${ }^{28} \mathrm{~A}$ mean value is imputed to the terminal class (e.g., in the U.S.A. in 1960, the average size of families with 7 or more members was 8.1 ). The value for each class is then multiplied by the projected number of families in the class $(2 \times$ the projected number of 2-person families, $3 \times$ the projected number of 3 -person families, etc.) and the sum of products is divided by the total number of families.

[^74]17. If the result of this calculation differs greatly from the average previously obtained, the major fault will likely be found in the assumption of constancy in the family-size distribution by age of head. It is possible that, by projecting trends in this distribution from data for past years, a set of future distributions will be found that yields an over-all projected family-size distribution consistent with the previously established average family size. On the other hand, inter-generational differences in age at marriage, childspacing, patterns of completed fertility, and ages at which children leave home, may be such that no conciliation is possible other than by means of a scheme such as Brown's which takes each of these factors into account.
18. A simple mathematical method has been used by Dousa to project the distribution of households by size for Czechoslovakia. ${ }^{27}$ Dousa first estimated the future mean size of all households. The future size distribution was estimated by an application of the Poisson coefficient to the estimated mean, with adjustments reflecting the very minor deviations of the Poisson prediction for 1950 from the distribution shown by the 1950 census. This method worked remarkably well in the 1950 data for Czechoslovakia and its component regions. One would like to see it tested on data for several countries in order to learn under what circumstances it works, before relying on it as a basis for projection.

## V. Rationalizing the assumptions

19. To a large degree, the assumptions currently employed in household projections are prepared ad hoc. That is to say, each characteristic in the projection scheme is introduced by assumptions that are independent of those for other characteristics. For instance, projections of proportions of widows by age are generally prepared without regard to the implications of the mortality rates used to project the population. Similarly, changes in fertility patterns assumed in the population projections have implications for the future distribution of families by size that are taken into account in only the most elaborate schemes for projecting this distribution.
20. One approach to the rationalization of household projection methods would be to design population projections with the requirements of household projections in mind. For instance, Wilson Grabill of the U.S. Bureau of

[^75]the Census has devised an experimental method of projecting births that he calls the "marriage-parity-progression method". ${ }^{28}$ Essentially, the method consists of the sequential application, to a population of initially single women, of marriage rates by age, and birth rates specific for birth order and interval since previous birth (or since marriage, for childless women). With some modification, Grabill's method ought to be able to provide much of the information required to project the distribution of U.S. families by size. The additional information required would pertain mainly to marital dissolution, sharing of the home by relatives, and the age at which children leave home.
21. Another approach, by Orcutt and his associates, is the development of an electronic computer model in which individuals rather than classes of persons are subjected to probabilities of marriage, divorce, childbirth, and death. ${ }^{29}$ Experimental work of a similar

[^76]nature is being conducted at the Bureau of the Census. The simulation of demographic processes in models such as these can be expected, in the long run, to provide more satisfactory household and family projections than methods in which the assumptions take the form of statistical distributions.

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# Population projections in which allowance is made for migration 

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[Translated from Russian]

1. After the Second World War, especially in the decade 1950-1960, higher rates of population growth were observed almost everywhere in the world. The rate of increase for the world as a whole was 20 per cent for the period 1950-1960, as against 11.4 per cent for 1940-1950 and 12.8 per cent for 1930-1940. In the economically developed countries, the rate was considerably lower, and in the developing countries it was higher. In 1950-1960, the rate of increase in Europe (excluding the Union of Soviet Socialist Republics) was only 7.8 per cent; in North America it was 19.8 per cent, in Asia (excluding the Union of Soviet Socialist Republics) 21.7 per cent, in Africa 23.2 per cent, in Central and South America 30.9 per cent and in the Union of Soviet Socialist Republics 18.9 per cent. In 1961-1964, the rates of increase continued to be high, although in some countries they were showing a tendency to decline.
2. The higher rates of increase after the war were due mainly to the fact that while the birth rate continued to be relatively high, the death rate declined sharply as a result of medical progress in the treatment and prevention of widespread diseases.
3. The rise in the rates of population growth is a cause of alarm to the Malthusians. With remarkable ingenuity, worthy of a better cause, they have raised an outcry in the Press over the prospects of population growth, declaring that it is a terrible disaster which will prevent any economic or social progress. They warn that if the rate of growth does not decline, the rapidly increasing population will soon not only
lack the means of subsistence, but will not even have any "standing room" on earth. One hundred and sixty-six years ago, Malthus declared that the population would double every twenty-five years. Although the population of the world has never doubled within twentyfive years, there are "scientists" who declare that the population will soon double in approximately such short periods of time. Without going into the social and economic causes of population growth, but attributing it to simple biological factors, the Malthusians, as in the last century, recommend an unwarranted policy of artificial birth control. It is quite common for them to appeal for abstinence, the use of contraceptives, sterilization and even the employment of compulsion to render a part of the population incapable of having children. Some even go so far as to reiterate that poverty, hunger, epidemics and war are the natural means of establishing a balance between population and the means of subsistence. The Malthusians divert people's attention from the substance of the matter and even prevent them from finding the real social and economic causes of population growth and from taking action to develop the economy to meet the needs of an increasing population.
4. The accurate forecasting of population growth has considerable scientific and practical significance. The population projections published in the world Press are often clearly exaggerated and merely lead to a further Malthusian outcry.
5. The main social and economic factors which influence the birth rate are the following:

Factors causing a rise
in the birth rate

## Improvement in living conditions.

Elimination of unemployment and uncertainty about the future

The attainment of political independence by colonial and dependent peoples

Factors causing a decline
in the bristh rate
Industrialization and the consequent increase in migration and in the absolute and relative size of the urban population
The granting to women of equal rights with men and increased participation by women in economic, cultural and political life

A rise in the cultural and sanitary standards of the population

## Factors causing a rise <br> in the birth rate

The democratization of the political system
Increase in government expenditure on the education of children and in the number of children's institutions (clinics, nurseries, kindergartens, etc.). Increased benefits for mothers

Expansion of the network of national health institutions providing free services, particularly prenatal and post-natal services and services for chidren

Factors cousting a decline
is 絃e birth rate
Higher age at marriage and reduction in the childbearing period of women

The break-up of family life and the sharp deterioration in the economic position of families as the result of war

A decline in the proportion of men of reproductive age as a result of war

A decline in the marriage rate as a result of war, economic depressions and other dislocations of the economy
6. In addition to the factors listed, there are also many others (legal, national, religious), which also influence the level of the birth rate, but they are either less important or operate for shorter periods. Such factors include, for example, the prohibition or permitting of abortions, legal recognition of the father's responsibility for the upbringing of his children, permitting of induced sterilization (use of contraceptives), the prohibition or permitting of divorce and the taxation of childless persons of reproductive age. In many countries, the level of the birth rate is also influenced to some extent by customs permitting or prohibiting marriage at an early age and by customs forbidding induced abortions, second marriages or marriages with foreigners or people of another nationality.
7. All these factors affect the level of the birth rate in different ways in different countries and are further influenced by the level of economic and social development, the political system, the national composition of the population, and natural, geographical and other conditions. The history of many countries and regions shows, however, that as they develop economically and culturally in the course of time, the influence of the factors causing a decline in the birth rate increases considerably. This is particularly true of industrialization and the consequent increase in migration and in the absolute and relative size of the urban population. These factors actively affect each other; in particular, the growth of industry and urbanization are accompanied by a rise in the level of culture, since modern industrial production is becoming increasingly impossible without a certain minimum level of general and technical knowledge on the part of the workers. In urban areas, women are to a greater extent drawn into production and into cultural and political life. It is these factors, taken together, which cause a decline in the birth rate. It is
the task of every researcher who wishes to deal objectively with the question of population growth to give close attention to the influence of these factors on the level of the birth rate and on the rate of population growth.
8. This paper has the comparatively limited objective of showing that disregard for even one factor such as the predominant growth of the urban population as compared with the rural population leads to considerably exaggerated forecasts of the growth of the population as a whole. This is especially true of population forecasts for the developing countries.
9. As we know, the developed countries at some time in the past all went through the same stages of economic and cultural development which the developing countries are passing through now. The birth-rate levels in the developed countries at those stages were similar to what they now are in the developing countries. In the United States of America, for example, the birth rate during the last century remained for a long time at a level of 40 to 50 per thousand and even went as high as 55 per thousand. In pre-revolutionary Russia (prior to 1917), which had a poorly developed industry and backward forms of agriculture, the birth rate was also extremely high, and even as late as the beginning of this century (in 1913) it was still 46 per thousand. At one time the birth rate was high in England, France, Germany and other countries which are now industrially developed. The birth rate and the rate of natural increase began to decline in these countries mainly as a consequence of industrialization, the growth of the urban population and the employment of female labour.
10. The changes that have occurred in the urban and rural poputation of the Union of Soviet Socialist Republics by comparison with pre-revolutionary Russia in 1913 and 1917 are shown in the following table:

Table 1

A. Territory of Union of Soviet Socialist Republics previous to 17 September 1939:

| 1913 | 139.3 | 24.8 | 114.5 | 17.8 |
| :---: | :---: | :---: | :---: | :---: |
| 1917 | 143.5 | 25.8 | 117.7 | 18.0 |
| 1920 | 136.8 | 20.9 | 115.9 | 15.3 |
| 1926 (December) | 147.0 | 26.3 | 120.7 | 17.9 |
| 1939 (January) | 170.6 | 56.1 | 114.5 | 32.9 |

B. Present territory of Union of Soviet Socialist Republics:

| 1913 | 159.2 | 28.5 | 130.7 | 17.9 |
| :---: | :---: | :---: | :---: | :---: |
| 1939 | 190.7 | 60.4 | 130.3 | 31.7 |
| 1950 | 178.5 | 69.4 | 109.1 | 38.9 |
| 1955 | 194.4 | 86.3 | 108.1 | 44.4 |
| 1960 | 212.3 | 103.8 | 108.5 | 48.9 |
| 1964 | 226.3 | 118.6 | 107.7 | 52.4 |

11. During the forty-six years of existence of the Union of Soviet Socialist Republics, there has been only one period-namely, 1917-1921-when there was a proportionate increase in the rural population. The explanation for this one exception was that during the period of economic dislocation caused by the First World War, the Civil War and the intervention of imperialist States against the young Soviet Republic, and also because of a bad harvest in 1921, there was some migration of urban population to the country. Except for those
years, the entire history of the USSR has been marked by an exceptionally high rate of urban population growth, owing to industrialization. According to population projections, the proportion of urban population in the Union of Soviet Socialist Republics will continue to increase and will be 58 per cent in 1970, 63 per cent in 1975 and 68 per cent in 1980.
12. Figures on the sources of the increase in the urban population of the Union of Soviet Socialist Republics from 1927 to 1963 are given below:

Table 2. Increase in the urban population of the Union of Soviet Socialist Republics
(In millions)

|  | Entire period |  |  | Annual average |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & 1927 \\ & 1938 \end{aligned}$ | $\begin{aligned} & 1939- \\ & 1958 \end{aligned}$ | $\begin{gathered} 1959 . \\ 1963 \end{gathered}$ | $\begin{aligned} & 1927- \\ & 1938 \end{aligned}$ | $\begin{aligned} & 1939 \\ & 1958 \end{aligned}$ | $\begin{aligned} & 1959 . \\ & 1963 \end{aligned}$ |
| Total increase (migration and natural increase) a | 29.8 | 39.6 | 18.5 | 2.48 | 1.98 | 3.71 |
| Migration from rural to urban areas. | 18.7 | 24-25 | 7.2 | 1.56 | 1.2-1.25 | 1.44 |
| Change of status from village to town. | 5.8 | 7 | 3.8 | 0.48 | 0.35 | 0.76 |
| Natural increase. . . . . . . . . . . . . . . . ** | 5.3 | 8 | 7.5 | 0.44 | 0.40 | 1.51 |

*The figures for 1927-1938 relate to the territory of the Union of Soviet Socialist Republics previous to 17 September 1939; the figures for other years
13. The industrialization of the Union of Soviet Socialist Republics required an increase in the urban labour force, whereas the collectivization of agriculture made it possible to release rural manpower by raising productivity. Rural-urban migration accounted for 82 per cent of the total increase in urban population in the period 1926-1938, for 80 per cent in 1939-1958 and for 59 per cent in 1959-1963; natural increase accounted, respectively, for 18
relate to the present territory of the Union of Soviet Socialist Republics.
per cent, 20 per cent and 41 per cent. The figures for the annual averages show that during the last five years there has been an increase in the rate of urban population growth from all sources-direct migration, change of status from village to town, and natural growth.
14. As the urban population increases, the level of the birth rate declines, as appears from the following figures:

Table 3

| Year | Number of birthy per 1,000 population |  | Rural birth rate asa petcentage of trban buth rate |
| :---: | :---: | :---: | :---: |
|  | In wrban argas | In rural areas |  |
| 1913. | 30.2 | 48.8 | 162 |
| 1926. | 34.1 | 46.1 | 135 |
| 1928. | 30.2 | 47.5 | 157 |
| 1935. | 27.8 | 31.4 | 113 |
| 1940. | 30.5 | 31.5 | 103 |
| 1950. | 26.0 | 27.1 | 104 |
| 1955. | 23.5 | 27.4 | 117 |
| 1958. | 22.5 | 27.9 | 124 |
| 1960. | 22.0 | 27.8 | 126 |
| 1963. | 18.6 | 24.0 | 129 |

15. During the fifty years between 1913 and 1963 the urban population increased more than fourfold, whereas the urban birth rate declined by more than one third ( 38.4 per cent). As a result of rural-urban migration-and especially the migration of males of working age, which altered the age and sex structure of the rural population-the rural birth rate declined at an even greater rate (more than twice as fast)
than the urban rate, although the level of the rural birth rate still continued to be considerably higher than that of the urban birth rate.
16. The proportionate increase in the urban population and the accompanying decline in the crude birth rate of the Union of Soviet Socialist Republics can be seen from the following figures:

Table 4

| Year | Urban population (percentage) | Crude bith rate of the USSR |  |
| :---: | :---: | :---: | :---: |
|  |  | Per 1,000 | Percentage of 1013 |
| 1913. | 18 | 45.5 | 100 |
| 1926. | 18 | 44.0 | 97 |
| 1939. | 32 | 36.5 | 80 |
| 1940. | 33 | 31.2 | 69 |
| 1950. | 39 | 26.7 | 59 |
| 1960. | 49 | 24.9 | 55 |
| 1963. | 52 | 21.2 | 47 |

17. Population projections show that by 1970, when the proportion of urban population will have reached 58 per cent, the crude birth rate will have declined still further and will apparently be less than 20 per 1,000 .
18. The growth of the urban population at the expense of the rural population and the parallel decline in the rate of growth of the population as a whole have occurred in all the industrially developed countries. In the United States of America, the birth rate fell during the period of industrialization and urban growth in the last century from a level of $50-55$ per 1,000 to a level of $31-35$ per 1,000 by the end of that century; by 1911-1913 the birth rate was 25.1 per 1,000 , i.e., only slightly higher than it is now ( 21.6 per 1,000 in 1963). In Germany, in the last century and at the beginning of this century, the birth rate was

35-39 per 1,000, and not until 1910 did it fall below 30 per 1,000 . The birth rate in the Federal Republic of Germany now fluctuates between 17 and 18.5 per 1,000. France is unusual as far as the birth rate is concerned. As early as the beginning of the second half of the last century the birth rate there had declined to between 25 and 26.5 per 1,000, and by the end of the century to 22.1 per 1,000 . In this century the birth rate was for many years so low that it was exceeded by the death rate, i.e., there was a population decline. At the present time, the birth rate in France is between 17 and 18 per 1,000. In England the birth rate was $34-35$ per 1,000 in 1870-1880, 24.3 per 1,000 in 1911-1913, and 18.5 per 1,000 in 1963.
19. The growth of urban population in the industrially developed countries has been ac-
companied by a decline in the crude rate of increase not only in those countries but also in a number of agricultural countries, especially in Europe. This has been mainly due to the considerable volume of migration from these countries to the countries with growing industries.
20. The proportion of urban population is steadily increasing. In many industrially developed countries, the urban population at present far exceeds the rural population. The size of the urban population by continents is as follows:

Table 5

|  | Total population at beginning of 1964 (in millions) | Urban population | Urban (population |
| :---: | :---: | :---: | :---: |
| World | 3,240 | 1,042 | 32 |
| Europe | 619 | 310 | 50 |
| Asia | 1,886 | 415 | 22 |
| Africa | 275 | 52 | 19 |
| America | 441 | 251 | 57 |
| North and Central | 284 | 182 | 64 |
| South | 157 | 69 | 44 |
| Australia and Oceania. | 19 | 14 | 72 |

21. In Europe, the following countries have a particularly high proportion of urban population: United Kingdom-78 per cent, German Democratic Republic- 72 per cent, and Federal Republic of Germany- 71 per cent. In France, the proportion of urban population was 56 per cent in 1954. By 1962 it had increased to 63 per cent, mainly as a result of the continuing trend of rural-urban migration. In America, the proportion of urban population is highest in the United States and Canada (70 per cent). The countries of Central and South America also have a high proportion of urban population, although numerous localities with a population of many thousand engaged almost exclusively in agriculture are classified there as urban areas.
22. In Asia, only Japan has a high proportion of urban population ( 63 per cent). In North Korea the urban population comprises 41 per cent of the population and in Iran and Turkey, 32 per cent. In other Asian countries, the proportion of the urban population is small, between 15 and 20 per cent. For example, in India it is 18 per cent, and in Pakistan 13 per cent. In Africa, only the United Arab Republic has an urban population of as much as 38 per cent; in the other countries, only a small proportion of the population lives in urban areas.
23. According to population forecasts published in the world Press, a further rise is expected in the crude rate of increase in countries of Asia, Latin America and Africa, where more than 70 per cent of the world population lives. According to these forecasts, the highest rate of increase is expected there during the period from 1975 to 2000 . On this basis, it
is contended that by the year 2000 the world population will be between 6,000 million and 7,000 million.
24. Both the assumed rates of increase in the countries mentioned and the world population figures based on them give rise to serious doubts, since all these assumptions fail to take into account the prospects for development and for social and economic change in these countries.
25. The countries of Asia and Africa and much of Latin America were until quite recently colonial and dependent territories and sources of raw materials for the imperialist countries. Agricultural methods there were extremely primitive. Some of the countries had almost no industry at all, and others had only processing industries in which both equipment and production methods were extremely antiquated. Having achieved independence and the right to decide their own affairs, these countries are taking measures to develop their national economy and expand industry and to increase the productivity of labour, especially in agriculture. There is no reason to believe that industrialization and the increase in the productivity of labour will not bring into operation there the same factors which caused a decline in the rates of population growth in the industrialized countries. In other words, the developing countries must go through the same stages of development as the industrialized countries have done. It is clear that in each developing country the course of development will have its own specific character. It will be influenced by the social, economic, historical, natural, geographical, na-
tional and other conditions prevailing there. There is, however, no doubt that, at the present level of development of productive forces and of science, technology and communications in today's world, industrialization and the cultural revolution will require considerably less time in the developing countries than was needed fifty to one hundred years ago. This will mean that urban population growth and the related factors, both direct and indirect, which cause a decline in the birth rate will come into operation much earlier than was the case in the past. As the fertility of women living in the urban areas is known to be lower than that of women living in rural areas, rural-urban migration, by increasing the female population of urban areas, in both absolute and relative terms, will cause a decline in the crude birth rate.
26. The increase in urban population likewise brings down the birth rate because ruralurban migration disturbs the normal ratio between men and women of the most fertile ages in both urban and rural areas, is conducive to marriage at a later age and so on. Even more notable, however, are the indirect effects of urban population growth in lowering the birth rate, since in urban areas: (a) women are drawn into greater participation in political, economic and cultural life; (b) the cultural level of the people rises much more quickly; (c) there are greater opportunities for using contraceptives and for relying on the services of medical institutions for preventing and terminating pregnancy; and (d) the question of finding housing for a family is much more difficult, and so on.

27 . Since the urban population in the developing countries will undoubtedly increase in the next few years, those countries will soon be facing a decline in their crude rate of increase, and this should not be overlooked in making population projections. When, however, such projections are prepared for individual continents and countries, the prospective increase in urban population and the related decline in the birth rate are not, as a rule, taken into account. The widely-publicized projection of a world population of between 6,000 million and 7,000 million by the year 2000 has been calculated on the basis of the current high rates of population growth, although a mere glance into the recent past shows that these rates of growth cannot be maintained for long.
28. Population projections for the Union of Soviet Socialist Republics published in the world Press are considerably exaggerated precisely because they do not take into account the continuing growth of the urban population
and the resulting decline in the birth rate. For example, in the United Nations publication The Future Growth of World Population, issued in 1958, the population of the Union of Soviet Socialist Republics in 1975, on high and medium assumptions, is estimated at 275 million, which is 14 million higher than the figures obtained after allowing for the increase in urban population. Even on the low United Nations assumption, the population of the Union of Soviet Socialist Republics is estimated at 5 million more than the figure obtained after allowing for migration.
29. In the projected trends of the growth of population and the labour force given in a paper (Report I-PTCE/I) issued by the International Labour Organisation in 1963, the mean annual population of the Union of Soviet Socialist Republics in 1975 is estimated at 271 million, which is 10 million higher than the figure obtained by Soviet statisticians after allowing for migration. The mean annual rate of population increase in the Union of Soviet Socialist Republics during the period 1960 1975 is estimated at 1.6 per cent according to the ILO projection but at 1.3 per cent according to a projection in which migration is taken into account.
30. In the United Nations Report on the World Social Situation (1963), it is estimated that the population of the Union of Soviet Socialist Republics in 1970 will be 18 per cent greater than in 1960; this means that in 1970 the population of the Union of Soviet Socialist Republics will be 252 million. On the basis of projections which allow for migration, it is estimated that the population of the Union of Soviet Socialist Republics in that year will be 246 million.
31. Population projections made by the statistical and planning agencies of the Union of Soviet Socialist Republics make allowance for rural-urban migration and its effect on the birth rate. A projection up to the end of 1980 was carried out on the basis of the survivorship function for 1958-1959 and the agespecific female fertility rates for 1960-1961. The calculation was made separately for urban and rural areas, taking into account the characteristics of the age and sex structure and the level of urban and rural birth rates and death rates in each of the Union republics. The calculation allowed for a possible decline in the age-specific death rate, and especially in infant mortality, and also for some increase in age-specific fertility rates in the individual republics. The increase in age-specific fertility rates allowed for in the calculations for some
republics may result from such factors as a levelling-off in the ratio between men and women, a further improvement in living conditions and an increase in government expenditure on such child-care facilities as nurseries, kindergartens and other children's institutions, thus easing the burden and expenses of families.
32. A distinctive feature of these projections as made in the Union of Soviet Socialist Republics is that they take into account the presumed movement of population from rural to urban areas, and also between republics and economic regions. The volume of migration for the period covered by the projection is determined by the planning agencies on the basis of the plans for the distribution of the forces of production, i.e., construction of industrial enterprises and provision of auxiliary services connected with the development of industry (construction, transport, housing and communal services, trade, public catering, health, education, etc.), and of the plans for supplying the necessary manpower. For example, the population projection for the largest of the Union republics, the Russian Soviet Federative Socialist Republic, for the period 1965-1970 is based on the assumption that up to 1968 departures from the Russian Soviet Federative

Socialist Republic will exceed arrivals from other republics, whereas from 1968 onwards, on the contrary, population coming to the Russian Soviet Federative Socialist Republic, and mainly to its urban areas, will exceed departures to other republics. At the same time, there will be a considerable movement of population from rural to urban areas within the Russian Soviet Federative Socialist Republic (more than 6 million people between 1966 and 1970).
33. From the technical point of view, population projections which allow for migration are considerably more complicated than those which do not, and they require more time both for the preparation of the basic data and for the actual calculation. The latter, however, is no longer a complicated problem because of the use of electronic computers. ${ }^{1}$
34. The projected population of the Union of Soviet Socialist Republics for the period 1965-1980, allowing for migration, is as follows:

[^77]Table 6

| Year | Population at end of year (in millions) | Urban population (in millions) | Rural (inulation ( th millions) | Urban population (percentage) |
| :---: | :---: | :---: | :---: | :---: |
| 1960. | 216.1 | 108.3 | 107.8 | 50 |
| 1963. | 226.3 | 118.2 | 108.1 | 52 |
| 1964. | 229.1 | 121.5 | 107.6 | 53 |
| 1970. | 247.5 | 143.4 | 104.1 | 58 |
| 1975. | 262.9 | 164.5 | 98.4 | 63 |
| 1980. | 280.0 | 190.3 | 89.7 | 68 |

35. The projected figures for the birth rate, death rate and rate of natural increase during the period 1965-1980, as compared with the actual figures for 1960 and 1963, are as follows:

Table 7

| Year | Per 1,000 population |  |  |
| :---: | :---: | :---: | :---: |
|  | $\underset{\text { rate }}{\text { Birth }}$ | $\underset{\substack{\text { Deuth } \\ \text { fate }}}{ }$ | $\begin{aligned} & \text { Rate of } \\ & \text { natural } \\ & \text { increase } \end{aligned}$ |
| 1960. | 24.9 | 7.1 | 17.8 |
| 1963. | 21.2 | 7.2 | 14.0 |
| 1964 | 19.7 | 7.0 | 12.7 |
| 1970. | 19.7 | 7.9 | 11.8 |
| 1975. | 20.8 | 8.2 | 12.6 |
| 1980. | 21.3 | 8.8 | 12.5 |

36. The considerable increase in the urban population, in both absolute and relative terms, is accompanied by a general downward trend in the birth rate. This projection also takes into account, however, some other factors which influence the birth rate, with the result that the number of births per 1,000 population will decline up to 1970 but will increase after 1972. This is mainly due to the fact that, beginning in 1962, women born during or shortly after the war (1941-1948) will be entering the 20-29 age group, which produces the largest number of births. As these women are fewer in number than those born in other years, the number of children born to them will also be relatively smaller. As from 1972, when the women born during the war years will begin to leave the 20-29 age group, the number of births, and thus also the birth rate, will gradually begin to rise. Moreover, the increase in the female fertility rate in certain parts of the country, which is foreseen in the projection, will also contribute towards a rise in the number of births and thus also in the future birth rate. The rise in the crude death rate, despite a certain decline in the age-specific death rate, is explained by the increase in the proportion of elderly people in the total population.
37. Population projections for the Union of Soviet Socialist Republics carried out by foreign specialists are often based on the birth rate and death rate for a given period of time for the country as a whole. In recent times, these projections have used the birth and death rates for 1950-1960 with the emphasis on the highest rates of natural increase for 1959-1960. The extent to which the population is overestimated in forecasts of this kind is demonstrated in the following projection.
38. In the period 1950-1960, the natural increase of the population of the Union of Soviet Socialist Republics as a whole averaged 17.4 per 1,000 annually. If this rate of increase is taken as the basis for projecting the future population of the Union of Soviet Socialist Republics, the figure by the end of 1980 will be 305 million, which exceeds by 26 million, or 9 per cent, the projected population determined with due allowance for migration between urban and rural areas and for changes in the age and sex structure of the population.
39. The mean annual rate of increase in the period $1950-1960$ was 16.0 per 1,000 in urban areas and 18.6 per 1,000 in rural areas. If separate projections of the urban and rural population are made on the basis of these rates, without any allowance being made for migration, the total population of the Union of Sovict Socialist Republics by the end of 1980 will be seen to be almost the same as in the projection based on the crude rate of increase, i.e., 304 million. In comparison, however, with the projection in which allowance is made for migration, the urban population ( 151 million) is under-estimated by 39 million, and the rural population ( 153 million) is over-estimated by 63 million. According to the projection considered here, the proportion of rural population in 1980 will be higher than it was in 1963.
40. A projection also produces misleading results when it is based on the average rates (of fertility, mortality, etc.) for the country as a whole and the population figures thus obtained are then distributed between urban and rural areas according to their relative proportions. It is clear that in a projection carried out by this method no account can be taken of the decline in fertility resulting from the much faster rate of growth of the urban population by comparison with the rural population.

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41. Projections of the world population must allow for the prospective change in the ratio between urban and rural population. It should be borne in mind in this connexion that, whereas the urban population of the countries which are now industrialized grew slowly over many decades, this process will be greatly accelerated in the developing countries, for the advance of industrialization in these countries is taking place at a time of exceptional progress in science and technology. Also, such developments as a rise in the cultural level of the people and the participation of women in production, which accompany the development of industry and the growth of the urban population, will also, as a rule, proceed more rapidly there. All these factors must soon result in a decline in the rate of population growth.

# Some principles and methods of projections of urban-rural population by age and sex 

Jacob S. Siegel

1. Urban and rural populations tend to differ sharply in their demographic, social, and economic characteristics, and these differences have become intensified in many countries by a continued heavy migration from country to city. As a result, the problems and needs of these two population segments differ. National policy and social and economic development programmes should take these into account. For this purpose, projections of urban and rural population by age and sex serve as a necessary tool. Projections of the urban-rural sectors may serve as the basis for designing realistic national goals relating to urban and rural development. Furthermore, they may be useful in deriving, and appraising the demographic implications of, projections of national population by age and sex, which are basic ingredients in a wide variety of projections needed for developing and implementing national plans.
2. The principles and methods of projections of urban-rural population by age and sex are similar in many respects to those for geographic areas within countries. The subsequent discussion calls attention to these common principles and methods and treats urban-rural projections as a special case of projections for geographic areas within countries.
3. Population projections may be viewed as approximations of probable future population size and changes resulting from various stated assumptions. In view of the considerable uncertainty regarding future changes in the urbanrural sectors, it is desirable to develop a set of several projections employing alternative assumptions with regard to the various components, particularly those which show great variation or uncertainty and potentially great impact on population size. The components vary with the method chosen. It is recommended that the principal series of projections employ only probable or realistically possible assumptions so that, as a set, the projections give an indication of the range in which the future size and age-sex distribution of the urban and rural populations will very probably fall.

Such projections are not to be interpreted as predictions even though realistic approximations to future population size are sought. In fact, projections may be rendered seriously inadequate as predictions if, on the basis of the figures, the national plan specifically attempts to modify the course of regional growth to achieve preset national goals. Although planners tend to prefer only a single series of projections, it is more realistic to recognize the very wide range of uncertainty in urban-rural projections and to reflect it in the projections prepared. Furthermore, a "medium" or "most probable" series may best be avoided as prediction in a special guise. Accordingly, an even number (e.g., four) of principal series of projections are recommended; this does not preclude the preparation of additional "analytic" series for interpretative purposes, however.
4. It is suggested that projections of urbanrural population by age and sex be prepared at 5-year time intervals for a period of about 20 years after the latest census date. For example, census data for 1960 may be carried forward to 1980. Projections for longer periods are quite speculative and are subject to such large errors that they would hardly serve as useful guides for planning. Available evidence indicates that projections for geographic areas within a country may become seriously unrealistic after 20 years, and urban-rural projections are subject to even greater uncertainty. The projections should be subject to frequent review and revision, not only as new data become available and new population trends develop but also as public policies change. Furthermore, the mere passage of time, however "successful" the last set of projections, necessarily renders certain series out of line with current population developments in a brief period, and a revision is then indicated.
5. Although the computations may be carried out in terms of 5-year age groups, in recognition of the large probable errors, the results should be combined into broader classes
such as under $5,5-14,15-24,25-44,45-64$, and 65 and over. As a minimum, ages under 15, 15-44, 45-64, and 65 and over (or under 15, 15-39, 40-59, and 60 and over) are needed to distinguish the working ages from the nonworking ages and to compute dependency ratios. The specific age detail will, of course, have to take national needs into account.
6. Projections of urban-rural population involve, in addition to the usual problems of projections for geographic areas within countries, special problems of the availability of adequate basic data, both in terms of quantity and quality, concern with additional factors of change (e.g., reclassification of areas), complexities in methodology, and special problems of international comparability. These problems will be considered below.
7. The wide differences in national definitions of urban-rural population would seriously affect international comparability of any projections based on official definitions. Alternative definitions which would improve comparability would divide the population into one or more size-of-locality intervals, say at 10,000 or 20,000 . Another alternative is to separate the population into that residing in the principal urban agglomerations and the remainder and, possibly, further to subdivide the latter into places above and below 20,000 . Use of such a definition may prove more convenient and useful for national purposes, too.
8. A first requirement for the preparation of projections of urban and rural population, by age and sex, are census data on the age and sex distribution of the urban and rural population or for areas permitting estimation of the age-sex distribution of the urban and rural population. Tabulations by age and sex may be available only for principal political subdivisions, principal cities, or administrative centres. It may be necessary, then, to assign the age-sex distribution of the population of the primarily urban subdivisions or the principal cities to the national urban total, or to project only part of the urban population, e.g., the population in the principal cities. Most methods call for comparable census data for at least two censuses. Since this requirement cannot be met in many countries, a somewhat less elaborate method based on only one census may often have to be employed.
9. A first step in the preparation of urbanrural projections is the evaluation and possible correction of the basic census data for net underenumeration and age misteporting. Particularly in the statistically less developed countries,
such errors may be substantial. Methods of evaluating and adjusting census data have been described elsewhere.
10. Where possible, postcensal information on urban-rural changes should be taken into account. For example, the results of recent national sample surveys or population estimates for principal cities or major political subdivisions may give useful suggestive indications of recent trends.
11. The method selected for preparing the projections will vary with the basic data available, the resources available for effecting the computations, the detail required in the results, and the quality of results needed. A number of methods are available, each being appropriate for different circumstances. As requirements and the available resources differ from country to country, a uniform procedure cannot be prescribed. It may be useful to test more than one method until an effective approach is established. Detailed consideration cannot be given here to the methods of projections of urban and rural populations. Rather, I propose to consider several types of methods briefly and illustratively, noting the general procedure and the problems presented by each method. In some of the methods described below, prior projections of the population of the country as a whole by age and sex and of the total urban and rural population are required. The projections of the former type are often available, or established techniques for preparing them are at hand. Projections of the total urban and rural population are much less frequently available, and, in fact, are sometimes derived by prior calculation of age-sex projections of urban and rural population.
12. Projections of total urban and rural populations may be derived rather simply by a ratio method, that is, by projecting the trend of the percentage urban in the national total on some mathematical or other basis and applying the projected proportions to the available national totals for future years. For example, the rate of change in the proportion observed in one or more previous intercensal periods may be assumed to approach zero gradually by some terminal date; i.e., the proportion urban would eventually reach stability. Or the proportion may be projected by analogy with the past change in the proportion in some much more urbanized country. An even simpler device may be applicable. The average annual rates of change in the rural population for a number of past intercensal periods are often consistently low or negligible while the urban population grows rapidly, absorbing all or nearly all the
national population increase. Given projections of the total population and an assumption of a specific, constant rate of growth of the rural population, it becomes a simple task to derive projections of the urban and rural populations.
13. Two ratio techniques of projecting the age-sex distribution of regional population, applicable to urban-rural projections, have received special attention in the literature. The first employs the ratio of the per cent of the urban (rural) population in each age-sex group to the corresponding per cent for the total (urban plus rural) population from the last census or censuses. It may then be assumed that the ratios of the per cents will not change, will change according to the intercensal "trend," or will approach unity by some distant date. The projected ratios are then applied to the projections of the percentage age-sex distribution for the country as a whole to obtain projections of the percentage age-sex distribution for the urban (rural) population. Each of these per cent distributions must then be proportionately adjusted to 100 per cent for all ages before being applied to the projections of the total urban and rural populations, respectively, to obtain absolute numbers. Proportionate adjustments of the urban and rural figures at each age to the national totals at that age, and of the age-sex figures for the urban and rural populations to the urban and rural totals, respectively, follow in order. This cycle of adjustments is repeated to obtain full agreement with rim totals (known as the Registrar General's Square Table Method or two-way raking).
14. Two-way raking is also applied in the second ratio procedure. Here, the total male population and female population at each age at the first projection date is distributed by urban and rural residence according to the urban-rural distribution at the last census, and the results are then adjusted proportionately to the previously projected total urban and rural population. The resulting figures are again subjected to the same adjustment cycle until complete reconciliation with assigned rim totals has been achieved. The final results are then utilized as a basis for deriving the projections at the next projection date by the same procedure, and so on. These two ratio techniques described may be effectively merged into a single procedure. The first technique, using (urban-rural) residence group-to-total ratios of the per cents in each age-sex group, may be applied to each projection year on the basis of the final projections for the preceding projection year after raking is completed.
15. The ratio methods described depend on the availability of adequate recent data on the age-sex and urban-rural distribution of the population as well as of adequate projections of total population by age and sex. Mechanical methods of this kind have the advantage of simplicity of computation, but they also have the shortcoming that little is offered as to the demographic or socio-economic implications of the indicated trends. They are capable, however, of providing satisfactory projections for use as a basis of overall population, economic, educational and other projections.
16. Other methods of projecting urban and rural population attempt to take more explicit account of the demographic or socio-economic components of population change, and hence provide more meaningful results for use in national development plans or as bases for more specialized projections. They are, therefore, viewed as superior. They are also likely to provide more realistic projections, but this has not been demonstrated since no testing of the accuracy of urban-rural projections has been done. They also require a greater body of basic data, greater technical know-how, and more computational resources. For this brief presentation, I shall refer to the ratio method employing agricultural labour force, the cohortcomponent method, economic analysis method, the area-component procedure, and use of migration and population models.
17. The first of these involves the relationship between the proportion of the labour force in agriculture to the proportion of the population in rural areas, by age and sex. Prior projections of total population by age and sex and of labour force by age and sex, in agriculture and not in agriculture, are required. The latter may be developed by correlation techniques using geographic areas within a country to provide a guide as to possible future changes related to various presumed levels of industrialization. The difference, absolute or per cent, between the proportion of the labour force in agriculture and the proportion of the population rural should tend to show a considerable regularity or even stability. This difference, possibly projected, can be used to convert the proportion for agricultural labour force to the proportion rural. This procedure can be applied on an age-sex specific basis as well as on the basis of total population. Projections of rural population in the non-working ages (say, under 15 and over 65) may be estimated either in relation to the rural population of working age or by applying projected fertility rates to the rural female popu-
lation of childbearing age. Projections of the urban population are derived by subtraction of the rural from the total population.
18. The cohort-component method, the second of the analytic methods enumerated, involves carrying forward the current urban and rural populations by age and sex, to future dates by allowing separately for fertility, mortality, migration, and other changes. This method is especially appropriate for projections by age and sex. Growth of the urban and rural populations may be viewed as consisting of (a) overall growth of national population leading to increased density and reclassification of areas from rural to urban; (b) urban-rural differences in fertility and mortality; and (c) internal migration leading to growth of urban areas at the expense of rural hinterlands. The cohortcomponent method directly deals with the fact that the strategic demographic variable in urban-rural projections is internal migration although fertility also is subject to wide variation. The method thus poses the difficult problem of securing recent data, by age and sex, on urban-rural differences in fertility and mortality and net migration between urban and rural areas (and, possibly, reclassification of areas from rural to urban). (A general simplification of the cohort-component method involves computation of "migration-survival" rates-rates of net change by age cohorts-for the urban and rural populations.)
19. Data on urban and rural mortality are usually not available but, if overall mortality can be established, differences are not expected to be so great as to have any substantial impact on the projections. An indication of the urbanrural difference in mortality may possibly be secured from data for the principal city and for the remainder of the country, or for the principal political subdivisions grouped as principally urban or rural. In the light of the inadequacies of registration data in many countries and the further difficulties of securing death statistics according to the definition of urban and rural used in the population census, it is often not possible to secure satisfactory information on urban-rural mortality differences from this source. There is the possibility of securing estimates of crude death rates for the urban and rural sectors from a national sample survey, but experience and success with this approach are still quite limited. The possibility of borrowing the age-sex specific pattern of urban-rural differences in mortality from another country, to be used in combination with the overall level of mortality in the country under study, should also be considered.
20. The next task is the projection of the
mortality rates to future dates. This may be done in proportion to prior projections of overall mortality. Whether urban and rural mortality will converge with the passage of time, as seems generally reasonable, and what the rate of convergence will be, are matters of judgement. This step would be aided if there were available a system of model urban-rural life tables related to various levels of overall mortality.
21. The estimation of current differences in urban and rural fertility is somewhat more important for projections than differences in mortality but the task may be easier. The registration system may not provide reliable indications of the difference, but the census is a valuable source. The basic census data on the urban and rural population by age and sex represent a ready basis for measuring the difference in the level of recent urban and rural fertility, although ratios of children to women are affected by other factors, including differential net undercounts of children and women and migration of families between urban and rural areas after a child is born. Historical changes are reflected in such ratios from several censuses or in data on children ever born per 1,000 women who have completed or nearly completed their childbearing. The data on children ever born, which describe lifetime fertility, may be converted into age-specific birth rates by differencing the rates at successive ages and, if similar data are available for a prior census, interpolating between census years as required.
22. Projection of urban and rural fertility rates presents a more difficult task than for mortality rates since the range of effective uncertainty is greater. Once again, urban and rural rates may be extended in relation to total fertility. Convergence of fertility rates may or may not occur in the projection period; an analysis of urban-rural differences in relation to the level of total fertility for prior census dates or for a number of countries should prove useful in this regard. The method requires that general fertility rates or age-specific birth rates for each projection period be applied to females of childbearing age, producing births for each 5-year period.
23. The most difficult problem is the measurement of the component of net migration, Information on this component may possibly be provided directly by a census or sample survey. Census data on place of birth or place of residence at some previous date for the population classified by current urban-rural residence, age and sex, are occasionally tabulated
in terms of prior urban-rural residence, or even farm residence. To use the data on place of birth from two censuses to derive migration for the intercensal period requires considerable manipulation, however. Census or survey data which show inter-area streams of migration in a specific past period may permit a more refined representation of the direction and volume of migration.
24. A more general possibility is to obtain estimates of net migration, by age cohorts and sex, as a residual by removing natural change from total change, by age cohorts, between two earlier censuses. There are a number of difficult conceptual and technical problems in applying the residual method. Such a residual would ordinarily represent a combination of net migration and reclassification of population from rural to urban. The effects of reclassification can be excluded if "urban" is defined not merely by a size criterion but also as referring to a specified list of areas such as "county seats". "Census survival rates" may serve as a useful tool for estimating past migration between urban and rural areas by the residuai method. Censal survival rates are ordinarily based on national data by age and sex from two censuses and theoretically are used to eliminate from the total change by age cohorts the parts due to mortality and to changing net census undercounts in the two censuses. Thus, applying national censal survival rates to the urban and rural populations provides estimates of net migration (and reclassification) for each sector, A similar national censal survival rate based on births permits estimates of net migration of young children. The problem presents itself both of converting intercensal net migration to net migration for 5 -year periods or to an annual average basis, and of determining the base for the migration rates.
25. A variety of assumptions regarding future net migration are then possible. One useful assumption recognizing the continuity of demographic changes is to employ the "pattern" of net migration in the previous intercensal period. Whether amounts or rates are employed is a matter of judgement. Gradual change to half or some other proportion of the previous intercensal amounts or rates by some future date is a type of alternative assumption. Because of the characteristically wide difference between the fertility of urban and rural areas, it is important to consider whether migrants will be assigned the rates of their area of origin or destination during the 5 -year period of their arrival and subsequent periods.
26. Considerable error is possible in projec-
tions of urban-rural migration and hence of urban-rural population. The evidence is that, although the major migratory currents are persistent, the volume of migration varies considerably over time. The component method may easily grossly under- or overestimate the prospective urban population while over- or underestimating the prospective rural population, depending on the assumptions made with respect to the various components. Furthermore, only infrequently can it be manipulated to take explicit account of future reclassification of areas from rural to urban, the effect of which may vary considerably from one period to another. The method has severe limitations if comparable data by residence are not available from two previous censuses for estimating net migration, and it cannot allow for any future change in the definition of urban and rural.
27. The differences in the economic condition and structure of urban and rural areas, specifically in job opportunities and per capita income, basically determine the flow of migrants from one type of area to the other. It would seem useful, therefore, to design a method of projecting rural-urban migration which takes explicit account of the difference in relative economic status of urban and rural areas, past and prospective. Studies are necessary to determine the predictive value of various economic indicators for urban-rural migration. Regression techniques applied to spatial, if not temporal, units may be useful here. The demographic trend in the area of origin, usually rural, may be quite important too. One indication of the number of persons who will migrate from farms, a major factor in rural population change for many countries, is the replacement ratio-the excess of the number of persons reaching working age over the number leaving through death or retirement (e.g., number $10-14$ as per cent of the number 60-64). Similarly, the change from one census to another between the population aged $20-$ 29 and the expected population 20-29 (allowing only for death since the preceding census), or the ratio of the population $20-29$ to the population 10-19 in the same census, may be used to reflect the change in the potential supply of labour (an economic variable). The relation between these ratios and net migration of the working-age population from rural to urban areas could be analysed by a regression method and possibly used in projections. Of course, economic series may be used directly to project the population of working age or the total population of urban and rural areas rather than the net migration component.
28. A somewhat different approach to urban-rural projections is employed in the areacomponent method. Here, projections are prepared for individual urban agglomerations, individual "urban" provinces, or urban parts of provinces or regions; these are then combined to represent the total urban population. Or the entire country may be divided into "economic areas"-small economically integrated areas akin to metropolitan areas or type-of-farming areas-which may be identified as primarily urban or rural and for which separate population projections can be prepared. To project the population of each area, various methods, including those described earlier, may be used. We may mention here especially the cohort-component method, or its simpler version employing local migration-survival ratios, and various types of economic analysis. In the latter method, the cconomically active may first be projected and then converted to total population, following a study of the economic prospects for the area. One approach involves separate consideration of several main branches of the economy, proceeding from national to local employment in these branches and then to net migration and total active population related to such employment, and finally to inactive population and to total population. These more intensive procedures are difficult to apply since they require considerable data and involve the problem of demographic and economic interdependence. Furthermore, even if the simplest method is employed, the calculations become voluminous when age and sex detail is included and projections are prepared for a large number of areas. Under these circumstances, it would be desirable, or rather necessary, to carry out the work by electronic computer. The proposed projections for each individual area should finally be submitted for review by local planning agencies and other local authorities.
29. Another approach to be considered is to develop a model of urban-rural migration or population change, or to incorporate urbanrural population changes by age and sex into a national demographic model. J. V. Grauman
has suggested a model of urban-rural population change which would, in effect, incorporate migration into a system of stable population models. The model would take into account a number of pertinent variables and it would be possible to determine how much variation in the projections of population would result from change in one or another of the variables. The possibility of developing a model of internal migration for use in projecting population has been reviewed by H. ter Heide. He believes that, although there has been substantial progress in the development of a model which describes past migration, the problems of employing this model for purposes of population projections are almost unsurmountable, if only because of the general lack of projections of the several independent variables on which the model depends. Further research on this method is indicated.
30. This review of the methodology of urban-rural population projections suggests the following concluding reflections. A key problem is the improvement of the basic data on urban and rural population by age, both as a base for the projections and as a necessary element in the measurement of net migration. Progress in the improvement of urban-rural projections may depend primarily on progress in internal migration research. More information on the causes of migration and the characteristics of migrants is needed. Is it possible, on the one hand, that continued migration to cities can cause such deterioration in the conditions of city life as to render the "pull" factor inoperative or, on the other hand, that the spread of urban conveniences to the countryside and the rising status of a declining rural population would stem the "push" factor? There is a need for evaluation studies. A number of reports with projections of urban-rural population were published several years ago so that some evaluation studies could now be carried out. A wide variety of estimating techniques need to be applied, both simple and complex, to serve the variety of needs of projections, including simple short-cut procedures.

# The methods of drawing up the current and planned balances of labour resources in the Union of Soviet Socialist Republics 

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[Translated from Russian]

1. The basic purpose of planning in the Union of Soviet Socialist Republics is to ensure the fullest possible satisfaction of the various needs of society through the most efficient use of the country's material and labour resources.
2. The quantitative expression of the most important links and relationships is to be found in the balance of the national economy. Of this balance, the balance of labour resources is an organic part.
3. In socialist state planning the balance method is a tool to promote the rational use of available labour resources and the balanced distribution of labour expenditure among the individual branches of the economy and individual territorial subdivisions, so as to obtain the maximum saving of manpower and work time and raise the productivity of social labour.
4. The Soviet Union, whose population as of 1 July 1964 was about 228 million, has enormous labour resources. The uninterrupted growth of industrial and agricultural production in the Union of Soviet Socialist Republics is accompanied by a steady increase in the number of manual and non-manual workers. In 1963 the number of manual and non-manual workers in our country was almost five-and-ahalf times the 1913 figure. Over the last fiveyear period (1959-1963) the annual growth in the number of manual and non-manual workers in the Union of Soviet Socialist Republics averaged 4.1 per cent (not counting the increase in the number of workers on state farms organized on the basis of some collective farms). The level of employment is also rising: over the past five years the total number of workers in the national economy has risen from 82 to 86 per cent of the total ablebodied population (not counting servicemen).
5. Since the establishment of the Soviet system there has been a redistribution of the employed population among the branches of the national economy. The proportion of workers employed in industry and construction in 1963 was almost four times greater than
in 1913, and now constitutes 34 per cent of the total number of persons employed in the national economy of the Union of Soviet Socialist Republics.
6. Before the Revolution, 75 per cent of all workers were employed in agriculture. In the period 1913 to 1963 this proportion declined to less than half that figure.
7. As a result of the steady rise in the cultural level and material well-being of the Soviet people the proportion of workers employed in education, health, science and scientific services increased thirteenfold over the same period. The number of persons employed in these branches now constitutes 13 per cent of the total number of persons employed in the national economy of the Union of Soviet Socialist Republics.
8. Over a twenty-year period (1961-1980) the Soviet Union plans to increase its industrial production by at least 600 per cent and its agricultural production about 350 per cent, while the total volume of material production (or the so-called gross social product) will approximately quintuple, the number of workers increasing by about 40 per cent over the same period. The productivity of labour will grow over this period by 400 to 450 per cent in industry and by 500 to 600 per cent in agriculture. Here it should be borne in mind that the approximately fivefold increase in the volume of material production is to be achieved without an increase in the working time expended in the sphere of production, since in the course of this period the working day will be considerably shortened and vacations lengthened, and there will also be a more rapid increase in the number of workers in the non-productive sector.
9. In these conditions it becomes particularly important to secure the most rational use of labour resources. For this purpose it is necessary to draw up current and plan balances of labour resources, and particularly plan balances for a long period ahead.
10. The drawing up of current balances is a prerequisite for the drawing up of a plan balance of labour resources. Without assessing and analysing the quantitative proportions already prevailing in the expenditure of labour, without ascertaining the existing composition of the labour force and the sources from which it is replenished, it is not possible to draw up a balance of labour resources for the plan period on a rational basis.
11. The current balance of labour resources, like the whole complex of statistical operations of which it is a part, is subordinated to the tasks of state administration and planned guidance of the economy. It characterizes the availability and composition of labour resources and their territorial disposition and utilization.
12. According to Soviet statistical practice, current balances of labour resources are drawn up as of 1 January and 1 July of each year, and also on an annual-average basis. The parpose of drawing up current balances as of 1 January and 1 July is to study the status and utilization of labour resources in the periods of minimum and maximum employment in agriculture. By comparing the balances of labour resources drawn up as of the dates of minimum and maximum employment, we can judge the seasonal fluctuation in the employment of labour resources.
13. The balance of labour resources expressed in terms of the average for the year characterizes the availability, composition and utilization of labour resources on an average annual basis. Whereas the dated balances are based on indicators valid at a particular time and, consequently, the accounting unit in these balances is physical persons, the balance of labour resources averaged over the year is based on annual-average indicators.
14. Current balances of labour resources are drawn up not only for the country as a whole, but also for individual geographical areas. In order to characterize the geographical disposition of labour resources, current balances are drawn up individually for the Union republics and, within them, for major economic areas, regions, territories and autonomous Soviet Socialist Republics.
15. Labour resources in the Union of Soviet Socialist Republics include:
(a) The population of working age (men aged $16-59$ and women aged $16-54$ ), excluding non-working, non-able-bodied periods in these age brackets;
(b) The working population outside the limits of the working age, i.e., older people who work (men aged 60 and over and women aged

55 and over), and working juveniles under 16 years of age.
16. The present upper limit of the working age corresponds to the legislation in force in the Union of Soviet Socialist Republics concerning old age pensions for manual and nonmanual workers. Under this legislation men may retire at 60 and women at 55 . Manual and non-manual workers employed underground, in unhealthy working conditions, in hot workshops, and in other occupations with arduous working conditions, and women who have borne five or more children and raised them to eight years of age, may retire five to ten years earlier. The fixing of definite ages for retirement does not mean that persons reaching those ages lose the right to work guaranteed by the Union of Soviet Socialist Republics Constitution. Many old people do not retire, but continue to work.
17. The present lower limit of the working age was determined on the basis of the law concerning compulsory universal eight-year education, which provides that juveniles under 16 must be at school.
18. The limits of the working age are not permanent. They may change with changing socio-economic conditions of life and work.
19. Current balances of labour resources, both dated and averaged over the year, are drawn up in two parts: the first part characterizes the availability and composition of labour resources, and the second the distribution of labour resources by employment. A schema of the current balance of labour resources is given below:
(1) All labour resources
of which:
(a) The able-bodied population of working age (population of working age minus nonworking, non-able-bodied persons in this age bracket);
(b) Older working persons and working juveniles.
(2) Distribution of labour resources
(a) Manual and non-manual workers, broken down by branches of the national economy;
(b) Collective farmers working in the public sector of collective farms, broken down by branches of the national economy;
(c) Other able-bodied persons (craftsmen and others not organized in co-operatives);
(d) Students aged sixteen and over studying full time;
(e) Able-bodied persons of working age employed on personal subsidiary plots, and in housekeeping and the care of children.
20. The balance of labour resources according to the above schema is drawn up both for the country as a whole, and for urban and rural areas.
21. Depending on the purposes of the investigation, the balance of labour resources may be constructed according to a more extended schema. In Soviet statistical practice such a
balance of labour resources is drawn up by social groups of the population-manual and non-manual workers and members of their families, collective farmers and members of their families, other population groups (craftsmen not organized in co-operatives and others).
22. An extended schema for the balance of labour resources is given below.

| Total | Of which: |  |  |
| :---: | :---: | :---: | :---: |
|  | Manual and non manual workers and mambers of their families | Collective farm warkers and members of their jamilies | Other population (craftsmen and others not ordanised in co-operatives) |

(I) All labour resources of which:
Abled-bodied population of working age
Older working persons and working juveniles
(II) Employed in national economy of which:
In State, co-operative and public enterprises, institutions and organizations and on collective farms
On the personal subsidiary plots of collective farmers and the families of manual and non-manual workers
Other population (craftsmen not organized in co-operatives and other groups)
(III) Students aged 16 and over studying full time
(IV) Able-bodied persons of working age employed in housekeeping and the care of children
23. To compile the balance of labour resources according to the schema given above, the population employed in the national economy is broken down into persons employed in branches of material production (in industry, construction, agriculture, forestry, transport, communications, trade, public catering, supply and sales) and persons employed in nonproductive branches (education, health, science, housing and community services, organs of state administration, etc.).
24. Compiling a current balance of labour resources involves a whole complex of calcula-
tions based on labour statistics, population statistics, surveys of the budgets of manual and non-manual workers and collective farmers, statistics pertaining to agriculture, education, social security and so forth, and data from population censuses.
25. Individual items in the balance of labour resources are calculated as follows:
(1) The size of the population of working age is determined, separately for urban and rural areas, from population census data and the once-yearly record of the sex and age composition of the rural population, and from
data on the natural movement and migration of the population. To determine the size of the urban and rural population of working age in the years following a census, the following changes are made in the basic data for each year:
(a) The number of persons attaining working age by the beginning of each postcensus year is added;
(b) The number of persons passing the upper limit of the working age by the beginning of each post-census year is subtracted;
(c) Persons of working age deceased during the year elapsed are subtracted;
(d) The increase representing the balance of migration of persons of working age over the year elapsed is added;
(e) The population of working age of rural inhabited localities which have become urban localities during the year elapsed is added in the case of urban areas and subtracted in the case of rural areas.
The number of non-working non-able-bodied persons of working age for the balance of labour resources is determined from the records of the social security authorities. The size of the working population outside the workingage bracket (working juveniles up to sixteen years of age and older working persons-men aged sixty and over and women aged fifty-five and over) is calculated from the once-yearly registration of the age and sex distribution of manual and non-manual workers, and in the case of collective farm workers from the annual returns of collective farms.
(2) The number of persons employed in the national economy is computed from current labour statistics, full-coverage and sample surveys of the size and composition of the work-force, and the annual returns submitted to the state statistical authorities by all state, co-operative and public enterprises, institutions and organizations. The employed population includes: manual and non-manual workers of state, co-operative and public enterprises, institutions and organizations; collective farm workers employed in the public sector of collective farms; craftsmen not organized in cooperatives and other employed persons; collective farm workers and members of the families of manual and non-manual workers of working age employed on personal subsidiary plots.
The number of persons employed in the national economy is determined separately for each of the enumerated types of employment, in the following manner:
(a) The number of manual and non-manual workers employed in state, co-operative and
public enterprises, institutions and organizations and their breakdown branches of the national economy are calculated from current and anmual labour returns (records of the number of manual and non-manual workers are submitted to the state statistical authorities by all enterprises and organizations of productive branches monthly, and by institutions and organizations of non-productive branches quarterly) ;
(b) The number of collective farm workers employed in the public sector of collective farms is determined from the annual returns of collective farms concerning the participation of collective farms in the work of the farms. Since collective farm workers are usually employed over the year in occupations relating to different branches of activity (in addition to their agricultural work, they may be employed in repair shops, at construction sites, etc.), the breakdown of collective farm workers by branches of the national economy in the balance of labour resources is effected on the basis of data concerning the time worked by them in the various branches of collective-farm activity;
(c) The number of able-bodied persons of working age employed on the personal subsidiary plots of collective farm workers and the families of manual and non-manual workers is determined from sample budget surveys designed to ascertain the unit labour cost of work on private plots and from returns indicating the extent of private subsidiary farming (head of cattle privately owned by the population and the extent of the agricultural areas in private use).
(3) The number of persons aged sixteen and over studying full time is determined from the returns of general education schools, higher and secondary specialized educational institutions, technical and vocational colleges and schools and other educational establishments.
(4) The size of the able-bodied population of working age employed in housekeeping and the care of children is determined as the difference between the total labour resources and the number of persons employed (including those employed on personal subsidiary plots) and persons of working age studying full time.
26. The study of the composition of labour resources is of great importance in Soviet statistical practice. The following are used for this purpose: population census data, which allow a more detailed study of the age and sex structure of the labour force, the level of education and distribution of the employed population by occupation, and so forth; current statistics on the size and composition of the labour
force, based on the regular returns of enterprises, institutions and organizations; data from the annual statistics on the size and composition of the body of specialists with higher and secondary specialized education employed in the national economy; data from the periodically compiled statistics on the composition of the labour force by sex, age and length of service, and also statistics reflecting change in the composition of the labour force by occupations and skills occasioned by the rapid development of Soviet science and the rapid mechanization and automation of production; reports on the training of skilled workers carried out both directly in industry and through the system of vocational and technical education, and a number of other operations.
27. Population census data concerning the composition of the unemployed population of working age, and particularly the composition of the female component by age, possession of children and other characteristics, makes it possible to determine the extent to which they may be brought into social production. It should be noted that in the USSR today almost half of all employed persons are women. In a socialist economy, with no unemployment and equal pay for equal work, the evergrowing participation of women in social production is bringing about a further improvement in the level of living of the workers.
28. The current balances reflect the actual size of labour resources, their disposition and the level of employment of the population in social production, the quantitative proportions in the distribution of labour resources by type of employment, branch of the national economy, etc. The current balances are the basic data, the starting point for the compilation of the plan balances of labour resources.
29. The main practical purpose of the plan balance of labour resources is to ensure that the national economy is supplied with manpower in accordance with the targets of the state plan for the development of industry and cultural construction.
30. One of the key functions of the plan balance of labour resources is to establish the most rational proportions in the expenditure of labour as between the various branches of the national economy. In this connexion, the rational distribution of workers between the sector of material production and the nonproductive branches assumes particular importance.
31. The following are preliminary requirements for the planning of labour resources:
(a) A full accounting of all labour resources for the plan period and full employment of the able-bodied population;
(b) Ascertainment of the aggregate and supplementary manpower requirements;
(c) Ascertainment of the sources from which supplementary manpower requirements may be met in each branch and each geographical area;
(d) Establishment of the need to improve the qualitative composition of labour resources in accordance with the requirements of the national economy (training of skilled workers, training of specialists, advanced training, etc.);
(e) Determination of the extent to which manpower has to be redistributed.
32. Compiling a plan balance of labour resources, particularly a long-term balance, means above all establishing such proportions in the distribution and use of labour resources as will ensture the greatest possible rise in the productivity of labour and the material wellbeing of the workers.
33. The plan balances of labour resources for individual territorial units (regions, republics) determine how far the manpower requirements of all branches of the national economy may be met from local resources, and how far supplementary manpower may be drawn from other parts of the country.
34. The plan balance of labour resources is compiled on an annual average basis for republics and regions, urban and rural areas being dealt with separately.
35. The number of manual and non-manual workers in the plan balance of labour resources is determined on the basis of a plan for the number of manual and non-manual workers drawn up independently. The number of workers employed in the sector of material production (industry, construction, agriculture, transport, etc.) is calculated on the basis of the projected volume of production and rates of growth of labour productivity. The number of workers in non-productive branches (education, health, housing and utilities etc.) is determined on the basis of plans for the expansion of public service facilities and the norms governing services to the population.
36. The number of collective farm workers working in the public sector of collective farms is included in the plan balance of labour resour-
ces in accordance with the figures for the plan balance of collective-farm labour resources prepared on the basis of the plan for the development and mechanization of agricultural production and the planned growth of labour productivity.
37. The number of students aged sixteen and over studying full time is determined on the basis of the plan for admissions to, and
graduations from, educational institutions in the plan period.
38. Provision is made in the plan balances for a gradual reduction in the numbers employed in personal subsidiary farming and housekeeping. Enlistment in social production of the able-bodied population thus employed is one of the most important purposes of the better use of labour resources.

# The analysis of family structure in projecting the number and composition of families 

A. G. Volkov

[Translated from Russian]

1. With the development of economic planning in many countries, demographic projections not only of the total population and its age-sex composition but also of the number and composition of families are coming to play an increasingly important role.
2. While we now have a sufficiently detailed standard method for making general demographic projections (the application of aging factors derived from mortality tables to particular age groups), the methods used in the long-term projection of the number and composition of families are essentially still in their infancy. Attempts to estimate the future number of families and their size distribution have been made in many countries. In the majority of cases, however, such calculations are limited either to projecting the average family size and then determining the number of families on the basis of long-term population figures obtained in the usual way, or to extrapolating (with various qualifications) past trends in the changing number of heads of families. These calculations are too general in nature, and suffer from the drawbacks inherent in any extrapolation. In addition, since it has to be based not on transient but on constant trends, extrapolation requires a number of successive censuses, each not only providing for special study of the family but also preserving continuity of method in the registration and processing of family statistics.
3. The above-mentioned methods of computation rarely deal in sufficient detail with the initial composition of the family and the changes it may undergo. The influence of factors affecting population reproduction is concentrated in the family and directly connected with its composition in terms of age, sex and the relationship among its members. The formation and development of families is an uninterrupted process: young families arise in the bosom of the old and are then separated from them, giving rise in their turn, after a certain time, to new families. Families differing in their composition have extremely
different development prospects. Thus, for example, the possibilities for development of two three-person families are completely different if one consists of a married couple with one child and the other of a mother and two adult children. It may therefore be rewarding to analyse the composition of families at a certain moment in time, from the standpoint of their possible further development. ${ }^{1}$ This paper gives an account of some results of such an analysis.
4. For the analysis of the internal structure of the family we used the materials of the trial population census conducted as of 1 August 1957 in the town of Bolotnoye and the Bolotninsk district of the Novosibirsk region (Russian Soviet Federative Socialist Republic) to test the schedule and organizational plan for the 1959 All-Union Population Census. The urban population of the Bolotninsk district in 1957 was about 26,000 , and the rural population about 33,000 . Data concerning some 16,000 families and persons living alone were available for analysis. Although this town and the surrounding district were chosen as being to some extent typical of the small provincial town, the material of the trial census cannot be regarded as fully representative of the country as a whole. ${ }^{2}$ In addition, although the trial census was very little different from the 1959 census in method, the material may contain certain inaccuracies and mistakes due to inexperience on the part of the census personnel. The data given here should therefore be regarded mainly as illustrative of methodology.
5. In both the trial and the main censuses, a family was understood to be a group of persons living together, connected by blood or

[^78]marriage and having a common budget. Thus defined, the concept "family" is somewhat different from the concept "household", which does not necessarily require kinship. It is also broader than the concept "family" understood as a biological nucleus (parents and children), since it covers families comprising two or more married couples and other relatives. The study of family composition was not a specific purpose of the trial census. However, the population count was effected family by family, the head of the family usually being registered first and the other members of the family being indicated in terms of their relationship to him. By special processing of these records it proved possible to isolate the married couples, their children, other relatives and so forth, i.e., to reconstruct the internal structure of the families. The youngest complete married couple with or without children or one of the spouses with children was taken as the basis of the family. The other members of the family were then disposed according to their degree of relationship to this married couple. Only those living with the family permanently were taken into account.
6. In order to ascertain the distribution of families by composition, the families were
divided according to the nature of the kinship ties into families consisting only of persons related in the direct line (children-parentsgrandparents) and families consisting of persons related in the indirect as well as the direct line (with relations of one of the spouses or their parents).
7. The majority of families processed- 92.8 per cent in the town and 91.3 per cent in the country-consisted of persons related in the direct line only. Of the families including persons related in the indirect line, most consisted of brothers and sisters of one of the spouses living with the married couple's parents, with or without children, i.e., families in which the older children continue to live with their parents after marriage. The comparatively small number of families consisting of persons related in the indirect line indicates that, as a rule, the oldest child, once married, soon leaves the parent family.
8. Table 1 shows how families are grouped by the number of generations in the family, and presents similar data from a number of other surveys. ${ }^{3}$

[^79]Table 1

| Number of generations $\stackrel{i n}{\text { family }}$ |  | Percentage of families |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Bolotninsky district, Novosibirsk region. Russian Federative Socialist Republic | Viryatino village, Tambovsk regions, Russian Soviet Federative Socialist Republic | Transcarpathian Ukraine | Lithitanian Soviet Socialist Republic |
| 1 |  | 12.0 | 19.3 | 6.6 | 13.6 |
| 2 |  | 70.4 | 60.3 | 64.2 | 65.3 |
| 3 |  | 17.3 | 20.0 | 24.2 | 13.0 |
| Other |  | 0.3 | 0.4 | 5.0 | 8.1 |
|  | Total | 100 | 100 | 100 | 100 |

9. Although the above data reflect differences in registration methods, the general picture emerges fairly clearly: in all cases the basic family type is the family comprising representatives of two generations (parents and children).
10. Since in the monogamous family the basic unit is the married couple, the analysis of family composition should provide for the breakdown of families by the number of married couples. Processing of the material for the Bolotninsky district along these lines revealed the following:

Table 2

| Number married couples family |  | Percentage of families |  |
| :---: | :---: | :---: | :---: |
|  |  | Town | Country |
| 0. |  | 21.6 | 28.5 |
| 1. |  | 75.8 | 69.4 |
| 2. |  | 2.5 | 2.1 |
| 3. |  | 0.1 | - |
|  | Total | 100 | 100 |

11. The existence of a fairly large number of families without married couples is explained mainly by the losses sustained by the population of our country in the last war. The majority of these families are women with children, who lost their husbands on the field of battle. The development of these families must of course be taken into account for the purpose of short-term projections, but in general this type of family is a passing phenomenon. A certain proportion of the families without married couples consist of young unwed mothers and their children; the existence of such families is also connected with the disproportion between the sexes resulting from the war. The bulk of the families, however, have one married couple. Of the families with two married couples, the overwhelming majority are shown on analysis to be families in which one
of the children is married and continues to live with the parents. Cases in which both married couples belong to the younger generation are comparatively rare.
12. A more detailed breakdown of families by types is presented in table 3. This table shows that the family consisting of a married couple with or without children, living with or without their parents, may serve as the basic type. These families may be called "simple families". From the standpoint of the prospects for further development, it is useful to distinguish the following three groups of families:
(1) Simple families consisting of childless married couples ;
(2) Simple families with children;
(3) Families consisting of one spouse with children (with or without parents).

Table 3

| Type of family | Town |  | Country |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Percentage of families | $\begin{gathered} \text { Percentage } \\ \text { of womeon } \\ \text { aged } \\ 15-49 \end{gathered}$ | $\begin{gathered} \text { Percentage } \\ \text { of } \\ \text { famies } \end{gathered}$ | Percentage of womes 15.49 15.49 |
| Families with a complete basic married couple. | 78.0 |  | 71.0 |  |
| Of which: |  |  |  |  |
| Married couple without children and without parents.... | 13.5 | 52.3 | 12.8 | 39.2 |
| Married couple without children but with parents | 1.8 | 95.6 | 1.8 | 93.9 |
| Married couple with children but without parents | 53.1 | 89.4 | 47.6 | 84.9 |
| Married couple with children and parents | 9.6 | 97.7 | 8.8 | 97.7 |
| One of the spouses with children but without parents | 18.1 | - | 23.2 | - |
| One of the spouses with children and parents | 2.6 | - | 4.0 | - |
| Other types of family............ | 1.3 | - | 1.8 | - |
| Total | 100 | - | 100 | - |

13. As far as the first group is concerned, the distribution of these families by the wife's age makes it possible to distinguish married couples in the initial or concluding stages of family development, i.e., not yet having children or no longer having them, the children having left the family and living independently.
14. The families in the second group are the most numerous- 62.7 per cent of the whole in the town and 56.4 per cent in the country. If these families are to be considered in terms of the possible increase in the number of their children, we will find, bearing in mind our purpose, that cohort tables-increasingly used
for demographic projections-may be a great help here. With certain qualifications, such tables can also be constructed on the basis of census data, if the census includes a question concerning the length of marriage, and if in the processing the children of particular mothers are grouped according to their date of birth.
15. The third group of families, as we have already indicated, is atypical. Understandably, they contain fewer children on the average than families with a complete married couple. It might be thought that in these families the children would be less likely to leave on marrying ; on the contrary, however, the mar-
riage of the children is connected to a greater extent than in other families with the advent of another spouse in the family.
16. An assessment of the long-term development prospects of the various types of family must naturally start from the grouping of women by age. A breakdown of all women of child-bearing age (15-49) in Bolotnoye was made according to their marital status, possession of children and composition of family. This breakdown is presented in table 4 (in percentages of the number of women in each age group). The table shows how the distribution of women by type of family changes with age. As may be seen from the table, the bulk of women at the age most favourable from the standpoint of potential childbearing are married, live without their parents and have children. It may be noted that there is a small
but relatively stable percentage of married women without children. In developing these data it is useful to ascertain the distribution of married women according to the number of their children (see fig. 1).


Figure 1
Distribution of basic married couples with children by number of children

Table 4


17. One of the most important questions from the point of view of projections is the rate of new family formation. This should be regarded as the process of separation from the parent families of, basically, young married couples, who either continue to live for a time with the family, or leave immediately after marriage. This is not just a question of the marriage rate alone, since we need to know not only the number of newly formed married couples, which gives us the marriage rate statistics, but also the effect of their departure on the size and composition of existing families.
18. A new married couple may arise from the marriage either of two persons living alone, or of one person living alone and a member of a family, or, finally, of two members of different families. Correspondingly, the newlyweds may either form a separate family, or live with the parents of one of them.
19. If marriageable men and women were divided equally into those living separately and those living with their parents, and if after marriage the spouses were equally likely ${ }^{4}$ to live either on their own or with the parents of one or other of them, it would be easy to calculate that of every twenty-four newly formed married couples, fourteen would live separately after marriage, five would live with the family of the wife's parents, and five with that of the husband's parents.
20. In practice, however, these probabilities are different and depend on the age of marriage, the rate at which members of the family have left hitherto, housing conditions and a number of other factors. According to our data, the ratio of unmarried women living alone

[^80]to those living with families (in the urban population) was 2:3 for the 20-24 age group and as high as $3: 2$ for the 25-29 age group. If we assume that the probability of marriage does not depend on whether a woman lives with a family or alone, then the ratio "living separately: living with parents" among those getting married must be approximately the same. It appears that the latter ratio also differs with sex.
21. Newly formed married couples are even less regularly distributed by families. Before the Great October Socialist Revolution, when the size of the allotment, i.e., the quantity of land available to the peasant household, depended on the number of men in the family, in the majority of cases the wife went to live in her husband's house. Today this factor no longer operates, although the tradition is still alive, not just in the country but in the towns too. However, in the towns another factor
comes into play-the availability of living space for the young family. According to a sociological survey carried out in Leningrad by A. G. Kharchev, ${ }^{5}$ of 500 newly-weds polled about 20 per cent intended to live with the groom's parents and 16 per cent with the bride's parents; 25 per cent intended to live on their own. Our material enables us to determine only the existing situation. We find that 16.7 per cent of complete married couples live with their parents in the town and 18.6 per cent in the country. As to the question with whose parents they live, this is indicated in table 5 (in percentages). Of the incomplete married couples, as is to be expected, 80 to 90 per cent live with the wife's parents. Here, apparently, reunion with the parents in most cases took place after the husband's death or departure from the family.

[^81]Table 5

| Type of family | Town |  | Country |  |
| :---: | :---: | :---: | :---: | :---: |
|  | (live evith parents of the) |  |  |  |
|  | Husband | Wife | Husband | Wife |
| Complete married couple with parents. | 69 | 31 | 73 | 27 |
| Mother only with children and parents. | 18 | 82 | 10 | 90 |

22. The probabilities mentioned above may be estimated by putting the appropriate questions to a sample of people about to marry, or even on the basis of census data (if the census provides for the registration of family status and length of marriage); in the latter case, use is made of replies given by persons who married in the year preceding the census, adjusted for mortality and divorce. In the absence of sharp changes in socio-economic conditions, these probabilities may be assumed to change relatively slowly with time.
23. Since the analysis of family composition is aimed at showing the process of natural development of the family, particular attention must be given to what may be regarded as the turning point in that development represented by the departure of the adult children. This is usually connected with the latter's acquiring economic independence and marrying.
24. Here it should be noted that the customary systems of indicators of fertility and increase in family size illuminate, strictly speaking, the process of childbearing itself, not the real change in family size. They fail to take into account, in particular, the fact that a woman's children do not remain with her
indefinitely and that, moreover, the older children may leave the family before the woman's fertile period comes to an end. For the purpose of analysing the development of the family, it is important to consider not only the total number of children born to a woman and the number of them who have died, but also the number of children living with the family at particular stages of its existence.
25. It should also be noted that the breakup of families is slowed by the broad participation of women in social production, thanks to which a young family, having acquired children, relatively more often remains with the parents, who can look after the children. Improvement in the provision of children's institutions will probably help to accelerate the process of family break-up. The rate of break-up will also rise with improved housing conditions.
26. As regards the direct analysis of family composition from this point of view, the rate of break-up cannot be measured on the basis of census data if the census schedule does not provide for the appropriate questions. Some idea of the time at which adult children leave the family is given in figure 2, which shows how the average number of children born to


Figure 2
Average number of children in family as a function of age of wife in basic married couple
one woman changes with age, in families with a complete married couple. As may be seen from the figure, the number of children in the family begins to decline when the mother reaches the $40-44$ age bracket. By the time mothers reach this age bracket, the majority of their children have already left behind them the early years during which mortality is highest, and their mortality may be disregarded. The decline in the average number of children is thus basically determined by the departure of adult children from the family or their marriage. (Women with married children were regarded as parents of a basic married couple and were not included in the calculation.)
27. If we consider the age of a family to be the length of time the basic married couple has been married, then the point at which the adult children leave the family may be timed by reference to a particular year of their parents' marriage. The rate of departure may be
measured by the ratio of the number of young married couples leaving in the course of a year to the average annual number of such couples living with their parents (again adjusted for mortality and divorce). The necessary data may be obtained by asking appropriate questions in a census or sample survey. Using a series of age-specific (parents' age) indicators we get a fairly detailed picture of the process whereby adult children leave the parent families.
28. It is useful to be able to take into account factors determining the time and frequency of such departures, in particular how the rate of departure varies with the economic independence of those leaving and also with the existence of wage-earning members of the family who remain in it after the others leave. The possession by both the departing and the remaining parts of the family of an independent source of income is probably a very important prerequisite for break-up.
29. On the basis of the above it may be considered that the search for improved methods to be used in the long-term calculation of the number and composition of families should be directed towards the study of the natural development of families, having regard to the socio-economic factors which bear on such development. This is because of the need to take into account the heterogeneity of the basic aggregate of families in terms of composition and to adopt a suitably differentiated approach in appraising the probabilities of changes in family size. In addition to changes due to fertility and mortality, it is important to take into account the rate of formation of new and fragmentation of existing families.

# Employment forecasting by professions 

P. DE WOLFF

## I. Introduction

1. For various reasons, interest in employment forecasts has increased very rapidly during recent years. The developing countries strive not only for an increase in the gross national product per capita, but also for a reduction in the visible and disguised unemployment often prevailing there. Consequently, they are greatly interested in the employment effects of their plans, as well as in the conditions their labour markets have to fulfil in order to make it possible to realize these plans. The developed countries, too, are becoming more and more interested in this field, as a high degree of employment nowadays is usually one of the most important goals of economic policy, and forecasts are often made of the probable future course of employment, to foresee if measures will be needed to maintain or to reach a desired level. Finally, in a number of these countries, it is felt that employment forecasts are indispensable as one of the tools of a well-designed growth policy.
2. However, it will already be clear from the preceding remarks that different types of forecasts are possible. We can distinguish pure forecasts and conditioned forecasts. ${ }^{1}$ As an instance of the first kind, we may think of an estimate of unemployment for a developed country at some future date, when no policy changes are assumed to be made. Employment forecasts connected with development plans are all conditioned, as they are based on the assumption that the plan is implemented so as to guarantee its realization. The difference between the two types is only gradual, since pure forecasts, strictly speaking, do not exist. Even in the example mentioned, certain assumptions will have to be made (e.g., with respect to economic policy in other countries). Nevertheless, the differences are large enough to justify the distinction.
3. A second important distinction bears upon the period covered by the forecast. It has

[^82]been customary to consider short-term forecasts as referring to periods of one year and less, medium-term forecasts as covering periods of about one to five years, and long-term forecasts as dealing with periods of over five years. ${ }^{2}$
4. The first category is of interest mainly for business-cyclical problems, where attention is paid to fluctuations resulting from rapid changes in external and internal aggregate demand. The second category plays a central role in development planning, whereas the third category is used in so-called perspective planning, often set up as background information for more detailed medium-term plans, and covering periods of up to twenty years. Moreover, this category is met in forecasting specific types of manpower requirements, in particular, those requiring rather long training periods (for instance, the academically-trained professions; see part IV).
5. Thirdly, forecasts can be classified into global and detailed ones. The short-term forecasts mentioned above are often global. The composition of the demand for labour is of little interest in the short run, and therefore, forecasts for such periods are usually restricted to total demand, although occasionally special key trades (such as building) are also taken into account. Medium- and long-term forecasts are, as a rule, much more detailed. The development with which they are connected requires information about separate sectors of economic activity, and the employment forecasts reflect this. They are often broken down into sectors, professions, and sometimes even into regions. In this paper dealing with forecasts by professions, we will restrict ourselves entirely to medium- and long-term forecasts.
6. Finally, it is important to consider separately the demand and supply forecasts. It is by no means sure that the demand for certain types of labour resulting from a given pattern of economic development will automatically be matched by a corresponding supply. Yet deficits

[^83]and surpluses need not always be harmful. Certain skills are rather flexible and applicable in various directions, or they may be switched after a fairly brief period of re-training. Demand for labour is not entirely independent of supply, and a surplus of a certain kind may lead to unforeseen technical developments, in which it may be utilized (for example, a relative abundance of science graduates seems to have had a favourable effect upon the early development of the German chemical industry). ${ }^{3}$ Gaps may also be bridged through an appropriate adaptation of the wage level. Very often, though, deficits will lead to serious bottlenecks, preventing the realization of a desired development, whereas surpluses, too, may cause serious problems (such as the surplus of certain types of academically trained manpower troubling several developing countries). ${ }^{4}$ This is particularly true in cases where demand and supply are rather inelastic.
7. Consequently, it will nearly always be necessary to forecast both demand and supply, and to design adequate corrective measures when unacceptable gaps are expected to develop. This paper will pay attention to both aspects of the problem. A description of the corrective measures clearly falls outside its scope. ${ }^{5}$

## II. Demand for labour

8. Every forecast of the demand for labour has to depend on a forecast or a plan for the volume of production. This quantity is the main determinant of the national income, from which the final demand for goods and services can be derived. Through the use of appropriate techniques (mainly so-called input-output methods), this final bill can be translated into indicators for the development of the production volume for the different sectors of economic activity, and these data form the basis for the estimates of future demand for labour in different categories. This procedure is much more complicated than might be concluded from the preceding brief description; but it is important that the same methodology is used, at least in principle, not only for categories of labour engaged in the production of, say, consumer goods, but also for categories supplying highly specialized types of services, e.g., physicians. The demand for this category, too, is determined by the share of available private

[^84]income spent on its services, together with the demand resulting from public spending.
9. The volume of production, however, cannot be forecasted per se. In medium- and long-term forecasts, it is usually based on the assumption that certain scarce factors in production need to be and will be fully utilized. Often this scarce factor is labour itself. This is the case, for example, in developed countries, where a high degree of employment has been attained and should be maintained. In these cases, the first step to be taken is to estimate the growth of the total labour supply (see part III). By combining this result with reasonable assumptions on the macro-economic increase in labour productivity, the total volume of production can be derived. The way labour productivity develops is dependent on the amount of investment to be made, and hence on the rate of saving. Obviously, this procedure will be consistent only when it turns out that the aggregate of the micro-economic labour demand estimates (i.e., at the sector level) is identical with the macro-economic starting point. This check must, therefore, be made, and if a serious discrepancy occurs, it discloses that mutually conflicting assumptions have been made and that changes are needed.
10. In other cases, e.g., in many developing countries, capital is the scarce factor; then a corresponding analysis will show which part of the forthcoming labour supply can be expected to be absorbed (the consistency check remains necessary, even in this case). Here, too, different alternatives are possible. The greater the importance attached to a reduction of unemployment, the less capital intensive the investments have to be, i.e., the lower their average capital-output ratios ought to be. But the possibilities for choice are limited by several economic factors. ${ }^{6} 7$
11. The relation between employment and production per sector requires estimates again of the increase in productivity. This is usually done by extrapolating trends, although use is made sometimes of a constant elasticity of employment, with respect to production (usually in the order of magnitude of $0.5-0.7)^{8}$ Both methods, however, require a considerable amount of statistical information about production and employment in sufficient detail over a period of several years. This information is not always available, particularly in countries

[^85]where development has started only recently. In such cases, recourse has to be made to international comparisons or to special studies. This is obviously also true for new industries and for the introduction of entirely new techniques into old industries. Also, the gradual increase of the average skill, due to improved education, may have a considerable influence. It will then be necessary to account for changes in institutional factors, such as working hours, number of holidays, etc.
12. The demand for labour is expressed by enterprises which can be grouped conveniently into sectors, but it is confronted with the labour supply, specified by professions; a statistical matching of the two evidently requires translation. Demand has to be broken down by professions, and since many professions can find employment in different sectors, a second phase of appropriate re-grouping is necessary. It will be clear that this second phase, in particular, makes it imperative to use a uniform classification of professions. As a starting point for such a classification, excellent use can be made of the International Standard Classification of Occupation (I.S.C.O.) developed by the International Labour Organization. ${ }^{8}$ It is set up to be useful for a wide range of applications, and it distinguishes some 1,500 occupations according to similarity in the type of work performed, condensing them consecutively into more comprehensive groups, viz., 200 unit groups, 75 minor and 10 major groups.
13. For various reasons to be explained in more detail in part III, it will seldom be necessary to base the adopted professional classification on the finest possible sub-division. But whatever grouping is used, the methods available to make the corresponding forecasts are still very rough, and much research will be needed to improve them and to make them more reliable. ${ }^{10}$ In part IV, a few examples will be treated in some detail; we will, therefore, restrict ourselves at this point to a few generalities.
14. Clearly, the simplest way to proceed is to assume that the professional structure in a given area of economic activity will remain the same during the forecasting period, and hence, that the sizes of the professional groups will

[^86]develop pari passu to total employment. As a first approximation, it may be justified in many cases, particularly when no rapid technological changes are expected. It is a well-known fact that increases in labour productivity are due only partly to an increased amount of capital per worker; perhaps to a greater extent, increases are due to better organization, better-trained workers, more specialists, or, in brief, to increased skills. Hence, the projected rise in productivity at the base of the sector estimates of total employment often pre-supposed not only certain investments in capital, but also in greater skills, in contradiction to an unchanged structure of professions. The number of academically-trained engineers of different types employed in industry is increasing much faster than total employment. This is true for developed countries, and still more true for developing ones. It also holds for technicians at medium levels. International comparisons can be very useful in allowing correctly for such factors. Developed countries, particularly, may profit from such information, which may help them to avoid unbalanced professional structures that may result from an abundant supply of university-trained engineers and a deficit of medium-level technicians. ${ }^{11}$ Very little is known still about the specific effects of increased skills on productivity levels. An interesting attempt has been made recently in Sweden, ${ }^{12}$ where, from time-series analysis, a relation has been found between output per worker and the number of engineers per worker in industry. It was not possible, however, to separate effects from increases in skill and in capital intensity. Moreover, the relation was rather inaccurate, and led to wide margins of uncertainty when extrapolated over longer periods.
15. Another procedure sometimes employed in solving this problem is to ask employers and experts for their opinions. The results of such investigations, however, have seldom been very valuable. The most promising method, perhaps, may be a study of cross-section data, industry by industry, and a careful analysis of certain large-scale projects. This will probably be possible only in a restricted number of countries, however, and it will require specially collected data.

[^87]
## III. Supply of labour

16. The importance of total labour-supply forecasts has already been mentioned in part II. These are derived from population forecasts by ages. Since there exists, in many countries, a legal minimum age for entering the labour force, and since several other countries are going to introduce similar measures in the coming years, forecasts can be restricted to age groups above twelve to fifteen years, and hence, do not depend, even for rather long periods, on birth rates, but on death and migration rates only. Migration is quantitatively important only in a small number of countries. In developed countries, death rates are rather stable; in developing countries, they are often falling rapidly, making accurate predictions more difficult. The labour supply is derived from the population estimates through participation rates, indicating for each group the proportion looking for jobs. For men between, say, 25 and 65, these rates are close to 1 ; for higher ages, retirement, depending mainly on prosperity and institutional factors, becomes important; below 25, the rates are determined largely by the structure of the educational system, and there is a strong tendency for rates to decline, particularly in the lower age brackets. For women, the problem is complicated further by differences in the preparedness and possibilities, especially of married women, to be gainfully employed.
17. Complicated as these problems may be, still greater difficulties arise in forecasting supply by professions. Here, essentially the same procedure is followed as for the labour force as a whole. The persons engaged in a profession constitute a stock subject to changes over a period of time. Supply is reduced by death, retirement and job changes. When the age distribution per profession is known (which seldom happens to be the case), then these factors can be fairly accurately accounted for. Otherwise, a somewhat rough general reduction rate has to be used. It is increased by new entrants into the labour force (and by jobchangers), i.e., essentially by the output of the educational system. This system, however, supplies only to a very limited extent the persons completely fit for certain professions. A great part of school-leavers has acquired skills at different levels, each applicable to a wide field of possibilities, for which final training is obtained on the job. Even vocational schools supply largely general skills, and to a small part only, specific ones, providing the possibility of rapid re-training when supply and demand do not match. Moreover, in many
developing countries, the results in vocational schools have been less satisfying than in general schools, underlining the importance of concentrating on general skills. ${ }^{13}$ Finally, the cohort entering the labour market annually, filling partly the vacancies due to retirement and death, and partly increasing the ranks, is a sizable one. According to the rate of growth of the population, this percentage may vary from 2 per cent to 5 per cent, yielding a great flexibility in supply, especially for jobs needing short training periods.
18. There is not much use for supply forecasts in general, due to these circumstances. These forecasts can be restricted to a relatively small number of broad educational levels. This is not true, however, for the highest levels. In the first place, they represent human capital with a long "gestation period", where changes in input may reflect output only after several years. In addition, at these levels, i.e., the university-graduate levels, the flexibility tends to become less. Physicists and certain types of engineers, or graduates of economics and law, may be able to replace each other within certain limits. Physicians, however, could not easily be employed outside their field of study.
19. In developed countries with a well established educational system, forecasts can be based on that system. From school statistics, drop-out rates can be computed for each school type and also for "transition probabilities," indicating how the stream of "leavers" will be distributed over the available range of possibilities for continued education, including the exit into the labour force. These co-efficients cannot be applied immediately to future cohorts of entrants. In almost all countries, there is a growing interest in continued education, manifesting itself in rising transition probabilities for the corresponding school types. Such tendencies have to be extrapolated. Sudden changes may occur, caused by a lengthening of the period of compulsory education or by improving grant and scholarship programmes intended to overcome financial barriers. Even vocational guidance programmes may influence the size of various flows. But here, too, further research is needed as changes occur from time to time, for instance, in the distribution of freshmen among various faculties, which cannot be explained on economic grounds. The increasing rates of participation in advanced education evoke another problem of interest to supply forecasters, viz., how long this rise can continue without reaching the limits of the

[^88]pool of ability. This problem has recently attracted the attention of psychologists and economists, and the tentative conclusion seems to be that even the most highly developed countries have not yet reached such boundaries. ${ }^{14}$
20. In developing countries, the supply problem is still much more complicated, as the educational system itself usually has to be built up in the course of the development process. Here, only very crude guesses are possible, and great care has to be taken to avoid bottlenecks. The teacher problem, a particularly serious one in every growing economy, may become a real stumbling block. Recently, an interesting effort has been made to develop a model, which can be used to explore the possibilities for balanced growth of the stocks of persons at different levels of education and with the required number of teachers in a rapidly growing economy. ${ }^{15}$

## IV. Some results

21. A considerable amount of material has been published on the subject of forecasting employment in general, and by professions in particular; it will, therefore, be possible to mention only a few of the most important sources.
22. Among the developed countries, France and Sweden have done probably the most comprehensive job. In France, this is done in connexion with the four-year plans, by one of the so-called horizontal commissions attached to it, viz., la Commission de la main-d'œuvre, working under the auspices of the Commissariat général au plan.
23. In Sweden, a special labour-market forecasting unit has been set up in the Ministry of Social Affairs and Labour, working on supply and demand forecasts for a large number of professions. Its main purpose is to supply information for vocational guidance work and educational planning. ${ }^{16}$ Sweden has developed a very active labour market policy, aimed mainly at a highly flexible labour supply; reliable, detailed employment forecasts are considered to be an indispensable tool in this respect.

[^89]24. In other countries belonging to this group, work has been done on a more restricted level, ustally with emphasis on either supply or demand for academically trained labour (engineers, medical doctors, sometimes even all graduates). This is the case in the United States of America, Denmark, Great Britain, the Netherlands and Norway. Sometimes these studies are made by public bodies or governmental committees; sometimes they are made also on a private basis in the United States. ${ }^{17}$
25. In developing countries, a considerable amount of work has been done, as most development plans contain more or less elaborate forecasts of their consequences for the labour market. As a typical example, the Turkish plan may be mentioned. ${ }^{18,19}$
26. International organizations have also been active in the field. In particular, the O.E.C.D. in Paris has strongly stimulated theoretical and practical work in recent years, mainly in an effort to support the development of education as one of the most important factors conducive to growth. Various publications bearing on this part of the organization's activities have been mentioned among the footnote references.
27. We shall end this paper with a few details of the manpower forecasts underlying the fourth French plan, covering the period $1962-1965,{ }^{20}$ as it is typical of the work done so far-in its strong points, as well as in its weaknesses. One of the strong points of the fourth French plan forecast is that it is complete; it refers to the demand for all types of labour, and makes an effort to match this demand with the predicted total supply. In fact, the annual growth rate of gross national product of 5 per cent has been chosen from several alternatives, because it was felt that this level had to be reached in order to absorb the total labour supply. On this basis, the Commissariat worked out a consistent set of sector forecasts for production and employment, along the lines indicated in part II, deriving productivity estimates from trend projections. For agriculture, a constant decline of employ-

[^90]ment was assumed. The sector estimates were submitted to the (vertical) sector commissions, which generally confirmed the results. This, however, probably shows no more than that these numerous experts could contribute very little new information to the complicated problem of the sectoral production functions.
28. The final demand for special types of services (physicians, dentists, nurses, social workers) is based largely on the opinions of the ministries involved; there is no indication of more elaborate market analyses having been conducted, except, however, of the demand for engineers. ${ }^{21}$ It is done on a sector basis, mainly by extrapolating ratios of engineers to total labour force, and partly by using expert information.

[^91]29. The translation of manpower requirements into skill levels has been performed in two steps. First, professions were classified into seven groups, viz, engineers, other top executives, technicians and draftsmen, foremen and supervisors, clerical staff, skilled and nonskilled operatives. Use was made of the results of special statistical investigations in 1952 and 1957, as well as of a survey based on a questionnaire. Finally, the results were transformed into six skill levels, corresponding to different periods of secondary and higher education, based on extremely crude guesses.
30. This description shows clearly that even in the case of a highly developed country, sufficient basis data, statistical as well as theoretical, are still lacking, and that much remains to be done in order to develop employment forecasting by professions into a reliable tool.

# Forecasting school enrollment 

## Meyer Zitter

## I. Introduction

1. In the recent surge of interest in projections of population and other demographic phenomena, school enrollment projections have received only secondary attention from demographers. However, there has been no dearth of requests for such projections. In the United States of America, interest in techniques of developing enrollment projections was heightened by the upsurge in the birth rate immediately following World War II and its effect as various waves of the baby boom progressed through the school system. Interest has more recently been centred on the impact on college enrollment, since babies born in the first years of the postwar baby boom are now on the threshhold of college age. The significance of enrollment projections has been reinforced by concern for the changing skills demanded by a highly complex industrial society. The recognition of the close relationship between education and economic well-being for individuals and countries has spurred interest in the subject on a greater, international scale.

## II. Review of methods in use

2. A review of material relating to future school enrollment suggests that most enrollment projections have been developed by generally similar methods; that the techniques lend themselves to a variety of manipulation yielding multiple results; and that only a limited number of variables has been considered in such projections. New or experimental approaches have not been readily forthcoming, although some new thinking is now being devoted to the subject. On the other hand, for some countries and some levels of education (for example, projecting elementary enrollment in the United States), the need for new tools of prediction is small, since the factors affecting school enrollment are limited, are generally known, and should be subject to predictions within narrow bounds.
3. The methods in use appear to fall into two general categories: (a) methods in which
the ratios of enrollment to population (enrollment rates) are projected to future dates and applied to existing, or especially derived, population figures in the appropriate ages for corresponding dates; and (b) methods in which enrollment by grade is carried forward grade by grade successively to the next higher grade using assumed rates of progression based on past experience. It is further assumed that entry into the school system occurs only (or mainly) at the entrance level (grade one). Separate projections for grade one are derived from the estimated number becoming old enough to enter school for the first time.
4. For the basic mechanics of these methods, Jacoby's report' prepared for UNESCO is of special interest. ${ }^{1}$ A bibliography on the subject of methods of projecting the school-age population has also been prepared by UNESCO. ${ }^{2}$ The key elements of present practices for projecting the percentage of each age group enrolled in school are summarized there as (a) continuation of past trends; (b) adoption of a level of school enrollment to be achieved by a certain date in the future, as a result of, say, an economic development plan; (c) maintenance of a constant level of school enrollment ratios, or achieving by a certain target date a ratio achieved by other countries; and (d) use of school survival ratios, that is, the proportion of children remaining in school that progresses from grade to grade.

## III. Evaluation of projections

5. Lacking a comprehensive analysis of all enrollment projection reports, one can only speculate that the record of successful prediction, as in other areas of projection, leaves

[^92]much room for improvement. As illustrative of the differences between projected enrollment and observed values, a review of such projections was made for the United States from reports published by the U.S. Bureau of the Census in the past two decades. Recognizing that not all of the differences between projected and observed values represent "errors" in projections or in methods, and, in fact, that some of the differences can be attributed to the lack of comparability among the several base series involved in the enrollment projections, nevertheless, such comparisons serve to identify the general magnitude of the problem.
6. Comparisons between projected and observed values are given in tables 1 and $2 .{ }^{3}$ Briefly, it appears that in the United States, total enrollment in elementary and high school combined was projected with a fair degree of success. Projections for elementary and high schools, separately, however, differed substantially from observed values, even in the short run. Differences between projected and observed values were particularly large in high school. Improvements in the projections, by level, are noted as we move from the earliest projections to more recent ones prepared in 1961.
7. Projections by individual grades differ substantially from the observed values even in the short run. The large differences between the projected grade distributions for 1949-1950 and the distribution from the 1950 census are particularly noteworthy because of the short time lag between the time the projections were prepared (1948-1949) and the 1950 census date. These extremely large differences that occur could have come about from inconsistencies between the basic distribution used to project the grade enrollment (based generally on statistical reporting systems) versus distributions obtained in the census from household interviews. That the problem of projecting adequate enrollment by grade had not been resolved is attested to by the fact that the latest enrollment projections prepared by the

[^93]Census Bureau in 1961 did not include projections by grade.
8. The problem of developing enroliment projections that will correspond closely to observed values is further aggravated as changes in the school systems occur. Thus in the United States, shifts in school system organizations, as well as the incorporation of kindergarten into the regular school system, probably had impact on the relative "accuracy" of past projections. In the future, trends in ungraded classes, as well as the establishment of "junior colleges," in the United States, will add more elements of uncertainty to enrollment projections.
9. The assumption here that the effectiveness of past projections lies in the extent to which the projections parallel observed values is, of course, not always valid. There will be instances where projections are used primarily to predict what the situation would be under the continuation of present policies, representing the kind of situation responsible offices want to prevent, and consequently steps are taken to prevent the projected outcome. Under such circumstances, different measures of effectiveness would be needed.

## IV. New methodological tools

10. The continued interest and need for enrollment projections have led to some experimentation in the United States in ways of improving such projections. One recent study pursued the notion of basing future enrollment rates of college-age groups on the educational attainment of the fathers. ${ }^{4}$ The essence of this procedure presupposes that data on educational status of fathers are readily available, easily predicted for the future, and have a casual relationship with enrollment rates of offspring. Recent reports by the U.S. Bureau of the Census on intergenerational education changes now provide much useful data for further exploration along these lines. ${ }^{5}$
11. Another approach involves the use of surveys for gathering information on college plans of youths, similar, for example, to surveys on consumer-buying plans, or on num-

[^94]ber of children planned. In a recent study, high school seniors were asked to report their intentions of attending college. ${ }^{6}$ Follow-up studies from the same group of individuals have also been conducted to measure characteristics associated with "successful planners". The potential of such intention surveys for shortterm enrollment projections is still to be more fully developed.
12. A recent report by Stockwell and Nam illustrates the application of life table techniques to data on school enrollment. ${ }^{7}$ The school life tables show the joint effects of deaths and separations (school dropouts) on school attendance patterns. The tables are based on the enrollment experience in the United States for the 1950-1952 and 1957-1959 periods. As such, of course, they would be of limited immediate use in many areas of the world. The underlying purpose is of interest, however, and may form the basis for developing a variety of school life table models applicable to a wide range of enrollment conditions. School life tables may join other "secondary" life tables, such as working life tables, nuptiality tables, as important tools in demographic research.

## V. Problems in relation to economic DEVELOPMENT

13. A change in the size and age structure of the population, as well as the large percentage of young persons attending school, have resulted in striking increases in enrollment in the United States over the past few decades. In the decade ahead, large increases in enrollment are to be expected in many areas of the world, at least on the basis of higher enrollment rates. The task of preparing adequate projections will obviously be complicated in many areas by the general lack of adequate data, by current low levels of enrollment, and substantial variations in enrollment practices between cities, villages, and rural areas. The introduction of compulsory education to specific school ages will, of course, have

[^95]tremendous impact, both in the short- and in the long-run, on enrollment rates and levels.
14. There are no unique solutions to offer under these circumstances. The procedures available, described earlier, offer some means of deriving approximate results. There is, of course, a need for initiating programmes which would provide basic population, vital statistics, and enrollment data, on a continuing basis. Sample surveys and registration systems, in particular, should be exploited to the fullest extent possible within the resources available. Statistical by-products of administrative procedures and records often offer inexpensive but fruitful sources of data.
15. In spite of the problems described earlier, enrollment projections, by level and by grade, are desirable goals to be sought in enrollment projection studies. Since the majority of children may spend only one year in a grade, projected annual increases, grade by grade, would demonstrate the diffusive effect in later years of unusual changes brought about by sharp changes in the annual level of births and birth rates, or by policy changes affecting initial enrollment, ${ }^{8}$ such as change in minimum permissible entrance age, or in compulsory age.
16. In considering the underlying factors that will determine the pattern of change in future enrollment rates, the competing requirements of other activities at the various schoolage levels need also be taken into account. The need for gainful employment, changing marital status, and perhaps even military requirements, are factors which can affect the propensity of children and youths to enroll in school. The broadening of educational opportunities and the incentives for education, either personal or government-directed, will have appreciable effect on other phases of planning. Those directly concerned with labour force needs will find changing enrollment rates of considerable importance in trying to measure future supply and demand of jobs and manpower. ${ }^{9}$ The number of new entrants into the labour force will be particularly affected by changes in educational policy. Aside from gross entrants, there will also be significant changes in the labour force mix, that is, in the skills and occupations. Thus, enrollment-projection stu-

[^96]dies is only one important phase to be considered, in conjunction with other aspects of
the population, in making any meaningful, longrange economic development plans.

Table 1. Per cent deviation of projections from observed figures: for the United States by grade
(Plus sign $(+)$ denotes projections are higher than observed; minus sign ( - ) denotes that they are lower)

| Grado | Elementary |  |  | High school |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Series P-25, no. 18 |  |  | Series P-25, no. 18 |  |  |
|  | 1949-1950 | 1959.1960 |  | 1949-1950 | 1959-1960 |  |
| Total | $+4.83$ | -9.95 | $+3.04$ | -3.52 | -15.75 | $-5.55$ |
| 1.......... | +33.11 | -13.50 | $+27.88$ | $+1.04$ | -12.88 | -0.08 |
| 2 | +11.21 | -20.56 | $+4.38$ | -3.01 | -10.98 | +1.26 |
| 3.......... | +6.03 | -14.27 | +5.01 | +2.69 | -15.56 | -7.69 |
| 4........... | $+5.59$ | $-4.64$ | +5.91 | -14.26 | -24.38 | $-17.05$ |
| 5........... | +2.85 | -1.06 | $+0.54$ | - | - | - |
| 6........... | $-6.70$ | $-0.40$ | $-0.17$ | - | - | - |
| 7. | -7.36 | -8.00 | $-12.49$ | - | - | - |
| 8. | -21.31 | $-15.75$ | -12.84 | - | - | - |

Sources: enrollment projections from the United States Bureau of the Census, Current Population Reports, series P-25, nos. 18 and 85 (series A and B ). "Observed" figures used as bases for comparison are from the 1950 and 1960 Censuses of Population.

Table 2. Per cent deviation of projections from observed figures: for the United States by level (Plus sign $(+)$ denotes projections are higher than observed; minus sign ( - ) denotes that they are lower)

| School year |  | Series P-25, \%o.18(1949) |  |  | Series $P$ 25,*o. 85 (1953) |  |  | Series P-25.no. 232 (1961) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Total | Elementary | High school | Totay | Elementary | High school | Total | Elewentary | High <br> school |
|  |  |  |  |  |  |  | ; |  |  |  |
| 1948-1949 |  | +3.08 | +4.45 | $-1.82$ | - | $\cdots$ | - | - | $\cdots$ | - |
| 1949-1950 |  | 1.2 .47 | $+5.27$ | $-5.91$ | - | $\cdots$ | - | - | -mome | $\cdots$ |
| 1950-1951 |  | $+1.04$ | $+4.49$ | $-9.56$ | - | - | - | - | - | - |
| 1951.1953 | ....*** | +1.23 | $\pm 5.08$ | $-10.75$ | $\cdots$ | $\square$ | $\cdots$ | - | $\cdots$ | $\underline{\square}$ |
| $1952 \cdot 1953$ |  | 41.79 | $+6.79$ | $-13.69$ | $\cdots$ | - | $\square$ | $\cdots$ | $\cdots$ | $\because$ |
| $1953-1954$ |  | $+2.09$ | $\pm 7.03$ | -13.65 | $-0.70$ | 4049 | -4.46 | - | - | $\cdots$ |
| $1954 \times 1955$ |  | $+0.14$ | +5.58 | $-17.03$ | $-0.70$ | $+0.49$ | -4.46 | - | - | - |
| $1955-1956$ |  | $-1.06$ | $+3.68$ | $-16.20$ | $-0.38$ | 40.95 | $-4.61$ | $\cdots$ | $\cdots$ | - |
| $1956-1957$ |  | 1.290 -500 | $\pm 1.62$ | -16.77 | $-0.26$ | 42.15 | -7.63 | - | - | - |
| 1957-1958 |  | $-5.80$ | -2.57 | $-15.64$ | $-0.50$ | $+1.68$ | $-7.13$ | $\square$ | - | $\square$ |
| 1958-1959 |  | --9.50 | $-7.18$ | $-16.83$ | -0.34 | $+1.85$ | $-7.65$ | $\square$ | - | - |
| 1959.1960 |  | $-12.38$ | $-11.62$ | -15.54 | $-0.45$ | +1.14 | $-5.31$ | -m | - | - |
| 1960-1961 |  | - | -- | - | $-1.55$ | $+0.66$ | $-8.07$ | +0.38 | $+0.25$ | +078 |
| 1961-1962 |  | $\cdots$ | $\cdots$ | $\longrightarrow$ | $-1.61$ | +0.99 | $-9.92$ | $+0.38$ | $+0.25$ | $+0.78$ |
| 1962-1963 |  | $\cdots$ | $\ldots$ | - | --0.51 | $+2.06$ | $-7.36$ | $+2.60$ | $+2.51$ | +2.83 |
| 1963 -1964 |  | - | - | $\cdots$ | $-2.03$ | $+0.87$ | $-9.32$ | $+2.28$ | $+2.73$ | $+1.09$ |

Sovrces: enrollment projections fron United States Bureau, of the Census, Current Population Reports, series Pr 25 , nos. 18, 85 (series A and B), and 232 (series IL-A), "Observed" figures used as bases for comparison are from results of annual supplement to Current Population Survey, as published in Curent Population Reports, series P. 20 (vations issues).

## SUMMARIES OF PAPERS

# A projection of the Austrian labour force until 1980 

Harald Hansluwka

In this paper, problems of projection of Austrian labour force until 1980 are discussed. It is pointed out that the social legislation now under way makes it extremely difficult to make a sound appraisal of the future course of activity rates for certain population groups affected by the legislative measures.

As a matter of convenience for the purpose of projection, the economically active population was divided into two groups, one for which reasonable assumptions can be made; the other one is a rather heterogeneous group, for which assumptions are subject to substantial mistakes.

A basis for the projection was the forecast of the total population by sex and age, assuming constant age-specific fertility and mortality rates for 1959-1961 (and excluding migration).

The results show that in contrast to a steadily growing total population, the number of the economically active population will decrease until 1970 and then raise and by 1980 approach the level of 1961. Efforts for expanding the economy may, therefore, be impaired unless reserves (above all married women) can be brought into the labour force. Of other possible alternatives, it may be mentioned that measures of rationalization may compensate for the-on the whole-stagnating labour force.

A short analysis tries to define the limits within which these results are conclusive. It is shown that the demographic assumptions of constancy, though they may be regarded as pessimistic, have little influence on the trend and volume of the labour force. However, some assumptions as to the course of activity rates are open to criticism, although existing evidence makes it likely that the direction was correctly appraised.

## Notes on the methods of the manpower projections

## Adam Józefowicz

The paper presents short comments on methods adopted and results obtained when
estimating the future manpower resources in Poland on the basis of the last population census.

In an attempt to establish the influence of population changes on future labour force supply due consideration should be given to both primary (number of survivors in working age) and secondary (assumed family patterns) demographic factors.

The projections of the future number of the able-bodies "exposed to the risk of entering the labour market" is carried out by deducting from the total adult population all the categories of people institutionally unfit for civilian employment. The gross supply of civilian manpower resources thus obtained has been, in turn, broken up into three main subdivisions:
(a) Economically active population;
(b) Non-economically occupied (students in full-time education, women with household responsibilities) ;
(c) Idle population without any occupation.

It is in the case of the second potential source of the manpower that the difficulty of reliable evaluation of the future changes in labour force participation rates comes in.

Another set of estimates has been made according to the above procedure in order toestablish the impact of projected raising of educational standard as well as expected changes in marital and family conditions on. age-specific activity rates of female population. Selected statistical illustrations are listed in five tables.

## Projections of families in Hungary : method and some preliminary results

József Tamásy

The life cycle of families is influenced by many different factors, therefore, the projection of families is a complex task. However, as a first step, using a simplified method of projections, some results of experimental computations are presented here.

The paper is based on two hypotheses: (a) that the distribution of the population by marital status in the different sex and age
groups will remain approximately the same during the period of projection, i.e., 1960-1981; and (b) that the proportion of the heads of family will remain unchanged within different sex and age groups as well as marital status. By comparing the 1960 number of the heads of family, detailed by sex, age-group and marital status, with the number of the population of the corresponding sex, age and marital status, the sex-specific, age-specific, and mar-ital-status specific headship rates have been obtained. Using these rates, we have computed the number of the heads of family of the projected population by sex and 5 -year age groups.

The examination of the series of the average family size and the pertaining percentage distribution by the number of family members in a regional breakdown of 1949, 1960 and 1963 have shown that the distribution is (approximately) determined by the average. On this basis-as the first variant-the solution that the corresponding distribution is assigned to the projected average family size from the mentioned series seemed acceptable.

According to the results of the projection, the disintegration of the families is continuing. Between 1960 and 1981 the average family size decreases from 3.26 to 2.91 , i.e., by somewhat more than 10 per cent. A considerable increase, amounting to about 26 per cent, may be expected in the number of single persons. The proportion of the two-member families will gradually increase (from 35 per cent to 44 per cent). The proportion of the three-member families will show a certain stabilization about 31-32 per cent already in 1966. The proportion of the four-member families decreases at a slower pace, that of the larger families quicker and to a greater extent.

Finally, the paper studies the additional variants of projections.

Some problems in projecting the economically active population

V. R. K. Tilak

Projection of economically active population is basic to manpower planning. It assumes special importance in developing countries where employment targets are determined in relation to the net additions to the labour market during a given period. The projection refers not only to the future size of economically active population but also to its composition. Given the population projection, the size of economically active population will depend on the activity rates anticipated. These rates could be applied in a variety of ways depending on the detail in which population projection and activity rates are worked out, but in a number of developing countries the range of application is rather limited owing to lack of adequate data. Illustrations of the projections made in Philippines, India, Ceylon and a few other countries have indicated that due to lack of data on past trends in regard to activity rates these rates were assumed to remain constant for the next 15 or 20 years. There is considerable scope for improving the techniques used in these countries in projecting the economically active population. A firm analysis of past trends in activity rates is the first step, as model activity rates do not fit into the realities of the situation obtaining in a country. Other aspects requiring attention include the projections of rural-urban population, schoolgoing population, development of a suitable classification system according to industry, occupation and education and a periodical review of the projections with the help of sample surveys during the inter-censal period designed to permit comparability and provide a link between the past and the future censuses.

# METHODS OF OBTAINING BASIC DEMOGRAPHIC MEASURES WHERE DATA ARE LACKING OR DEFECTIVE 

## PAPERS


#### Abstract

A method of estimating demographic rates in areas without census and vital statistics: experimental surveys carried out in Guanabara (Brazil) and Cauquenes (Chile)


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[Translated from Spanish]

1. The Governments of the developing countries urgently require more and better basic statistics with which to form an objective picture of their social and economic situation and thus to formulate their development programmes as efficiently as possible.
2. The most important of the basic statistics are those relating to demographic characteristics. With a proper knowledge of the changes in population structure and size, the necessary estimates can be made for planning economic development.
3. The traditional sources of demographic statistics, viz, population censuses and civil registers, which were originally intended to serve other purposes, have not hitherto yielded adequate information from the standpoint of quantity, quality and flexibility-for the preparation of such estimates. Censuses are major operations carried out at about ten-year intervals only and consequently they shed no light on the annual evolution of demographic variables such as mortality, migrations, etc., which must be taken into account in the formulation of health and social assistance programmes in general. Nevertheless, censuses are a valuable second best source of information for analysing many demographic, economic and social problems in the countries of Latin America. On the other hand, data obtainable from the civil registers in the under-developed countries are usually marred by errors of omission which are difficult or even impossible to correct.
4. This situation in regard to demographic statistics in the countries of Latin America has
led to the adoption of sample surveys as a means not only of remedying the shortcomings of the basic statistics now available but also of carrying out special studies which cannot be done in any other way.
5. This paper describes a method of determining demographic rates by sample surveys. The method was tried out in a typically urban area, the State of Guanabara, consisting chiefly of the city of Rio de Janeiro (Brazil), and it is now in use in another area with predominantly rural characteristics, namely the departments of Cauquenes and Chanco in the province of Maule (Chile). The following aspects of the method are briefly described below: I, analytical basis; II, application; III, estimated cost of a hypothetical survey.

## I. Analytical basis

6. In the final report on the Guanabara Survey ${ }^{1}$ the type of form used in the survey is shown in an annex. It seems unnecessary therefore to enter into a full description of it here and only its more important features will be discussed. The general or crude death rate will be used to illustrate and explain the method, which can be applied also to other crude age-specific rates.
7. According to the Multilingual Demographic Dictionary, ${ }^{2}$ "the crude death rate or

[^97]general death rate ... is generally an annual rate and consists of the ratio of the annual number of deaths occurring during a calendar year to the number exposed to the risk of dying during the same period". This may be expressed by the equation:
\[

$$
\begin{equation*}
m(a, a+1)=\frac{D(a, a+1)}{P(a, a+1)} \tag{1}
\end{equation*}
$$

\]

where: $m(a, a+1)$ represents the annual crude death rate:
$D(a, a+1)$ represents the number of deaths occurring in a calendar year; and
$P(a, a+1)$ represents the mean population.
8. Equation (1) can be generalized for observation periods other than a year. For this purpose, it is necessary to introduce the concept of a mean annual number of deaths and to define the concept of the mean population. Let $a$ and $b$ be any two times measured in terms of a year, where $b$ is subsequent to $a,(b>a)$, and $D(a, b)$ is the number of deaths occurring between $a$ and $b$. Then, the ratio $\frac{D(a, b)}{b-a}$ represents the mean annual number of deaths, assuming that the number of deaths is proportional to time.
9. Again, let $P(t)$, the population at time $t$, be a continuous function of time ( $t$ ). Its mean value between times $a$ and $b$ is given by the equation:

$$
P(a, b)=\frac{{ }^{0} \int^{b} P(t) d t}{b-a}
$$

The numerator ${ }_{a} f^{b} P(t) d t$ represents the time lived, between $a$ and $b$, by the individual members of a population, or in other words, the population-year. When $b-a=1$, the time lived is equivalent to the mean population. Substituting these concepts, equation (1) now becomes:

$$
\begin{equation*}
m(a, a+1)=\frac{D(a, a+1)}{(a+1)-a}: \frac{f^{a+1} P(t) d t}{(a+1)-a} \tag{2}
\end{equation*}
$$

and generalizing, the annual proportional crude death rate can be defined as:

$$
\begin{equation*}
m(a, b)=\frac{D(a, b)}{b-a}: \frac{f^{b} P(t) d t}{b-a} \tag{3}
\end{equation*}
$$

where, by cancelling $(b-a)$, we get:

$$
\begin{equation*}
m(a, b)=\frac{D(a, b)}{{ }_{a}^{b} P(t) d t} \tag{4}
\end{equation*}
$$

which, like equation (1), is an annual death rate.

It will be observed that the deaths occurring between $a$ and $b$ appear in the numerator and the time lived by the population during that period, appears in the denominator. The period ( $a, b$ ) is limited by any two times $a$ and $b$, such that $b$ is subsequent to $a(b>a)$. It may therefore be greater than, equal to or less than one year: $(b-a) \geqq 1$.
10. In equation (4), the denominator is the time lived by the population, i.e., the sum total of time lived by all the individuals. Equation (4) then shows the death rate as the ratio of the number of deaths occurring to the total time lived by the individuals in a given period. The concept of the proportional annual crude death rate can also be generalized in regard to the time lived by each individual in that period. We can now consider the possibility of computing the total time lived by various individuals in different periods and in different places, while noting the number of deaths occurring among the individuals covered. The ratio of the number of deaths to the total time lived by the individuals represents the proportional annual crude death rate. Consequently, the generalized form of the equation shows that the proportional annual crude death rate does not depend on the periods of observation of individuals being uniform: they can vary in length and be referred to different epochs.
11. When the denominator includes the total time lived by all individuals with common characteristics, for example, those belonging to the same sex, a given age group or a given socio-economic sub-group and the numerator includes the number of deaths occurring among those individuals, we obtain specific death rates by sex, age, socio-economic level or other distinguishing characteristic of the particular subgroup.
12. The same considerations apply in computing specific death rates as in computing the crude death rate. The generalized equation (4) is also applicable to specific rates. Thus, the time during which an individual is under observation can be divided into several periods corresponding to times lived under different conditions. For example, an individual may come under observation at age $x$ and during the period of study he may reach the age $x+1$. This change in the age condition is comparable to a migratory movement in which the individual emigrates from the group of persons aged $x$ to join another group aged $x+1$. Thus, other changes may come about in the socio-economic, marital and other conditions on which the specific death rate is based. Each change may be treated as a
migratory movement, as in the case of age. Then, in order to compute a specific death rate such as, for example, the proportional annual death rate of middle-class (previously defined) married women aged 29 years, we will include in the numerator the number of deaths occurring among women fulfilling those conditions, provided that the deaths occur while the women are in that sub-group; and in the denominator, we will put the sum of the time lived by middle-class married women aged 29 years.
13. The method employed in Guanabara and Cauquenes to determine demographic rates uses equation (4) directly in its generalized form, i.e., computations are based on observations carried out at different periods of the year, not necessarily the same periods for all individuals. A population or, more accurately, a sample of individuals is selected for the purpose and their particulars are taken down at a first interview. They are considered to be under observation from the moment of enumeration. During a certain period, which may be other than one year, several successive interviews are carried out for the purpose of noting deaths (or other events to be investigated) which may occur among the individuals covered. The number of such deaths $D(a, b)$ constitutes the numerator of the proportional annual crude death rate, while the sum total of the time lived by all individuals during the period of observation goes into the denominator.
14. Although so far the death rate has been used as an illustrative example, this explanation of the method can be easily extended to cover the computation of other demographic rates or any other kind of rates. Generally speaking, the method can be used to measure changes occurring in the social, economic, demographic or biological conditions of individuals.

## II. Application of the method

15. For practical reasons, a selected sample rather than the entire population of an area is kept under observation. The problem of the sample's design must be solved in a manner compatible with the statistical requirements and fundamental aspects of the method as described hereunder.
16. In describing the chief aspects, we must consider the method in its widest application, i.e., we must bear in mind that it can be applied to determine various types of rates which can be investigated simultaneously in the same survey.
17. The essence of the method lies in a basic principle with important practical con-
sequences which are analysed below. The principle is that the events which have to be included in the numerators of the ratios are those which occur among the persons under observation during the period of observation. It is necessary to define very carefully what is meant by "persons under observation" and "period of observation". The persons surveyed or under observation are those who (a) have been enumerated or registered at a first interview (the date of which is not uniform for all) ; and (b) reside within the selected area (in Guanabara and Cauquenes, the dwelling was taken as the point of reference for the person covered). Every individual must fulfil both these conditions in order to be considered under observation. The period of observation is peculiar to each individual: it begins at the moment when he is registered at a first interview and ends when he ceases to reside in the area, as a result of emigration or death, or because the date of the last visit to the individuals under observation marked the end of the survey.
18. This principle meets the requirement that the information obtained should be of high quality as regards integrity and accuracy. This can be achieved if the recording of events under investigation is confined to those which occur, among the persons under observation, during the relatively short periods (less than one year) between two successive interviews in which case the possibilities of mistakes due to memory are practically eliminated. Furthermore, each visit provides an opportunity to improve the information which, for various reasons, may have been incompletely or wrongly recorded during the previous visits. Noting the exact date on which the events occur is of fundamental importance for computing the denominators of specific ratios. As was stated above, the change in a particular condition of the individual marks the end of the time lived in that condition and probably the beginning of the time lived in a new condition.
19. The immediate practical consequence that follows from the adoption of the abovementioned principle is the need to keep a large population under observation so that lowfrequency events may attain real and stable values. If, as has been said, the recording of deaths, for example, is confined to those which occur during the period of observation of each individual, in order that the death rate of children aged between ten and fourteen years may have a value not significantly different from the expected value, a large number of children of those ages will have to be kept under observation. In the Guanabara survey, a
satisfactory value was obtained for the crude death rate with a total of 6,750 persons-year, but the results for rates by age were not so stable. In the survey now being carried out in Cauquenes, one third of the total population of the area was selected, i.e., about 18,000 persons. This could be taken to mean 18,000 persons-year if the interviews are held in a calendar year, thereby imparting stability to the rates by large age groups.
20. The disadvantages of having to survey a large number of persons are offset by the better quality of the data collected and by more rewarding sample designs, e.g., cluster samples.
21. Where a large number of persons is covered, the collection of data likewise necessitates the use of a short, easy-to-handle questionnaire, designed to facilitate the mechanical processing of vast amounts of data and for this purpose pre-coded questionnaires can be employed. The design of a census form along these lines will help to make interviews relatively short. In the Guanabara and Cauquenes surveys, the net average duration of interviews (excluding travel time) was about fifteen minutes.
22. It must be pointed out that the mechanical processing of data offers advantages as regards both the quality of the results and the speed with which they are obtained. In the Guanabara survey, the results were avail-
able ten days after the field work had been completed.
23. Finally, if a short, pre-codified, easy-tohandle questionnaire is adopted people with educational qualifications similar to those of census enumerators can be employed as interviewers and can therefore be found in any part of a country.

## III. Estimated cost of a hypothetical survey

24. One objection which will probably be raised against an operation like the one described is that the cost of repeatedly interviewing a very large population may be prohibitive and beyond the limited resources and the under-developed countries. The Guanabara and the Cauquenes experiments have shown, however, that the costs of field operations are low in comparison with those of other surveys. We thought it would be of interest to offer, by way of illustration, an estimate of the cost of field work for a hypothetical survey carried out under the same conditions as in the surveys already mentioned. It should be noted that the analysis covers only the cost of field work, i.e., the work which has a direct bearing on the method. Consequently, other items of expenditure such as advisory services, mechanical processing of data, administrative and other costs, which are of the same orders of magnitude in all surveys, have been excluded.

Statistics of the hypothetical population to be surveved

| Number of individuals to be covered |  |  | 20,000 |
| :---: | :---: | :---: | :---: |
| Number of dwellings to be covered. <br> (Urban dwellings: 1,500 ) <br> (Rural dwellings: 2,500) |  |  | 4,000 |
| Number of interviews (four per selected dwelling) in one year. <br> Net mean duration (excluding travel time) per interview $\square$ |  |  | $\begin{array}{r} 16,000 \\ \text { minutes } \end{array}$ |
| Cost of feld work |  |  |  |
|  | Total number of intertiews | Cost per interview | $\begin{aligned} & \text { Total } \\ & \text { cost } \end{aligned}$ |
| Four interviews at 1,500 urban dwellings. . <br> Four interviews at 2,500 rural dwellings. . |  | $U_{\text {tita }}$ | tes dollars |
|  |  | 0.15 | 990.00 |
|  |  | 0.30 | 3,000.00 |
| Cost of supervising field work. |  | crviews | 3,900.00 |
|  |  |  | 1,100.00 |
|  |  | WORK | 5,000.00 |

25. The result obtained, although derived from a hypothetical population, can be regarded as sufficiently realistic, since it is based on the Guanabara and Cauquenes experiments. The small figure of $\$ 5,000$ is not surprising if we bear in mind that surveys based on the method here described bear a greater similarity to a census operation than to other sample surveys.
26. Taking the above estimates as approximate but realistic, we must stress the important fact that for an outlay of $\$ 5,000$ on field work
it is possible to obtain rates of satisfactory quality and various specifications for a population of 20,000 persons observed during one calendar year where census and civil registry data are not available. Furthermore, by this procedure other non-demographic data, e.g., school attendance rates, morbidity rates, income distribution, structure of consumption and so forth, can be obtained more readily and cheaply than would be feasible by other methods and they are of higher quality.

# Use of sample surveys to obtain data on age structure of the population where respondents in a regular census enumeration cannot give accurate data: some Kenya experiments 

J. G. C. Blacker

1. The difficulties experienced in obtaining accurate statistics of the age distributions of populations in developing countries have frequently led to the assertion that the inhabitants of these countries do not know their ages. This generalization, however, requires an important qualification: the ignorance so frequently cited is an ignorance of age according to the western method of reckoning; and, although the western method may appear to be the most logical, numerous other methods of age reckoning are to be found the world over. ${ }^{1}$
2. In Africa ignorance of age in the western sense is certainly widespread. Yet it is also true to say that many Africans are more acutely conscious of age, according to their indigenous methods of reckoning, than are most westerners; for in Africa age tends to be associated with status in a way unknown in western society. For example, among the Kikuyu people who inhabit the Central Region of Kenya, different words are used to denote unweaned infants, children who have learned to walk but are not yet old enough to herd goats, those who herd animals, and again older boys or girls who have not yet been circumcised. The most important differentiation is made at the time of circumcision, when the youth or girl officially passes from childhood to adulthood. Among the Kikuyu, circumcision ceremonies have been held, with occasional exceptions, every year since the First World War, and all men and women who were circumcised in the same year are regarded as belonging to the same age grade, which is denoted by a special name. No person in possession of full mental faculties could ever forget his or her age grade, since in traditional Kikuyu society it governs even the smallest details of behaviour. "The whole Kikuyu society" writes Kenyatta, "is graded by age and the prestige which accompanies a status in age-grouping.... It

[^98]determines the different salutations used, the manners people may adopt in eating certain foods, the different tasks in homestead or garden; it rules habits of dress or demeanour in the community; and it explains the rights of different people in judging cases, in exercising authority in the clan or family, in ceremonial or religious proceedings." ${ }^{2}$
3. Thus, if a person's age grade is known, together with the date when that age grade was circumcised and the average age at circumcision, then the person's age, in the western sense, could clearly be determined with a fair degree of accuracy. If, in a survey aimed at determining the age structure of the population, the enumerators were armed with conversion tables of this sort, the data collected should be substantially more accurate than would normally be obtained by the process of blind guessing which all too often characterizes such enquiries.
4. Unfortunately, however, the compilation of such conversion tables is no easy matter, principally on account of the wide variations between different localities and peoples. In East Africa there are some tribes, such as the Islamic coastal peoples or the Turkana who inhabit the deserts west of Lake Rudolph, who do not practise circumcision or any other form or rite de passage. There are some who circumcise their males but not their females. The frequency with which the ceremonies are held varies from tribe to tribe, and there are often minor variations, both in frequency and in the nomenclature of the age grades, within the same tribe. Furthermore the average age at circumcision tends to vary, not only between tribes, but also over time, and in recent decades has generally been getting progressively younger. Thus, detailed investigations in each area are needed before the conversion tables can be constructed. To attempt to compile them on a nationwide basis for use in a full-scale

[^99]census would be a task beyond the capabilities of most African census organizations; and apart from the work involved in the construction of the tables, in towns and other areas experiencing labour immigration, where every tribe in the country is represented, the enumerators would have to be equipped with massive volumes of the tables. But for small-scale sample encuiries in rural areas the method clearly has considerable potentialities.
5. In Kenya, the full census held in 1962 was followed in 1963 and 1964 by some experimental field surveys in selected areas which were designed to obtain information on fertility and mortality. ${ }^{3}$ For this purpose, accurate data on the age distributions of the base populations were clearly essential. The surveys were conducted in three areas: in Kwale District on the coast, in the Kikuyu District of Nyeri in

[^100]the Central Region, and in Bungoma District in the Western Region. In Kwale the population had no age grade system which could be converted to western reckoning and other methods of estimating age had to be used which need not be discussed here. But in both Nyeri and Bungoma detailed age grade conversion tables were drawn up.
6. In both districts the survey was conducted in two areas (sub-locations) which were selected by random sampling. In Nyeri, although the two sample areas were only some 25 miles apart, minor variations in the age grade system were found, so that a separate conversion table had to be made for each area. In Bungoma both areas fell within the Kimilili Division, inhabited by the Bukusu clan of the Luhya tribe, so that a single conversion table sufficed for both sub-locations; had the sample areas fallen in different divisions, separate tables would probably have had to be used. A section of one of the Nyeri tables is shown below by way of illustration.

| $\begin{gathered} \text { Name of age } \\ \text { grade } \end{gathered}$ | Year of. circumcision | Approximate date of birth |  | Age in 1963 |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Males | Females | Males | Femates |
| Kimiiri | 1919 | 1902 | 1905 | 61 | 58 |
| Kibandi | 1920 | 1903 | 1906 | 60 | 57 |
| Munoti | 1922 | 1904-1905 | 1907-1908 | 58.59 | 55-56 |
| Muthetha | 1924 | 1906-1907 | 1909-1910 | 56-57 | 53-54 |
| Ciringi | 1925 | 1908 | 1911 | 55 | 52 |
| Kianduma | 1926 | 1909 | 1912 | 54 | 51 |
| Ndege | 1927 | 1910 | 1913 | 53 | 50 |
| Githingithia | 1928 | 1911 | 1914 | 52 | 49 |
| Ngigi | 1929 | 1912 | 1915 | 51 | 48 |

7. It will be observed that the table is based on the assumption that boys were normally circumcised at the age of 17, and girls at 14. These rules were of course by no means inflexible, but it is to be hoped that no systematic bias was introduced. The name of the age grade generally refers to some notable event distinguishing the year of circumcision: thus, Kianduma denotes an eclipse of the sun, Ndege the first appearance of an aeroplane in Kenya, Githingithia an earthquake, and Ngigi a plague of locusts.
8. The Bukusu age grades differ from the Kikuyu in that the ceremonies are held in alternate years rather than every year. Furthermore, they refer to males only; female circumcision (clitoridectomy), although once generally practised anong the Bukusu, tended to die out about the beginning of this century. However, girls participate in the circumcision ceremonies
in that they dance with the male initiates; such girls would normally be a year or two younger than their partners, and although occasionally a girl might dance at more than one ceremony, such an occurrence would be rare. Thus in the sturvey the women's ages were estimated by asking the age grade of the men they had danced with.
9. The age-sex distributions obtained from the Births and Deaths Survey in Nyeri and Bungoma Districts are shown in the appendix to this paper. To what extent, it may be asked, can these data be regarded as more accurate than would normally be obtained in a largescale population census? Before attempting to answer this question, however, it may be as well to outline briefly the types of errors normally encountered in African census agedistributions.
10. As in all developing societies, perhaps the most immediately obvious errors are those resulting from "digital preference"-the marked heapings on ages ending on 0 and 5 , with subsidiary heapings on ages ending in 2 and 8. If the misstatements were confined to rounding of this sort, the graduation of African age distributions would be a relatively simple matter; but unfortunately, more massive and deep-seated distortions are generally also present. These errors may be summarized as follows:
(a) A general understatement of ages of older boys and young men, resulting in an inflation of the $10-14$ age group, and deficits in the late teens and twenties;
(b) A general overstatement of ages of older girls and young women; this overstatement results not only in displacements from the $10-14$ to the $15-19$ age group and from the $15-19$ to the 20-24 age groups, but also from the $20-24$ to the $25-29$ age group, so that the number of women shown as aged 25-29 are generally of the same order as, and frequently greater than, those shown as aged 20-24;
(c) A general overstatement of ages of older people, frequently beginning to have effect in the thirties, and more pronounced among males than among females.
11. The effect of these distortions can readily be seen in the trend of the sex ratios with age: ${ }^{4}$ beginning generally with a small

[^101]excess of females in the 0-4 age group, the sex ratios rise steeply, reaching a peak in the $10-14$ age group, where the excess numbers of males frequently amount to over 20 per cent they then drop sharply, and relatively large excess numbers of females, sometimes as much as 40 per cent, are recorded in the twenties and early thirties; a steady rise is then shown, generally culminating in a substantial excess of males after the age of 50 , and frequently earlier. Patterns of this kind were revealed, not only by the 1962 Census of Kenya, but also in the censuses and sample surveys of Ghana (1960), Congo (Leopoldville) (1955-1957), Guinea (1954-1955), Gabon (1960-1961), Senegal (1960-1961), Togo (1958-1960), and Upper Volta (1960-1961). ${ }^{5}$ It would appear to be a feature common to the whole of Tropical Africa.
12. To return to the Kenya Births and Deaths Survey, the extent of digital preference can readily be measured by "Whipple's Index", ${ }^{6}$ and thereby compared with the corresponding data obtained from the 1962 census, as shown in table 1.

Farrag, "Reduction of errors in census populations for statistically underdeveloped conntries", Population Studies, vol. XII, No. 3 (March 1959), pp. 258-263.
5 United Nations, Demographic Yearbook 1963 (United Nations publication, Sales No.: 64.XIII.1), table 5.
${ }^{6}$ See United Nations, Methods of Appraisal of Quality of Basic Data for Population Estimates (United Nations publications, Sales No.: 56.XIII.2), pp. 40-41. The index is calculated by "summing the age returns between 23 and 62 inclusive, and finding what percentage is born by the sum of the retarns of years ending with 0 and 5 to one fifth of the total sum".

Table 1. Whipple indices of digital preference

|  | Nyeri |  | Bungoma |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Mates | Females | Males | Females |
| Survey | 154.4 | 147.4 | 110.1 | 125.1 |
| Census | 265.8 | 265.9 | 161.9 | 168.5 |

13. The lower indices obtained from the births and deaths survey show clearly that there had been less heaping on noughts and fives than had occurred in the census returns, although the survey data for Bungoma would still only be classified as "approximate", and that for Nyeri as "rough", on the basis of the United Nations scale. ${ }^{7}$ But it does not

[^102]necessarily follow that the more serious errors of the type outlined above were also reduced. In this respect it is difficult to make an objective and quantitive assessment, since the trend in the sex ratios cannot be regarded as a wholly reliable guide: in the first place, the populations covered in the survey were relatively small, so that the sex ratios were liable to substantial random fluctuations, and secondly, they were subject to considerable distortions as a result of migration.
14. Both Nyeri and Bungoma are densely populated districts where population pressure has resulted in net emigration. The information on birthplace which was collected in the 1962 census showed that, of the total number of people who had been born in Nyeri, no less than 26 per cent were enumerated outside the district: the corresponding proportion for Bungoma was 8 per cent. The fact that the births and deaths survey was designed to cover the de jure as well as the de facto population will have partially but not wholly mitigated the influence of migration, since many people may have left the district permanently, and would no longer be regarded as being "normally resident" there. ${ }^{8}$ Thus, since men

[^103]tend to migrate more freely than women, an apparent deficit of males in the middle adult age groups may in fact represent the true situation, as well as being partly the result of age misstatement.
15. If the sex ratios of the de jure population are to be considered, no comparison can be made with the census data for the districts concerned, since the census was conducted on a de facto basis only. However, it is perhaps worth while comparing the de jure sex ratios obtained from the survey with those which the census showed for the African population of the whole of Kenya, where the net effect of migration can be regarded as negligible. This comparison, using fairly broad age groups in order to reduce the effect of random fluctuations, is shown in table 2.
viously unknown, thus precipitating a substantial permanent emigration from the district.

Table 2. Sex ratios (males per 100 females) for de jure population enumerated in Nyeri and Bungoma Districts in births and deaths survey, and total African population of Kenya as enumerated in 1962 Kenya Population Census

| Age group |  | Births and deaths survey |  | $\begin{gathered} 1962 \text { census } \\ \text { Kenya } \\ \hline \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Nyeri | Bungama |  |
| 0-9 |  | 103.1 | 95.5 | 98.4 |
| 10-14 |  | 103.5 | 104.3 | 120.0 |
| 15-19 |  | 118.7 | 102.4 | 104.6 |
| 20-29 |  | 100.0 | 84.1 | 71.6 |
| 30-39 |  | 77.0 | 87.0 | 85.3 |
| 40-49 |  | 65.3 | 75.5 | 105.2 |
| $50+$ |  | 96.7 | 106.0 | 123.6 |
|  | Total | 98.2 | 94.3 | 97.7 |

16. The results are moderately encouraging. The very heavy excess of males in the 10-14 age group shown by the Kenya census data is much reduced in both districts in the survey, and although the Nyeri figures show a 18.7 per cent excess of males in the $15-19$ age group, this can be explained, in part at least, by the presence of a large secondary school in one of the survey areas which had attracted boys in this age group from other parts of the district. ${ }^{9}$ The heavy excess of females in the 20-29 age group is substantially reduced in Bungoma, and in Nyeri the numbers of males and females are

[^104]even. As suggested above, the deficit of males shown by the survey in the $30-39$ and $40-49$ age groups may have been partially due to emigration, and the large excess of males indicated by the census among persons aged 50 and over is much reduced in the Bungoma survey, and disappears altogether in Nyeri.
17. Although the survey data are still far from perfect, we may nevertheless conclude that the technique of estimating ages which was adopted produced an appreciably more accurate age distribution than had previously been obtained. Thus, the general principle of equating the western method of age reckoning with that familiar to the population being surveyed is clearly worth pursuing and would be likely fully to repay the effort involved.

## APPENDIX

Kenya sample survey of births and deaths, 1964 de jure population enumerated in Nyeri and Bungoma districts by sex and five-year age groups

| Age group |  | Nyeri |  | Bungoma |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Males | Females | Maies | Females |
| 0-4 |  | 704 | 671 | 1,307 | 1,379 |
| 5-9 |  | 499 | 496 | 1,367 | 1,420 |
| 10-14 |  | 497 | 480 | 1,039 | 996 |
| 15-19 |  | 513 | 432 | 804 | 785 |
| 20-24 |  | 303 | 352 | 527 | 609 |
| 25-29 |  | 292 | 243 | 469 | 576 |
| 30-34 |  | 140 | 171 | 306 | 407 |
| 35-39 |  | 118 | 164 | 327 | 321 |
| 40-44 |  | 106 | 164 | 170 | 228 |
| 45-49 |  | 99 | 150 | 174 | 229 |
| 50-54 |  | 129 | 146 | 132 | 206 |
| 55-59 |  | 94 | 55 | 176 | 134 |
| 60-64 |  | 58 | 74 | 104 | 79 |
| 65-69 |  | 67 | 39 | 65 | 70 |
| $70+$ |  | 89 | 138 | 128 | 82 |
| Not stated |  | - | 2 | 2 | 1 |
|  | Total | 3,708 | 3,777 | 7,097 | 7,522 |

# The anamnestic method of studying demographic processes 

V. A. Bystrova

[Translated from Russian]

1. The newly independent countries are faced with a number of problems which require a thorough study of population and, in particular, of demographic processes. Demographic data are needed by these countries for economic development planning. Furthermore, without some knowledge of the size and structure of the population and of demographic changes, it is impossible to take the necessary steps for the provision of educational, medical and other facilities. In the countries which have recently freed themselves from colonial dependence and in which no system for the registration of demographic processes has yet been set up or is likely to be for some time, the lack of official demographic statistics can be partly remedied by means of a special method of research into demographic processes known as the anamnestic method.
2. This method has been known and used in various guises in a number of countries. It was successfully applied in several districts of the Union of Soviet Socialist Republics as early as the 1920's and has retained its scientific and practical importance to the present day. It is also used for the detailed study of demographic processes in connexion with social and economic factors.
3. In view of what has just been said, we shall attempt in this paper to describe what has been done in the field of anamnestic investigations in the Union of Soviet Socialist Republics.
4. In the first years after the Revolution, a need arose in our country for a thorough study of the demographic processes which had occurred in the past among various national groups living in former colonies of Tsarist Russia who in the pre-revolutionary period had been subjected to colonial oppression. In order to gain some idea of the population dynamics of these groups both before and after the Revolution, it was necessary to shed some light on their natural population movement.
5. The data ordinarily used for the analysis of demographic processes are those contained
in the current registers of births and deaths. Because such data for the population of the former colonies of Tsarist Russia were either lacking or incomplete, other means had to be sought to obtain them.
6. Professor G. A. Batkis proposed in 1925 that the anamnestic method should be used in demography in order to obtain information on the fertility and mortality of a population in circumstances where the registration of population data was non-existent or deficient.
7. The term "anamnestic" by which the method is known refers to the manner in which data on past events are obtained, i.e., by asking persons to supply information from memory; it is derived from the Greek word anamnesis meaning "recollection".
8. A feature of the anamnestic method of collecting data is that the informant is supposed to give the exact date on which the event being investigated occurred. Thus, in population inquiries carried out for the purpose of studying birth rates, female fertility rates and the survivorship function of children up to the age of fifteen years, the women are asked to provide information on births, on their children throughout the lifetime of the latter, and so on. They should state not only how many births there were, how many children died and so on but should also give the exact dates of these events. All the particulars are entered on inquiry cards.
9. The questions on the inquiry card should be worded in such a way that each event being investigated can be related to a specific date. This can be done by establishing the age of the subject at the time of the event or the number of years that have elapsed since then or, best of all, the calendar year in which the event occurred. Another indispensable condition in any inquiry conducted according to the anamnestic method is to determine the age of the subject at the time of the inquiry.
10. An example of a card that can be used to obtain information on births and child
mortality is the "women's inquiry card" that has been used in a number of anamnestic
surveys carried out in the Union of Soviet Socialist Republics.

## Women's inquiry card

(To be completed in respect of girls and women
aged fifteen years and over)

1. Surname, given name, patronymic
2. Ethnic nationality
3. Occupation
4. Age........... Year of birth
5. Married (yes, no)
6. Education
7. Husband's age
8. Husband's occupation
9. Total number of births............ Number of children alive at the time of the survey
10. Age at beginning of menstruation..... Age at end of menstruation

Information concerning births

11. As a means of making it easier to check the age and date particulars supplied by women concerning the events being investigated which occurred in their lives, a special kind of sliderule has been used in some of the surveys with the aid of which the ages and calendar years when the events in question occurred can be compared (A. M. Khamitova). The slide-rule consists of two graduated scales-an immovable scale divided into years of age from zero upwards, and a movable scale divided into calendar years. By matching the year of birth, if known, with zero on the age scale, or by matching the age, if known, at the time of the survey with the year of the survey, it is possible to make an exact comparison of the age and the calendar year when the event in question took place (see diagram).
12. For a study of the question of marital fertility, data on age at marriage and age at the termination of marriage must be collected. Thus, in a number of surveys the questions on the "women's inquiry card" intended to elicit this information were formulated as follows:


At beginning. ...... At end....... At beginning....... At end.......
13. For the study of adult mortality, use is also made of the "brothers and sisters" method. In this case, the adult members of the population are asked to supply the following particulars concerning their brothers and sisters: date of birth, age at the time of the survey and date of death. This information is recorded on a "family inquiry card".
14. Data collected at a given point of time can also be used for studying the dynamics of the phenomenon (fertility, mortality, etc.) being investigated because each respondent supplies information on events that occurred at different ages of life, and hence in different calendar years. This makes possible a chronological appraisal of the event being investigated.
15. The collection of data for different years at one time enables the investigator to analyse the data in the manner best suited to his needs, something which is impossible with the ordinary statistical methods. The use of data derived from current statistics and censuses ordinarily presents problems when comparisons must be made because of the lack of uniformity, differences in terminology and so on between the different sets of data. These difficulties are eliminated when data are collected by the anamnestic method.
16. The anamnestic method differs from other statistical methods not only as regards the collection of the information but also and to a greater extent as regards its processing. The precise dates of the events in a woman's lifetime divide her life, as it were, into various
periods. This division into periods facilitates the processing of the data.
17. At the processing stage, the primary unit of the data collected is not a woman but a year of a woman's life. The population of women is converted into a population of years. In this way the scope of the investigation can be said to be broadened.
18. The conversion of a population of women into a population of years gives a body of data similar to that derived from a population census or from current statistics, namely, an age-specific distribution of women by individual calendar years.
19. In contrast, however, with the data derived from a census or from current statistics, the data provided by an anamnestic survey relate to a single population observed at different periods of time.
20. In the analysis of fertility data derived by the anamnestic method, use is made of agespecific fertility rates obtained by comparing the number of births with the number of years lived by women during the period considered. The particulars entered on the inquiry card for the age at marriage and the age at the termination of marriage make it possible to determine the duration of the marriage period, i.e., the number of years of married life for each age.
21. In the investigation of mortality with the aid of the anamnestic methods, a procedure known in demographic statistics as the aging technique is used (see table 1).

Table 1


22. The layout of the table makes it a multipurpose table, i.e., it can be used for computing the age-specific probability not only of death but also of other events such as marriage, pregnancy, menses and so on. In the study of mortality this table makes it possible to compute the probability of death at a given age (column 7). The probability of death is the ratio of deaths in a specified (from $X$ to $X+1$ ) age interval (column 6) to the persons who have survived this interval, i.e., the persons whose observation during the period considered was completed (column 5). In order to determine the number of persons who survived a specified age interval, it is necessary to know the total number of persons who came under observation at that age (column 2) and the number of persons who have not yet reached the end of the age interval (column 3). Column 3 shows the number of persons who have attained the given age ( $X$ ) but have not yet reached the next age. These persons are therefore not observed in the period considered and are transferred to the following period.
23. To obtain the figure in column 5, the figure in column 3 must be subtracted from the figure in column 2 . In addition, if the study of mortality is conducted on a calendar-year basis, the figure in column 4 must be added to the difference between column 2 and column 3 in order to obtain the figure in column 5.
24. Column 4 gives the number of persons whose observation was not completed in the preceding period because they had not reached the end of the age interval in that period and were therefore excluded from the group under observation.
25. The total number of persons coming under observation at a given age (column 2) is determined in the following manner. The first figure in column 2 ( 1,913 ) represents the number of persons born in the period considered; the following figures in that column are obtained by computation. Thus, the number of persons attaining the age of two years is derived as follows:

$$
1,416=1,656-(360+104)+224
$$

26. The figures in the remaining columns (8,9 and 10) of the table show how many out of 1,000 persons attained a given age and how many came under observation.
27. Column 8-probability of survival to the next age. The figure in this column is obtained by subtracting the figure in column 7 from 1,000 .
28. Columns 9 and 10 -these figures represent the attrition per 1,000 persons, i.e., they
correspond to the figure $l_{x}$ (column 9) and to $1,000-l_{w}$ (column 10) in a life table.
29. With the aid of such a table it is possible to compute the age-specific probability not only of death but also of other events: marriage, pregnancy and so on.
30. Especially important is column 9, which represents the age-specific attrition in an original population of persons who have not experienced the given event. This column is used to compute the average number of persons in the given population who survive up to the occurrence of the event being considered (average age of women at marriage, etc.).
31. As noted above, an anamnestic survey makes it possible to study demographic processes retrospectively at various periods of time.
32. This is accomplished by using auxiliary tables. One such table, which shows the age distribution of female respondents both at the time of the inquiry and at the time of the occurrence of the variable, is known as the "triple measurement table". This table is constructed according to the principle of the Lexis diagram. In the vertical direction, it indicates the age at the time of the inquiry, and in the horizontal direction the age at the time of the occurrence of the event. If the figures in a table of this design are tabulated in three directions, three different populations will result, namely: horizontally, a population in which the given event occurred up to the time of the inquiry; vertically, a population in which the event occurred at a specific age; and diagonally, a population in which the event occurred during a specific calendar year.
33. A "triple measurement table" thus makes it possible to isolate the events which occurred at a specific age or in a specific calendar year (see table 2).
34. As noted above, the anamnestic method may also be used in localities where the official demographic statistics are sufficiently reliable. In such cases it is useful for making demographic studies under a broader programme than that provided for in the system of officially recorded data. In addition, it provides a means of studying the events in question among different groups in connexion with social, economic and other factors.
35. Thus, as early as the 1930 's an investigation was made to determine how the exercise of an occupation affected the female reproductive function (G. A. Batkis, R. B. Kogan, F. Y. Shufir). The anamnestic method was used to determine how fertility was affected by the employment of women in productive

Table 2. Distribution of women by age at time of the event being investigated

| Age at time of survey | Age at time of the event being investigated |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| 15. |  |  | 1 |  |  |  |  |  |  |  |
| 16. |  |  |  | 3 |  |  |  |  |  |  |
| 17. |  |  |  | 2 | 2 |  |  |  |  |  |
| 18. |  | 1 | 2 | 5 | 14 | 10 |  |  |  |  |
| 19. |  |  | 1 | 7 | 10 | 19 | 18 |  |  |  |
| 20. |  | 1 | 4 | 14 | 12 | 10 | 23 | 13 |  |  |
| 21. | 2 | 1 | 5 | 1 | 13 | 20 | 19 | 10 | 13 |  |
| 22 | 1 | 3 | 6 | 7 | 6 | 19 | 7 | 12 | 15 | 10 |
| 23. |  | 3 | 6 | 8 | 11 | 13 | 13 | 14 | 13 | 14 |
| 24 |  | 3 | 7 | 12 | 11 | 9 | 7 | 14 | 10 | 7 |
| and so forth |  |  |  |  |  |  |  |  |  |  |

activities, by the material and cultural level of the community and by living conditions.
36. The more important projects of this kind include: a survey of fertility and infant mortality in the USSR carried ont in 1934 by the budgetary statistics authorities (S. G. Strumilin) ; a similar fertility survey conducted in 1959 by the Central Statistical Board of the Union of Soviet Socialist Republics; and an exhaustive study of marital fertility in the families of urban workers carried out by the N. A. Semashko Institute for Health Organization and the History of Medicine, which comes under the jurisdiction of the Ministry of Health of the Union of Soviet Socialist Republics (N. A. Tauber).
37. An advantage of the anamnestic method in this case is that it obviates the need for a control group in order to study the effect of various factors on demographic processes. The anamnestic method affords the possibility of setting up separate populations on the basis of a particular variable without impairing the homogeneity of the data.
38. A knowledge of the exact data of occurrence of all the events under investigation, including the date of the factor whose influence is being studied, makes it possible to break down each respondent's life into two periods: that preceding and that following the occurrence of the event. The influence of the factor being studied can then be determined by comparing the level of the demographic process in each of these periods.
39. The anamnestic method is ordinarily used in conjunction with sampling procedures. A great advantage of this arrangement is that a sampling survey, because of the smaller body of data being investigated, can be organized more efficiently, and this in turn makes it possible to achieve a higher level of quality in
the information recorded on the statistical cards. The interviewer can give more time and attention to each respondent and is better able to determine the date of occurrence of the various events.
40. The effectiveness of sampling procedures depends on the manner in which the sampling is done and on the number of observations that are made. The number of observations required is determined according to the customary formula $n=t^{2} p q / \triangle^{2}$, where $n$ is the number of observations required, $\Delta$ is the accuracy of the sample, $t$ is the confidence coefficient, $p$ is the sampling fraction and $q=1-p$.
41. A drawback of the anamnestic method is the incompleteness and imprecision of data obtained on the basis of recollections. A study of the accuracy of data obtained by the anamnestic method was made by the author of this paper by comparing the results of two surveys carried out in the same areas in different years (rural areas of Soviet Georgia in 1940 and 1947). The inquiry cards of both surveys were used, and the information obtained in each survey from the same women was compared. In this way it was possible to determine the number and the character of the discrepancies in the replies given by the women on the occasion of the first and the second survey.
42. The comparison of the replies showed that the degree of accuracy was greatest for the information on the age of children and lowest for that on the age of the women at the time of the survey. The accuracy of the replies also varied with the age of the women; the older the woman, the less accurate were the statements she made.
43. The comparison revealed omissions in the information supplied by the women regarding children who had died, especially in the
case of children under the age of one year. Such omissions, as might be expected, were especially frequent in relation to events which had occurred many years before the date of the survey. Such errors are also possible in other similar surveys. As a means of smoothing out the inaccuracies in the age data that are obtained in anamnestic surveys, it is preferable to use indicators computed by age groups.
44. In view of the incompleteness of data
on persons who died many years in the past, it is advisable to treat such data with caution. On the other hand, the results of an efficiently organized anamnestic survey are more accurate than data from official registers that have not been properly kept.
45. The anamnestic method has been used in the Union of Soviet Socialist Republics for carrying out a number of health and sanitation studies.

# Reconstruction of the trends of population growth in Uruguay for periods prior to the 1963 census ${ }^{1}$ 

Alberto Cataldi

[Translated from Spanish]

## Background

1. Prior to the Fourth General Population Census of October, 1963, there were a number of unanswered questions concerning the size, structure, distribution and other characteristics of the population of the Eastern Republic of Uruguay. This was inevitable, since the last population census had been taken in 1908.
2. With the establishment of economic and social planning agencies, the need for up-todate demographic data and reliable estimates of future population became apparent. These could not be obtained by means of traditional computations based on the 1908 census and the annual figures of natural and migratory growth released by the General Directorate of Statistics and Censuses. Furthermore, although in recent times more than one study ${ }^{2}$ had been devoted to the determination of the total population and its age and sex structure, such studies clearly attempted to be consistent with the official estimates of the total population, which were the only existing point of reference.

## Purpose

3. Our aim was to estimate, with a minimal

[^105]margin of error, the size of the total population and its age and sex structure at a date close to 1962. These estimates should make it possible to make projections for the next twenty-five years of the total population by sex and age and a few other characteristics useful for general and regional development planning.

## Sources of data

4. Apart from the continuous statistics of population movement, which are fairly reliable, the main source of demographic data was the 1957 National Register of Inhabitants (NRI). This was, in fact, a census of the total population, showing its main characteristics, but it failed to achieve its purpose because of the many irregularities which occurred during the enumeration stage and which, in the opinion of those who took part in the operation, may have led to errors of unsuspected magnitude. All the NRI material was held by the General Directorate of Statistics and Censuses, so that some use could be made of the information collected in order to obtain yardsticks or indicators of the country's demographic situation.
5. Despite the obvious limitations of the NRI data, it was decided to use them as a basis in a new attempt to determine the essential demographic characteristics. Obviously, to process all the census returns was out of the question, owing to limitations of time, funds and staff. It was decided therefore to take a large enough sample of the NRI as to make estimates for the total population, with acceptable sampling errors and at low cost. After a number of analyses, it was decided to take a 2.5 per cent sample of the individuals enumerated in the NRI or, more accurately, of the total then available as a result of possible losses of material which were alleged to have occurred subsequent to the field work. The selected persons (systematic simple random sampling) were tabulated according to sex, age, civil status, nationality, literacy and type of economic activity. All the pre-analysis stages from selection to tabulation were carried out
in two and a half months. For reasons of space we shall confine our comments solely to the results obtained for the total population and the adjustments that were made to reach the final figures.

Total population results in the NRI SAMPLE
6. According to the results of a provisional count taken immediately after the NRI census, the population of Uruguay in 1957 numbered $2,162,988$. To take a 2.5 per cent sample of the individuals enumerated meant to extract the returns of 54,074 persons. After the selection was made, only 53,766 individual returns were obtained. This meant that the total population was $2,150,600$ persons instead of the figure resulting from the provisional count. Although it was realized that errors might have been made in the selection stage and that losses of material might have occurred, the only course left open was to attribute the difference to probable errors of arithmetic in the provisional count, since it was plain that subsequently other, and certainly more important, defects would have to be detected and corrected.
7. In its annual computations of total population based on the 1908 census and on natural and migratory growth, the General Directorate of Statistics and Censuses gave an estimated figure of $2,730,000$ for the population in 1957. If the official estimate was correct, the difference between it and the NRI results (almost 580,000 persons) would have to be attributed to errors made in the NRI enumeration and, in relative terms, that was 21 per cent of the estimated total population. This could easily have occurred in a country, such as Uruguay, having no census tradition and in an operation which had been carried out without the guidance of specialized technical bodies. Nevertheless, we proposed to demon-strate--since we already had some inkling of it -that the NRI error was not as great as suggested by the first collations and that the official estimates were partly to blame for its apparent magnitude.
8. The migration figures, computed annually and taken into account in the population estimates, were based on the records of persons entering and leaving the country by the principal access routes. If it is accepted that over a period of almost fifty years a figure showing a positive balance signifies real immigration, the fact should be reflected in the size of the non-indigenous population resident in the country.
9. Although both the 1908 census figure and the figure for deaths in the 1908-1957 period may contain errors of unknown magnitude in either direction, it is obviously the figure for the migration balance which most affects the results in table 1. Fairly substantial numbers
Table 1. Probable foreign population in 1957, according to official estimates and the results obtained from the NRI sample

| Foreigners enumerated in the 1908 census | 181,222 |
| :---: | :---: |
| Official migration balance, 1908-1957 | + 473,703 |
|  | 654,925 |
| Deaths of foreigners, 1908-1957 | - 180,101 |
| Estimated number of foreigners in 1957 | 484,824 |
| Foreigners enumerated by the NRI in 1957 | 181,600 |
| Difference | 303,224 |

of migrants have, at least in some periods, entered the country. This is confirmed by the 1908 census itself, according to which the foreign population was 18 per cent of the total. Uruguay is, however, clearly a land with tourist attractions, and this partly explains why the numbers of persons entering and leaving the country have, at some periods, reached high levels. A glance at the records of passengers entering and leaving the country between 1908 and 1957 confirmed this fact, but the discovery of serious discrepancies cast doubt on the accuracy of these records. The variations in the data as between years in which nothing occurred to affect tourism suggests, at first sight, the presence of errors. For example, there was a positive balance of 28,000 persons: in 1956, 7,000 in 1957 and 30,000 in 1958. At the same time, the number of permanent immigrants ${ }^{3}$ in the year 1956 was only 6,575 persons. ${ }^{4}$ It is difficult to account for such discrepancies unless we entertain the possibility that a large number of the tourists entering the country decided to settle there permanently. Moreover, if the official balance for the period 1908-1957 were correct it would be still more difficult to accept that the NRI should have made an error of such selective under-enumeration as regards nationality, for if, in principle, the over-all error was of the order of 21 per cent, 63 per cent of the foreigners, that is to say three times the percentage of nationals, would have been omitted.

[^106]10. These considerations, which were largely speculative, it is true, together with detailed analyses of the figures which cannot be described in this summary, suggested that the official estimate was too high by some 300,000 persons (table 1) as a result of erroneous computation of the migration balances. The difference between the NRI and the official estimate was thereby reduced to 280,000 persons ( 11.5 per cent), which number was attributed to errors in the NRI enumeration. It was important to determine whether that omission had been selective as regards sex and age.
Result of the NRI sample by sex and age
11. Population aged 0 to 19 years. From the statistics of births for the twenty years preceding the NRI-duly corrected and adjusted to eliminate the effect of late registrations-and the annual statistics of deaths by age and sex, an estimate of the population under 20 years of age in 1957 was obtained and collated with the tabulation of NRI sample by individual ages. The results revealed an important NRI omission in the $0-4$ years age group ( 14.6 per cent), a progressive diminution of the error in the next two groups and a new rise in the 15-19 years age group ( 7.5 per cent). A comparison of the NRI results in the 5-14 years age group with primary school enrolment figures again confirmed the earlier results. It was, therefore, decided to take the estimate based on the vital records as the population aged 0-19 years.
12. Population aged 20 years and over. Unfortunately, no control data were available to assess the NRI coverage of this great sector of the population. The principal means of checking were the central mortality rates ( $5 m_{x}$ ), computed on the basis of deaths noted in the three-year period 1956-1958, and the population figures by five-year age groups derived from the NRI. The rates were compared with various mortality models prepared by the United Nations, ${ }^{5}$ not so much to see whether the magnitudes were reasonable as to study the trend according to age and to detect irregularities providing a yardstick by which to judge the reliability of the NRI in those age groups. The only significant omissions discovered by this method were in the age range 50 to 64 years, where the rates were considerably in excess of the trend suggested by the models. The observed rates were then adjusted to the trends shown in the models. As the

[^107]number of deaths was left unchanged, this procedure selectively modified the census totals. A correction of 11.5 per cent, corresponding to the probable over-all error in the NRI, was then applied to all figures.

## Final result

13. After the results of the NRI sample had been fully checked and corrected, it was decided:
(a) To fix the total population figure for mid-1957 at $2,400,000$. This figure was obtained by subtracting from the official estimate about 300,000 , a number included in the annual statistics through errors in the computation of the migration balance. To avoid giving a false impression of accuracy, the result was rounded off to the nearest hundred thousand;
(b) The age and sex structure of the NRI sample, adjusted as described in paragraphs 11 and 12 above, was applied to the new total for the mid-1957 population.

## Population projections

14. By using the "components" method ${ }^{6}$ for five-year periods between 1957 and 1982, projections by sex and age were made in order to obtain estimates for the year in which the work was carried out (1962) and subsequent periods.
15. Mortality assumption. An abbreviated mortality table for 1957 was constructed, taking into account the estimated population and the registered deaths. The expectation of life at birth for both sexes was found to be about 67 years. Projections of the quinquennial survival functions ( ${ }_{5} p_{x}$ ) were made according to the method proposed by A. Campbell. ${ }^{7}$
16. Natality assumption. Only one assumption was made concerning fertility, viz., that it would remain constant throughout the projection period. Specific fertility rates were obtained from the figures for the estimated female population and the adjusted registered births classified according to the mother's age. The gross reproduction rate was found to be 1.34 per thousand and the gross natality rate 22.1 per thousand, both for the year 1957.

## Conclusion

17. In the light of the results obtained, undoubtedly the most important conclusion was

[^108]that a substantial deduction had to be made from the official estimate of the total population, which had been used hitherto without serious reservations. A 12 per cent reduction immediately produced significant modifications in various socio-economic indicators in which the population figure was used as the denominator.
18. The estimated sex and age structure merely confirmed a situation which had been observed in many previous studies, viz, a low proportion of children under the age of fifteen (27.7 per cent) and a moderately high percentage of persons aged sixty-five years and over ( 6.7 per cent) ; both phenomena are unparalleled in the Latin American demographic picture (with the possible exception of Argentina). Furthermore, a significant dent was again observed in the $15-24$ years age group of the population pyramid; this group includes the survivors of the generations which were born between 1933 and 1942. In that decade
there was a marked decline in absolute births, probably as a result of world economic events.

## Author's note

19. The Fourth National Population Census of Uruguay took place on 16 October 1963. The total population fgure, duly corrected in accordance with post-enumeration tests, was $2,644,500$. The projection for the same date, made as described in this report, yielded an estimated total of $2,595,400$ persons. The difference ( 1.9 per cent of the enumerated population) should probably be attributed to the lack of adequate quality control of the data taken from the NRI sample and also to probable errors in the assumptions on which the projections were based. The sex and age structure, as revealed by the census, is practically the same as that obtained from the adjusted figures of the 1957 National Register of Inhabitants, bearing in mind that censuses were six years apart.

# Theory of surveys to estimate total population 

W. Edwards Deming and Nathan Keyfitz

1. The purpose of this paper is to discuss some of the statistical problems encountered in estimating by sampling the total number of a population, without benefit of a previous census, and to present a device for this purpose which may have other uses as well. We will speak of two kinds of situation: (a) the population is fixed, each person being nominally attached in some recognizable manner to a fixed location, such as a dwelling unit; (b) the population is mobile-here today, somewhere else tomorrow. Always, in addition to the population that is fixed, a certain number of people are not identified with any fixed location; this applies in countries that have regular modern censuses as in those that have never taken a census. We make only brief mention of the fixed population, as it is already treated in books. We introduce some theory for the moving population, in the hope that knowledge of the theory will encourage practical application.
2. Sampling to estimate a fixed population -the area principle: the main difficulties are about the same for the use of sampling as they are in conducting a first complete census. The basic requirement for either a complete census or a sample of a fixed population is a frame. A frame is a list of sampling units, the totality of which covers the population to be counted. For a fixed population, a good set of maps constitutes an implicit list or frame. Without a frame, there can be neither a complete census nor a sample. Without a frame, there would be no way to allot work to interviewers, nor any way to know whether or when the work of taking the census is completed, nor is there any way to carry out a control.
3. The sampling unit for a census of a fixed population is most commonly an element of area. The enumeration district, with clearly defined boundaries and designed to contain 500 to 1,000 persons, is an example. Enumeration districts may be of any shape or size-they may contain a small number of people or a large number of people. There is of course preference for uniformity in so far as the enumeration district is the work load for one enumerator, and in so far as it is a sampling unit
from which an estimate of the total number of inhabitants is to be made. Pre-existing welldefined and well-established administrative units, or city blocks, may be used. We also call attention to an instance of square areas, 3 km . by 3 km . marked off by points designated as their corners, and conspicuous enough so that the enumerator might know whether he is inside the designated sample area. ${ }^{1}$
4. Area samples may become complex as their designers strive for efficiency, to achieve a desired precision at minimum cost. They employ stratification, ratio-estimates, regression, multiple stages, composite estimates, and a host of other ingenious devices. But underneath all of these remains the fundamental principle of the simple random sample: that out of $N$ areal or other units defined in the population $n$ are chosen at random for enumeration. In a large-scale sample-survey, prepared in stages, it is necessary to delineate only a fraction of the $N$ units, but there are still $N$ units in total, in hundreds of strata. Every acre in the territory has a chance of $n / N$ of inclusion, likewise every household, every store, and every individual resident has a probability $n / N$.
5. As the probability of selection is $n / N$, it is possible to estimate the total number of people in the frame merely by multiplying the number of people in the sample by $N / n$; and similarly to estimate the total number of houses in the frame by multiplying the number of houses in the sample by $N / n$; and similarly to estimate the total number of acres, households, stores, or individuals. The raising factor $N / n$ is simply the reciprocal of the probability of selection.
6. Point sampling: we come now to a type of sampling in which the factor $N / n$ is not built into the design, but must be estimated. Consider a situation where the population is mobile, not attached to any areal unit. Area sampling could still be used if the people would stay in one place long enough to be counted on a sample of areas. In the circumstances that

[^109]there are no maps, or that the people are too mobile, area sampling is impossible. Here we are driven to a sample of points, and it is necessary to seek an entirely different basis of design and estimation than we have just described.
7. Sampling to estimate a mobile population from a set of points: the sample of points takes advantage of the mobility of the population. The more people are moving, and the more rapidly they are moving, the more efficient the point sample will be. It turns an obstacle into an advantage. Suppose indeed that people are in motion in such fashion that they all have the same chance of passing every point. The first step would be to place enumerators at a number of random points; they might be put down by helicopter or make their way on foot. The techniques for ensuring randomness would be the same as in crop cutting. The enumerators would remain at their stations for a given period of time-say a day or a week. Suppose that they encounter $n_{1}$ persons in total, and that to each one, they give a card or a button to show that he has been enumerated. This enumeration would constitute the first round.
8. The enumerators would then be allotted to a second set of random points in the same territory, and they would again enumerate all persons that they encounter, establishing, among other items on the questionnaire, whether the person has been enumerated before. Suppose that on this second round they enumerate $n_{2}$ persons in total, including $n_{12}$ persons that had been enumerated before. The three numbers, $n_{1}, n_{2}$, and $n_{12}$, provide an estimate $n_{1} n_{2} / n_{12}$ of the population of the territory, along with an estimate of its variance. In fact, $n_{2} / n_{12}$ is the raising factor by which we multiply $n_{1}$, just as we would use the multiplier $N / n$ in areal sampling.
9. Point sampling with three rounds: for three rounds we should need the additional notation:
$n_{3}$ the number of inhabitants enumerated at all posts at the third round
$n_{23}$ the number of inhabitants enumerated in the third round that were also picked up in the second round
$n_{123}$ the number of inhabitants enumerated on all three rounds.
Let $N$ be the (unknown) number of mobile inhabitants in the territory. Then the following estimates of $N$ are available. The estimate $N$ in eq. (vi) combines all the information from the three rounds.
\[

$$
\begin{align*}
& N_{12}=n_{2}\left(n_{1} / n_{12}\right)=\frac{n_{1} n_{2}}{n_{12}}  \tag{i}\\
& N_{13}=\frac{n_{1} n_{3}}{n_{13}}  \tag{ii}\\
& N_{23}=\frac{n_{2} n_{3}}{n_{23}}  \tag{iii}\\
& N_{231}=\frac{n_{2} n_{23}}{n_{123}}  \tag{iv}\\
& N_{132}=\frac{n_{1} n_{13}}{n_{123}}  \tag{v}\\
& \hat{N}=\frac{n_{1} n_{2}+n_{1} n_{3}+n_{2} n_{3}+n_{1} n_{13}+n_{2} n_{23}}{n_{12}+n_{13}+n_{23}+n_{123}+n_{123}} \tag{vi}
\end{align*}
$$
\]

The uncertainty attributable to accidental independent variations, including sampling, could be ascertained by analysis of the variance in these quantities between individual points or by short-cut methods similar to those that have been developed for area sampling.
10. Hypothetical example of point sampling: in order to see how the calculations work out in practice, suppose that there is a migratory population of about 100,000 persons, and suppose that enough points be chosen for the point sample so that about 5 per cent or 5,000 persons would be incladed in the first round. On the second round an expected 5,000 would again be included, of whom about 250 would be repeats from the first round. On the third round, there would be 5,000 in all, including 250 repeats from the second and 12 from the first. In terms of the first two rounds of the preceding model, the expected values are $n_{1}=5,000, n_{2}=5,000, n_{12}=250$. Substituting these expected values in eq. (i) gives

$$
N_{12}=n_{1} n_{2} / n_{12}=5,000 \times 5,000 / 250=100,000 .
$$

On binomial probabilities, the coefficient of variation of the estimate of $N$ would be about 9 per cent. An area sample that contains 10,000 persons (equal to $n_{1}+n_{2}$ ) would do better than this point sample if it were arranged in efficient clusters.
11. Sketch of derivation of formulae: a rough estimate of the standard error in the estimate of $N$ could be obtained from three rounds by comparing $N_{12}, N_{13}, N_{23}$. A modicum of effort in design would provide replication, by which, in each round, there would be two or preferably three to ten replications. Each pair of replicates provides an estimate of the standard error, by formulas that are well known.
12. In order to gain some insight into the formulas that might be expected under one set of possible circumstances, suppose that
binomial probabilities apply, which is to say that every person in the mobile population has the chance $p$ of being enumerated in any round. Then for the first round, the chance of encountering exactly $n_{1}$ persons would be

$$
\binom{N}{n_{1}} \quad a^{N-n_{2} p^{m_{1}}}
$$

For the second round, the chance of encountering $n_{2}-n_{12}$ persons among the $N-n_{1}$ who had not been enumerated before is

The chance of encountering $n_{12}$ among the $n_{1}$ is

$$
\binom{n_{1}}{n_{12}} \quad q^{n_{1}-n_{12}} p^{n_{12}}
$$

If these three probabilites are independent, the likelihood of the sample consisting in all of $n_{1}+n_{2}=n_{1}+\left(n_{2}-n_{12}\right)+n_{12}$ persons is the product of the three separate probabilities.
13. We now take the logarithm of the likelihood, but put it into a more tractable form by replacing all factorials by the Stirling approximation, in which $N$ ! is proportional to $N^{x+1 / 2} / e^{N}$, and hence $1 n N!=K+\left(N+\frac{1}{2}\right)$ $1 n N-N$. As we have no interest in the likelihood itself, but only in its derivatives with respect to $N$ and $p$, we need not concern ourselves with terms not involving these variables. Hence the logarithm of the likelihood, $1 n L$, is $1 n L=K+\left(N+\frac{1}{2}\right) 1 n N-\left(N-n_{1}-n_{2}\right.$ $\left.+n_{12}+\frac{1}{2}\right) 1 n\left(N-n_{1}-n_{2}+n_{12}\right)+(2 N$
$\left.-n_{1}-n_{2}\right) 1 n q+\left(n_{1}+n_{2}\right) 1 n p$.
The derivative of $1 n L$ with regard to $N$ and to $p$ when equated to zero gives

$$
\begin{gather*}
\frac{\partial 1 n L}{\partial N}=1 n N-1 n\left(N-n_{1}-n_{2}+n_{12}\right)+ \\
21 n q=0 \quad \text { (viii) }  \tag{viii}\\
\frac{\partial 1 n L}{\partial q}=\frac{2 N-n_{1}-n_{2}}{q}-\frac{n_{1}+n_{2}}{p}=0 \quad \text { (ix) } \tag{ix}
\end{gather*}
$$

terms in $1 / N$ being omitted. It follows from eq. (viii) that

$$
\begin{equation*}
q^{2}=1-\frac{n_{1}+n_{2}-n_{12}}{N} \tag{x}
\end{equation*}
$$

and from eq. (ix) that

$$
\begin{equation*}
\frac{p}{q}=\frac{n_{1}+n_{2}}{2 N-n_{1}-n_{2}} \tag{xi}
\end{equation*}
$$

or

$$
\begin{equation*}
p=\frac{n_{1}+n_{2}}{2 N} \tag{xii}
\end{equation*}
$$

Substitution of $p$ from eq. (xii) into eq. (x) gives

$$
\left[1-\frac{n_{1}+n_{2}}{2 N}\right]^{2}=1-\frac{n_{1}+n_{2}-n_{12}}{N}
$$

or

$$
\begin{equation*}
\hat{N}=\frac{\left(n_{1}+n_{2}\right)^{2}}{4 n_{12}} \tag{xiii}
\end{equation*}
$$

The maximum likelihood estimate of $N$, which we designate $\hat{N}$, is thus the square of the total of the sample in the two rounds divided by four times the common portion,

$$
\frac{\left(n_{1}+n_{2}\right)^{2}}{4 n_{12}}
$$

and of $p$ is

$$
\hat{p}=\frac{2 n_{12}}{n_{1}+n_{2}}
$$

The relative merits of eq. (xiii) and eq. (1) depend on the degree to which the binomial conditions are fulfilled.
14. Point sampling as a residual method: if one were in possession of a good frame for an area sample, he would use point sampling only for that portion of the population that is mobile and elusive. In many circumstances, one would combine the two methods. In fact, they are combined in the United States census, which can be thought of in principle as a 100 per cent sample of areas, plus a 100 per cent sample of points for the transient population. The area sample consists in the division of the territory of the entire country into enumeration districts which are assigned one to each enumerator who is instructed to cover it solidly in respect of all residents. The point sample is enumerated on a single night, called $T$-night; enumerators are stationed in the lobbies of known hotels, flophouses, and other points which transients pass. In the United States the mobile population is a small enough proportion of the whole that it ordinarily is dealt with as a residual in censuses and disregarded in sample.
15. Combination of a sample of areas and a sample of points. The combination of area and point sampling would require an initial division of the whole territory (say of a country) into suitable areas and the usual random selection from these, perhaps at several stages. In each one of the areas an enumerator takes his post and counts the people that reside in or pass through the area over a stated period of time. These areas would be situated in the various geographic zones in the country whose population is to be counted, and where the enumerators happened to be located at any
moment as they go their rounds would constitute random points. The persons found within the sample areas during the time of enumeration would be treated differently according as they are (a) fixed residents of the area; or (b) transients encountered by the enumerator as he makes his rounds.
16. The enumeration at a sample of points must be repeated another day to make at least two rounds. The procedure in round 1 is to enumerate (in addition to the regular inhabitants of the designated areas) those that happen to be passing through, and to provide, in some manner, each person enumerated as a transient with identification so that he can be recognized if he is picked up in the second round, or in the third round.
17. Theory needed for the combined sample: although the theory of area sampling is now expounded in books, and there is also a considerable literature on point-sampling, combination of the two has so far, to our knowledge, not been suggested. The advantage of the combination is not in the reduction of variance so much as in cancellation of biases. The area
sample gives too small a chance of inclusion to persons that are mobile, while the sample of points gives to any person a probability of inclusion proportional to his movement. The combination suggested in the preceding section, by which the enumerator counts not only people resident in selected areas, but also outsiders that happen to be in his area while he is on his rounds, might be designed to give approximately equal probabilities to all. Any combination of probabilities would serve the purpose, if the probabilities could be evaluated. The present paper may thus be of interest even in countries that have highly developed census methods for the stable population, but which place less emphasis, with possible bias from undercount, on mobile elements.
18. The drawback that point sampling suffers from is the need to include a sufficient proportion of the population in each of two or more rounds. Point sampling is to be used only in cases where area sampling alone is impracticable. As there is a mobile population in every country, point sampling offers a general contribution to statistical method.

# The Indian programme for improving basic registration 

S. P. Jain

1. India has nearly a century-old system of registration of births and deaths but it is far from satisfactory at the present time. Arrangements which worked not too badly under the simpler living conditions of the early days got dislocated during the Second World War period of abnormal activity. This was followed by administrative changes and rapid expansion of governmental activities in various directions on the country attaining independence in 1947. Registration work was relegated to a place of secondary importance. The problems of national development were so many and so glaring that in the formulation of the first two Fiveyear Plans the obvious got all the attention and the study of population, which is basic to any kind of planning, did not receive the consideration it deserved. Some studies carried out after the 1951 census made it pretty clear that the country was experiencing a distinctly higher growth rate of 2 per cent per annum instead of the placid 1.3 per cent, round which the rate had kept during the preceding three decades. This unexpected increase drew attention to the population problem and the need to keep a finger on the pulse of population growth. Naturally, eyes were turned on improving the current system of basic registration in addition to exploring the possibilities of the non-traditional methods, such as sample surveys and sample registration, which are expected to give quick results and serve the immediate purpose, and the need of the individuals for authentic proof of occurrence of a birth or death and of age, nationality and parentage in the case of every person born. Further, individual events are the focal points for starting personal services, such as care of the child and the mother, hygiene and prophylactic services and family planning. Although these uses do not have much force in the present setting, they are likely to gain importance under the complexities of modern life. However, to set up an efficient system of registration is a long and slow process. If, as seems to be the case, there is a strong likelihood of greater demand in the near future for individual registration records, it is necessary to make a start now.
2. The considerations mentioned in the preceding paragraph paved the way for the
acceptance by the Government of India of a programme of improving basic registration over a period of five years commencing from 1964 at an estimated cost of 31 million rupees. The programme does not go far enough. It attempts at tackling mainly the problem of strengthening the existing superstructure. It is expected that the successful implementation of the programme should lead to very substantial improvements. Even admitting that it may not succeed in the establishment of an acceptably efficient system of registration, it will at least reveal the directions in which further efforts need to be made. In that case, the present programme will form the first but important phase in the attempt to put up a good system of registration throughout the country. This may appear to some to be a truncated approach. To appreciate the reasons which led to this course, it is necessary to review certain basic factors, which have a bearing on the registration system. It seems very likely that most of the developing countries, which are similarly situated in the matter of registration, may find that they have much in common in the matter.
3. India has limited resources and considering other calls on them any acceptable scheme of improvement of registration has to work under the rigours of utmost economy. To set up an independent machinery for registration is practically out of the question, because of the resources required without any visible commensurate return. Nor does the workload justify an independent field agency. The country has 565,000 villages with a significant concentration of small-sized ones, as is shown by the following figures:

| Population size |  |  |
| :---: | :---: | :---: |
| Less than 200 | 31.2 | 4.9 |
| 200-499 | 30.7 | 16.0 |
| 500-999 | 21.1 | 23.3 |
| 1,000-1,999 | 11.6 | 24.9 |
| 2,000-4,999 | 4.7 | 21,3 |
| 5,000 and above. | 0.7 | 9.6 |
|  | 100.0 | 100.0 |

The above shows that 83 per cent of the villages accounting for 44 per cent of the rural popula-
tion have less than 1,000 persons each, who will register much less than 120 events in a year. A full-time person to register births and deaths located in each village is a luxury. The practical alternatives, therefore, are either (a) to have a registrar located at a central village with jurisdiction extended over a substantial number of surrounding villages in order that he may have an adequate workload; or (b) to utilize the services of the available staff of a local authority on a part-time basis. The choice depends on several other factors.
4. Villages gencrally have appreciable distances between them. Transport and communication between them is not adequately developed. Travelling time and poor facilities of transport are major hurdles to the registrars' covering neighbouring villages from a central place. The incentives to report events of births and deaths to the registrar are weak. The general population is illiterate and ignorant and has little use for a birth or death certificate. Apart from the fear of penal provisions, which are rarely imposed, there is little incentive for registering a birth or death. Registration certificate is not the only admissible evidence of the occurrence of the event or proof of age or identity-alternatives are freely accepted. Statistical uses of registration data have not been able to assert themselves effectively and the non-availability of reliable statistics is usually accepted as something to be endured. Registration is not linked with the rendering of personal public services. Poor incentives result in bad data, and bad data inhibit development of incentives. For instance, it is difficult to insist on production of birth or death certificate without causing harassment to the public, unless registration facilities are adequate and the maintenance of records satisfactory to ensure that a certificate can be had when wanted. In certain areas, e.g. Goa, where production of a registration certificate on different occasions in insisted upon, relaxation of the provision by regular notifications is common, since a good number of events are not registered. This has brought the law into contempt without much helping the cause of registration.
5. A close study of the registration system in the advanced countries shows that efficiency of registration is directly connected with the spread of medical and public health facilities and the integration of the use of birth and death certificates in the civic needs of the population. Areas where these two factors are weak, do not have satisfactory registration. However, the reluctance of the medical profession to get involved in registration work is common. It is more prominently in evidence in a country
like India, where inadequacy of medical and public health personnel-even in areas where they are in position-gives the profession some sort of justification to its indifference to the requirements of registration. Much needs to be done in India to get hospitals to extend their effective assistance in registration. However, in the country hospital services are inadequate and by themselves cannot ensure completeness of registration. Bulk of the births are delivered at home. Even in the capital city of Delhi only 65 per cent of deliveries occur in institutions. The system of home delivery is common in the country. A sizable proportion of births in the rural areas are delivered by relatives and not by professional midwives. Even the midwives are not registered and most of them are not trained. Hence, it is not practical to track all of them to ensure registration of births delivered by them.
6. Regarding deaths there is the possibility of making use of the attendant at places of disposal of dead bodies to give information about the dead. For this approach to be effective requires regulation of the disposal arrangements and setting up of machinery for the regular collection of notifications from such persons. In certain areas and communities, the practice in the country is to throw young ones in a running stream or to bury a very young infant in the home courtyard or even in the room where she was delivered. Even places of disposal of dead bodies are not demarcated. Public health laws require control of these malpractices but enforcement is ineffective. There is no system of burial permit. It is doubtful if the Government will introduce it for the present.
7. There are few instances in which community life is regulated by Government. The need to maintain a register of citizens has been felt in connexion with certain activities, like rationing of foodstuffs, electoral lists, malaria eradication programmes and panchayat (village administration) organization, but only disjointed ad hoc measures have been taken to tide over the immediate problems. No long range integrated scheme has been adopted. A register of citizens was prepared from the census records. of 1951 but it did not work out successfully. Panchayat rules provide for the maintenance of a list of residents of the areas under its jurisdiction, but the inability to keep it up to date has made it almost a useless record. It cannot be denied that the maintenance of a register of citizens will go a long way in ensuring completeness of birth and death regis-tration.
8. It is clear that any scheme of improvement has to take into account the situation stated above. In view of the enormity of the problems, the main emphasis for the present has to be on netting every birth and death. The problem of ensuring correctness of registration particulars, which in the present circumstances have to be simple, can be tackled by insisting on the particulars being verified from the household concerned.
9. From the foregoing account, it is evident that for completeness of registration a local registrar cannot wholly depend on household or the institutional reporting. This is an important difference in the duties of a local registrar from those in countries where registration is complete. There he has to record the events faithfully as reported to him. But in a country like India, he must take steps to get information of every birth and death to ensure that unregistered events are duly registered. In other words, he has to develop a system of notifiers from amongst those who come to know of a birth or death in the performance of their own specific duties or because of the social position they occupy in the community. Notifications will give the addresses where birth or death occurred and thus enable detection of events which are not registered by the household. Registration particulars will still be furnished by the household. Potentialities of developing agencies of notifiers vary from area to area so greatly that it is difficult to lay down any cut and dried formula; much depends on the local initiative. In fact, one of the major tasks of the local supervising agency would be to guide the local registrar as to the steps he should take to ensure completeness of registration. In the municipal areas, it is possible to use as notifiers the agencies of midwives, domestic sweepers and attendants at places of disposal of dead bodies, and arrangements can be made for collection of the information and passing on to the registrar. In other areas, such services are not available and the registrar will himself have to contact the notifiers. It may have been true in the earlier days that in villages everybody knew everybody and hence anybody could furnish information about the occurrence of a birth or a death in the village, which, being unusual events, automatically attracted attention. The present experience is that even in villages these conditions do not obtain, and particular types of persons have to be tapped for the purpose. The village indigenous midwife and other persons socially integrated in the village life are useful in this connexion.
10. In the previous times, the village watch-
man or the petty revenue official was easily able to gather such information and report weekly or fortnightly or monthly to the subdivisional headquarters police or revenue post. But these agencies are now disappearing or are at least finding it difficult to attend to registration work properly. They are yielding place to the panchayat organization, which is a sort of local administration by the village representatives. In theory, it is logically the right agency for registration work. Each panchayat has a paid, educated secretary. His jurisdiction may vary from one village to as many as eight to ten villages. He has to visit each village regularly and his activities have an intimate impact on the village life. He has to keep in touch with the more important elements in each village and can, without much extra effort, get information on births and deaths while he is going about his other normal duties. However, the snag is that as at present the administrative control on the secretary is not effective enough to ensure disciplined work, such as was possible under watchman-reporting in the old days. The alternative of having a full-time registrar for a compact number of villages is unlikely to yield good results, besides being expensive. A more intimate integration of the registrar into the social life of the village is necessary than would be possible for an outside, visiting registrar. An appropriate arrangement is to have a locally resident registrar in each village, but, if that be impracticable, to have one who would cover a small number of villages and who would function almost as a local person in each one of them. It appears preferable to make the local administration responsible for registration and to utilize the part-time services of the locally available staff for registration work. However, this poses the important problem of local supervision, public education and training of registrars in guiding them as to how they should go about their job. The superstructural arrangements are built on this foundation.
11. The first stage in the edifice is the district organization under a district registrar to stimulate and develop good registration in the villages. The district health officer has a network of field staff spread over the district and has a direct interest in good registration statistics. His offices are proposed to be utilized for improving registration. He is to be an exofficio district registrar. The country has about 350 districts, which means that on the average each district has about 1,500 villages with a little over a million persons to handle. The function of the district registrar is to ensure timely submission of a monthly abstract of regi-
stration entries by the registrars, to organize inspection of registration work including spot checking of the completeness of registration, to conduct training of the registrars, to give guidance in regard to registration practices and procedures for ensuring completeness of registration and to organize public education in regard to the requirement of registering births and deaths. One of the present maladies is the non-submission of periodical returns by the local registrars. Careful studies carried out in somewhat better registration states show that 20 to 25 per cent of the returns do not reach the state office, and others are sent quite late. Only a few returns are received in time. It has been found that regularity in the submission of returns inculcates better attention to registration work, which would improve the data quantitatively and qualitatively. Another responsibility of the district registration office is to organize inspection and on-the-spot checking of registration work. This is an important measure in the scheme of improvement, as the local registrar is apt to fall into negligence if there is no local inspection. The peripatetic staff of various bodies like the health department, the state statistical bureau and the community development department is to be utilized for carrying out inspection on a systematic plan of local visits.
12. For organizing the above activities only a small staff, say a couple of assistants, is provided to the district registrar. The field work is to be carried out by the available field staff of public health and medical departments and other agencies. The district registrar's office is mainly to act as a liaison agency between the local registrars and the state office and as a watchdog to ensure that the programme outlined by the officials at the state and the district is actually carried out by the field staff of the different departments. The system of inspections, notifiers and cross-checking will give information on the efficiency of registration, on the basis of which the district registrar is to take toning action with the help of the appropriate authorities. In the initial stages, it may mean launching of systematic drives to promote good registration. A distinct role is to be played by the field staff of departments like bealth and community development in conducting propaganda for registration by the usual audiovisual means in fairs and festivals and public gatherings. This approach, of utilizing the good offices of the available network of other departments part-time, is dictated by considerations of cost and workload. An exclusive staff for registration only would be prohibitively expensive.
13. Only 17 per cent of Indian population lives in areas classified as urban, but of this just a small proportion have municipal committees with a well-spread field force of vaccinators and sanitary staff and a distinct health department for each town. A different approach is possible in the case of such towns, as they have hospitals, private medical practitioners, midwives and defined places of disposal of dead bodies. By regulating their role in registration substantial improvements can be made. It seems possible to secure good registration by enforcing household reporting supported by a notifier system to detect unregistered events. For this purpose it is found essential to strengthen the statistical unit at the town office for administering the registration byelaws and procedures. Co-operation of the public is to be sought not only by educational propaganda but also by creating incentives through institution of measures like production of a birth certificate on school admission and other contingencies, and of a death certificate for proof of death. Efforts are to be concentrated on getting reliable cause of death statistics by enforcing medical certification of cause of death and their separate tabulation. Inasmuch as vital statistics are of operational interest to the health department, municipalities are to be encouraged to compile their registration data, provided necessary facilities are available. On considerations of cost, a phased programme of covering municipalities of different-size groups has been chalked out, the bigger ones-where comparatively smaller assistance is neededbeing taken up first. In fact, throughout, the programme visualizes development of a rapidly widening area of good registration on a phased basis.
14. It is evident that a programme of the type outlined above, which banks on utilization of a part-time staff of various departments, requires a strong unit at the state office to control and develop registration in the state. Great importance is attached to the setting up of such a unit and the staff at various levels of clerks, assistants and officers is suitably reinforced. The officer-in-charge of the unit is to have a sufficiently high status with a wide outlook so that he may be able to elicit co-operation of other departments and organize an efficient working system.
15. Further, mechanical tabulation unit is an important instrument in the scheme of improvernent. Vital statistics will be compiled at the state office from abstracts of registration entries. Not only will it avoid errors that creep in at the different stages of flow due to lack
of scrutiny of data and in different compilation, but also it will facilitate detection of areas of deficient registration and those not submitting returns, so that remedial action may be taken. It will be easy to prepare as a by-product an efficient index of births and deaths registered from the punched cards. Such an index will make tracing of events a simple matter. This should stimulate use of birth and death certificates and hence encourage good registration. It will also be possible to undertake analytical studies for finding out the typical characteristics of events, which are not reported. Special units for registration, promotion and operational research in data collection are being set up by the central Government. A separate action research fund to give financial assistance to local registration authorities in the initial implementation of new registration procedures and practices has been set up. The reinforced state unit is expected to play the dynamic role in developing good registration.
16. Sample surveys and sample registration to serve the immediate need of data to indicate trends in vital rates have already been mentioned. Efforts are to be made in another direction also to collect reliable vital statistics for certain areas by tapping the potentialities of rural health centres. These centres have a network of peripatetic staff for rendering public health and medical services. The family planning organization also is putting in its field force. It is also interested in good national
vital statistics for evaluating results, tracking trends and operational purposes. A scheme has been outlined for collecting information on births and deaths through the agency of such staff. The data so collected will serve as a check on normal registration, which is proposed to be kept distinct. The health centres are preoccupied with their specific health activities. Special attention is being paid to the collection of cause-of-death data through the para-medical personnel. The staff would contact the household and collect information on the circumstances of death so as to fix the cause according to a non-medical list. A pilot study has shown that it is practicable to collect data, which should be quite useful to public health and medical workers for organizing their activities. If they will not give a precise cause in many cases, they would still serve the useful purpose of indicating areas, which should be studied more closely by investigating individual cases.
17. The programme is further supported by the enactment of a Central Registration Act, which blinds the registration staff in a single hierarchy vesting the central Government with adequate powers to direct states to take steps to develop a good system of registration. So far the states and quite often local areas have their own laws and rules. The Central Act aims to bring all these areas and states with diverse rules and regulations under one enactment, so as to ensure a minimum standard for all.

## Criteria for data adjustment

Nathan Keyfitz and E. M. Murphy

1. For many countries, states, cities, and other territories, we have information regarding (a) population by age and sex; (b) births; (c) deaths; and (d) migration, at a number of points of time, this information being either incomplete or self-contradictory or both. From the viewpoint of such basic demographic data, countries may be ranged in a continuum from Sweden, where items (a), (b), (c) and (d) are available with considerable apparent accuracy at five-year intervals since at least 1780 , through France, Britain, the United States and India, in which the period covered by official data is shorter, but nonetheless considerable, down to countries which have one or two recent censuses and nothing else. An attempt will be made in this paper to set up a framework in which the problem of extracting a consistent and realistic numerical description of demographic evolution of a country may be discussed. The object is to provide a view of the choices to be made, since even in a realm in which arbitrariness is inevitable, decisions are likely to be better when they are made explicitly, and with alternatives in mind.
2. Consider a workmanlike procedure, of a kind which furnishes the inspiration for any more systematic plan. With a set of more or less accurate censuses, plus the assumption that over-enumeration in censuses is rare and underenumeration common, plus some guesses at the expectation of life or other index of mortality as it changes over the period covered by the censuses, plus some statistics or guesses at the amount of net immigration and its incidence by age and sex, one can do a great deal. Referring for concreteness to Swedish data, on which we have done some computation, the first step would seem to be interpolation to a standard set of five-year age groups. The result of this is such statements as that there were 97,267 males 15-19 in 1780, and 91,167 males $20-24$ in 1785 . The probability of surviving five years, ${ }_{5} L_{20} / 5 L_{15}$, is given by the life table we calculate from 1780 deaths and population to be 0.96991 , and from 1785 deaths and population, to be 0.95419 . We could average these two survivorship ratios, obtaining 0.96205 , multiply this by the 97,267 males 15-19
in 1780, to obtain 93,576, an excess of 2,409 over the 91,167 males $20-24$ supposed to be counted in 1785 . There would have been a gain in precision by using a life table based on all the deaths between the two censuses, or a simple subtraction of the actual deaths recorded at the relevant ages between, without the need for making a life table. If, on the one hand, no death statistics had been available, we could have made a guess at the expectation of life (actually 32.91 years for males in 1785 on our calculation), and then used a model life table with the guessed $\dot{e}_{0}$. If, on the other hand, the recorded emigration were taken into account we would have a closed set of data, and could have used the relationship existing in the closed set to obtain one degree of freedom for estimating errors.
3. But all this is pressing the data very hard. For these figures bear on (a) the completeness of the two censuses in question; $(b)$ the accuracy of the life tables; as well as (c) the accuracy of the emigration statistics. There is a minimum of four different facts or unknowns to be inferred in respect to this particular cohort and only one equation from which to infer them. The system is indeterminate in this statement, and no technique can be devised for dealing with it that does not incorporate some assumptions. Either we must obtain further equations to include in our model, without correspondingly increasing the number of parameters to be inferred; or alternatively we must somehow reduce the number of unknown parameters assumed to be aoting down to the number of (independent) equations from which we attempt to infer them.
4. It is not difficult to reduce the number of unknowns. Indeed, all one needs to do is to assume that the two censuses are complete and the life table is appropriate, and immediately one has net emigration of 2,409 , which may be used to assess the recorded net emigration. Or if one assumes the recorded net migration and the two censuses, the survivorship rate is available. To put the matter in general terms, any set of assumptions which sufficiently restrict certain of the parameters
will permit solution of the equations, so that the remaining parameters can be ascertained. Far from being insoluble, the problem has many solutions, and our work is to find which is the least unsatisfactory.
5. The general principle is to make assumptions which are as weak as possible. It seems weaker, for instance, to assume that birth rates for a given year are equally understated for the several ages of mother than to assume that they are all correct. It seems fairly weak to assume that a linear trend will describe completeness of death registration, subject to random errors, the slope of the trend line and the variance of departures from it to be ascertained from the data. If we are inferring numbers of births in a given cohort, say that of 1770-1775 for Sweden, by working back from censuses, then it seems weaker to assume the 1775-1780 life table value of $l_{0} / 5 L_{5}$ and the number of persons 5-9 in 1780 than to assume the 1850 census number $80-84$ and the validity of the 1775-1780 $l_{o} / 5 L_{80}$.
6. A presentation which makes the possible choices explicit is most compact in matrix terms. ${ }^{1}$ Our matrices will be assumed to operate on vectors consisting of standard five-year age groups $-0-4,5-9, \ldots, 40-45 .\left\{K_{\theta}\right\}$ is the vertical vector showing numbers in the nine age groups for one sex. If the projection matrix $M$ may be considered as a sum of $S$ which contains the survivorship factors and $B$ which provides for births, the only non-zero elements of $S$ are in the sub-diagonal, and of $B$ are in the top row. We think of the movement of the population from one date to the next as produced by a premultiplication by the operator $M=S+B:$

$$
\begin{equation*}
M\left\{K_{1780}\right\}=(S+B)\left\{K_{1780}\right\}=\left\{{ }_{c} K_{1785}\right\} \tag{i}
\end{equation*}
$$

where simple $\{K\}$ indicates the recorded statistics for the specified date, and $\left\{{ }_{e} K\right\}$ the calculated. We can compare $\left\{{ }_{0} K_{1785}\right\}$ with $\left\{K_{1785}\right\}$, and out of such comparisons derive information which can be fed back into the programme to secure better-or at least more consistent-results. In this presentation all formulx relate to one sex at a time.
7. The vector difference $\left\{K_{1785}\right\}-\left\{{ }_{c} K_{1785}\right\}$ contains nine numbers whose magnitudes are related in different ways to discrepancies in the data, such as differences of completeness of listing at each census. Let us call the completeness of the census $1 / u_{t}$ for time $t, u_{t}$

[^110]being an ordinary scalar number like 1.05 , so that the true age vector for 1780 , for example, is estimated by $u_{1780}\left\{K_{1780}\right\}$. We are not for the moment differentiating $u_{t}$ by age; if experience shows that we ought to recognize different degrees of completeness at different ages, then $u_{t}$ will become a diagonal matrix, in which there will be at least two different pro-portions-perhaps one for $0-4$ and one for subsequent ages.
8. What about the survivorship component of the projections? We could not properly apply a single factor to the survivorship ratios, ${ }_{5} L_{5} / 5 L_{0}$ etc., which constitute the matrix $S$ : it is deaths rather than population whose defective registration would be the major element of any error in $S$. Hence we subtract $S$ from the matrix with unity in its subdiagonal elements, which may be called $I_{s}$, and apply the correction $v_{t}$ at time $t$ to this, so that in place of $S$ we will write $I_{s}-v_{t}\left(I_{s}-S\right)$. Here, the fraction $1 / v_{t}$ represents the completeness of the death registrations. As in the case of the census we might later wish to differentiate completeness at the youngest age group from that of older groups.
9. The adjustment for under-registration of births requires a factor which we will call $w_{t}$, chosen in such fashion as to bring about an agreement between the projected population under five years of age and that which is shown at the census date to which the projection is made. Here as elsewhere the factor chosen to make the corrected data for successive periods consistent includes the incompleteness of the source or the simple inappropriateness of model fertility tables if these are used.
10. It is evident that much less information is available on age-specific fertility than on mortality. Probably in most situations, all that can be done is to assume a pattern of agespecific fertility, and then adjust the level by a constant factor. To adapt the viewpoint of econometric and psychometric theory, the separate true age-specific rates are not in general identifiable from the equations in the observations. ${ }^{2}$ If we think of an underlying structure as giving rise to the observations, so that a given structure generates one and only one distribution of the observed variables, then the question of identifiability is the question whether two or more structures could generate the same joint probability distribution of the observed variables. If they could, then they may be said to be equivalent, and only those parameters which are the same in all

[^111]equivalent structures are identifiable. For a parameter which may vary as among structures that give rise to the same distribution of observed values cannot be inferred from the observations, no matter how extensive these are. ${ }^{3}$
11. In so far as age distribution of mothers does not change from one date to the next, a variety of age-specific rates-assumed constant over time-will account for the changing numbers of births. Only if there are considerable alterations in the age-distribution of women of reproductive age, and the age-specific rates may be assumed constant, or changing in a known fashion, will it be possible to infer the several age-specific rates from the age distribution of censuses alone. Discrepancies between the projected number of children under five and the census count, if the age distribution of women were shifting appreciably, might lead to the inferring of both an adjustment for level and, say, the fact that the age-incidence pattern assumed involved relatively too high rates for the older ages. This last fact could be translated into a linear adjustment. One might even, if the variations in age distribution were very great, be able to infer a quadratic adjustment, using orthogonal polynomials. Even though without any strong hope of their being used, we can consider the diagonal matrix of linear terms, $L_{t}$, and of quadratic terms, $Q_{t}$. Hence the corrected or fitted birth rate matrix would be $B\left(w_{t} I+L_{t}+Q_{t}\right), I$ being the usual identity matrix consisting of ones in the diagonal and zeros elsewhere.
12. Again, there is no possibility of identifying separately the age distribution of migrants at each census along with the other unknowns, but we may reasonably hope to find their total number if they happen to be of a distribution by age distinct from the population which remains. Suppose the age distribution of net emigrants on a unit basis is given by the vector $\{E\}$ and their number by $x_{t}\{E\}$.
13. We are now ready to rewrite (i) in terms that we hope will bring the number of unknowns below the number of equations, and in addition will be of such structure as to permit identification of the correction factors:
\[

$$
\begin{array}{r}
{\left[I_{t}-v_{t}\left(I_{s}-S\right)+B\left(w_{t} I+L_{t}+Q_{t}\right)\right] u_{t}\left\{K_{t}\right\}} \\
-x_{i}\{E\}-u_{t+1}\left\{K_{t+1}\right\}=0 \quad \text { (ii) } \tag{ii}
\end{array}
$$
\]

Before going on to discuss the solution of (ii), we note that it represents as special cases a number of commonsense procedures for ad-

[^112]justing census and vital statistics results. If $v_{t}=w_{t}=u_{t}=u_{t+1}=1$, and $L_{t}=Q_{t}=0$, i.e., if all data except on migration are available and trustworthy, then the solution in $x_{t}\{E\}$ is the inferred migration by age. If $v_{t}=w_{t}=u_{t}=1$ and $x_{i}\{E\}$ is known, then $u_{t+1}$, the correction at the second census, may be inferred several times over. One could similarly infer $v_{k}$ if the censuses and migration are presumed known.
14. This way of looking at the matter is likely to be most fruitful if applied to a lengthy sequence of censuses. Then we may make the assumption that the correction functions $u_{t}, v_{t}$, $w_{t}, x_{t}$ are either constant, change gradually, or if they change sharply do so for all ages at the same time, or at least are the same for groups of ages. Assumptions of this kind would seem to be weaker than importing a life table from elsewhere, or at least can check the appropriateness of the life table.
15. For each intercensal period, the vector equation (ii) is made up of nine scalar equations, and accumulation over a number of periods provides an abundance of information that may be allocated between estimates and error of estimates. If we make $w_{t}$ a linear function of $t$ over each twenty-year period, put $L_{t}=Q_{t}=0$, and assume $u_{t}$ and $v_{t}$ to be quadratics for each successive nine censuses or forty years, we would have $8 \times 9=72$ equations over the eight intercensal periods, and only ten unknowns. (The unknowns would consist in two parameters for each of two periods for $w_{t}$; three parameters for each of $\psi_{t}$ and $v_{t}$.) With this abundance of equations, we could divide the period into shorter intervals, obtain separate solutions, and note the variation among solutions. We could thus secure some information on the consistency of our assumptions by assembling the equations into groups, solving for such unknowns as $u_{t}$, and then comparing the solutions. This would not cover the entire range of variation to which the system would be subject (e.g., it would not reveal a consistent under-enumeration uniform in all times and ages), but would still give some indication of the arbitrariness of the work.
16. We reduce the number of unknowns down to fewer than the number of equations, and also make the equations identifiable, by linking together the successive censuses and assuming that incompleteness changes in linear or quadratic fashion. Indeed, we go beyond this and have some extra data for estimating error by such linkage-we have a multiplicity of estimates. Once the superfluous estimates are on hand the problem is to select among
them. It is by no means obvious what criterion ought to be used in this selection. The choice of a median estimate; the arithmetic mean of the several estimates; these and other possibilities present themselves in sampling from an unknown universe. But in demography there is asymmetry between under- and over-enumeration; the former is far more common, and this precludes a fitting by any symmetric average.
17. The situation may be seen as similar to sampling from a distribution whose probability is J -shaped, e.g.,
$d F=\frac{d \delta}{2 \sqrt{\alpha \sqrt{\alpha-x}}} d\left|F \quad \frac{1}{2 \alpha}\right|_{\text {, }}$
where $\alpha$ is the true population of the country and $x$ is the number counted in a census; we assume a number of censuses to be taken all of which give a value of $x$, say the size of a given cohort, i.e., the births in a particular year. One estimate of the right-hand limit $\alpha$ of the distribution of $x$ is simply the largest element of the sample. One would take that set of parameters which gave the largest figure for the cohort, if inferring births from several censuses.
18. However, it is possible that in the foregoing we have made the whole problem more difficult than it need be. The fifteen non-zero elements in the $9 \times 9$ matrix are not independent facts; they and the many more elements generated in the powers of the matrix can be fitted fairly well into a three dimensional space, of which the axes are the three characteristic vectors having greatest modulus of the projection matrix. This being the case, we may try confining the fitting operation to the first three
vectors and the latent roots to which they correspond to represent the growth of the population.
19. Suppose now that an investigator has contrived a set of assumptions which enables him to replace the inconsistent data with a perfectly consistent set. In the case of Sweden it should be possible through the application of such assumptions as are described in the foregoing to arrive at a collection of life tables, census totals, births, and deaths such that starting with the adjusted population of any date, subtracting adjusted deaths and net immigration, and adding adjusted births, brings one exactly to the adjusted population at the next census date, age by age and for each sex. This very large fitting operation will substitute for over 10,000 originally published figures a complete new set. Call this new set, the first adjustment, $A_{1}$. With different rules, one can arrive at other adjustments, say $A_{2}, A_{3}$, etc., each perfectly consistent with itself and different from the raw data on all or practically all figures.
20. Some scoring system will be required for choosing between $A_{1}$ and $A_{2}$. One such system would score each discrepancy between the original and the adjusted figure by an amount equal to its square, with a weight of 10 if the adjusted figure was lower than the original census or other count, and a weight of 1 if it was higher than the original count; with a weight of 5 for births and deaths against 1 for migrants and numbers of population. The scoring system would have to be carefully thought out; relative to it all comparison of adjustments becomes perfectly objective, and it is possible to say which of the adjustments $A_{1}$ and $A_{2}$ is on the whole better, by noting which has the lower score.

# The problem of estimating vital rates in Pakistan 

Karol J. Krótiki

## Introduction

1. This paper deals with three aspects of estimating vital rates in Pakistan: an obstacle, an impossible solution and an unorthodox alternative. The obstacle is the inability of the current registration systems ever to become comprehensive, owing to inherent characteristics. The impossible solution is the use of certain analytical techniques: untraditional errors in age reporting prevent an accurate estimation of fertility, while inter-censal growth (and consequently, mortality, as a residual of subtracting growth from fertility) is suspect because of political and religious migration and enumeration biases. The unorthodox alternative is the population growth estimation experiment, known in Pakistan as the PGE experiment.
2. Variety, unreliability and importance of vital rates. In the short period of a few years, the rates of population growth used in official documents grew from 1.4 per cent in 1957 through 1.8 and 2.2 to 2.6 per cent in $1963 .{ }^{1}$ There are now strong indications that the current rate is considerably higher. ${ }^{2}$ While there was probably an acceleration in the rate of growth, the figures quoted are not proportionate to changes in growth. With the role of vital rates critical to the future of Pakistan, the uncertainty about their actual level is a serious cause for concern. The endeavours to narrow this uncertainty are described below.

## The obstacle

3. The vested interest of the public. No

[^113]views about the rate of population growth can be formed from the products of the current vital registration systems. They cover a small and erratic proportion of all vital events. To improve the systems within a reasonable period of time, it would be necessary to overcome the obstacle of over-all inertia, which may be divided into four parts.
4. The first is that the public is content to continue with the current erratic systems. In fact, the people see an actual advantage in not having births registered, in that the absence of a birth certificate makes it difficult to enforce rigid age limits at stages of one's life when age is a determining factor: admission to school, early marriage, admission and promotion in public life, and/or compulsory retirement. Unless a law is passed immediately, stipulating that in six years' time the admission of a child to school without a birth certificate will involve a stiff admission fee, any attempt to spread registration will be defeated by the advantages of not being registered.
5. Organizational vacuum. The registration of vital events is one of a score of statutory duties of the village organization under one department. At the top the responsibility rests with another department, which has a multitude of other and different interests, the task being handed over ${ }^{3}$ at stages of the service channels, varying between different parts of the country. Plans for a truly national registration system concentrate on the organizational structure and tend to ignore problems at the village level.
6. International influence. Thirdly, attention given to the problem is influenced by the prevailing international atmosphere. Parallel to a Panel on Vital Statistics, a Panel on Health Statistics has been established, as if any progress at all could be made with determining

[^114]causes of death. The prevailing climate of international opinion, combined with advice to do everything that the developed countries have done, cannot be resisted however detrimental it may be to the solution of problems which need effective and urgent attention. ${ }^{4}$
7. The gap between economics and demography. The fourth obstacle is the lack of demographic knowledge on the part of economists and the narrow horizon of demographic analysis. The economists are primarily concerned with the rate of growth; they then take off, if not necessarily in the Rostowian sense, into the realm of economic calculus with the population $r$ as an independent and given variable. Once a rate of growth is established in some manner, often by "being mentioned", the interest in having up-to-date and more accurate rates wanes.

## The impossible solution

8. Effective methods of demographic analysis. Vital rates of many a country with inadequate statistics have been estimated recently through the stable population theory. Birth rates are estimated from age distributions and as long as some estimate of intercensal growth can be obtained, the death rate becomes a mere residual.
9. Crucial to this procedure is a good estimate of age zero by sex or at least of age group 0-4, also preferably by sex. However, large omissions at these age groups are frequent. Statistics on age group 5-9, "even where the age data are generally very defective ... appears to be more accurate than others". ${ }^{5}$ After an extensive investigation of age groups in Asian countries it has been concluded that "practically in all cases, the age group 5-9 loses a little to the age group 10-14. The age group 5-9 can be assumed to give a fair estimate of the birth rate". And, again, the "effect of

[^115]under-enumeration of children can be overcome to a large extent, if instead of children in the age group 0-4, those in the age group $5-9$ are used". ${ }^{\text {B }}$ In addition to sound information on age distribution, the analytical procedures call for some estimates of inter-censal growth and as little migration as possible.
10. Deterrents to effective demographic analysis in Pakistan. The population of Pakis$\tan$ has been unable to avail itself of the advantages of the quasi stable-population theory because of deficiencies in three vital areas: recent age distributions are suspect, four recent inter-censal rates of growth were distorted and there was considerable migration.
11. During the 1951 census, fewer questions were asked in respect of persons below age 12 . Whether this or some other cause resulted in heaping below 12, there were other influences (population losses during the 1947 partition, usual heaping at age 10 and usual underenumeration of children) to draw suspicion away from this heaping. Analysts may, therefore, have had some excuse for taking the 1951 age distribution seriously, though the fact that contrary to historical experience, West Pakistan was showing higher fertility (because there was more heaping) than East Pakistan should have been a warning.
12. In 1951 the cut-off age was lowered from 12 to 10 and the questionnaire was rearranged to make it less worth while for the enumerator to classify teen-agers as being below 10 . Whether, despite this change, there was some heaping below age 10 , is the most crucial question in Pakistan demography. In any case, age group 5-9, a firm pivot in other populations, on which entire age distributions are built, is under suspicion in Pakistan.
13. The inter-censal rates of growth are suspect because in the last five censuses there were such special influences as under-enumeration (which occurred during a passive disobedience campaign against the imperial régime) and over-enumeration (owing to communal eagerness to show communal gains in population size).
14. Migration was a source of trouble to demographic analysis long before the Partition. The areas in the Indus valley brought under cultivation through increasing irrigation attracted immigrants into what is now West Pakistan. Calcutta and the tea-gardens of Assam always attracted immigrants from what

[^116]is now East Pakistan. The post-partition exchange of population between Pakistan and India was about equal (over 7 million each way) and, being largely of the family type, need not have done much violence to the requirements of the stable-population theory. Unfortunately for the application of the theory, East Pakistan being the loser of population and West Pakistan the gainer, the movements did not counterbalance except, perhaps, in the limited sense of treating the two populations of Pakistan as one (which is demographically uninteresting).
15. Palliatives. Confronted with an unhelpful situation, demographers had recourse to unusual alternatives, such as the use of statistics of primary vaccination against smallpox. ${ }^{7}$ Surveys depending on respondents and recollection, after an initial hope, ${ }^{8}$ produced inadequate results. It is surprising that the dearth of analytical material did not, so far, provide a fertile ground for drawing analytical conclusions from the relationship (reverse, contrary to intuition) between fertility and size of household.
16. There are available, of course, the various methods of analysis suggested, and also tried, in respect of populations with inadequate data, by Bourgeois-Pichat, Brass, Clairin, Coale, Demeny, El-Badry, Jain, Lorimer, Myburgh and others, including the active group of students and teachers at the United Nations Demographic Training and Research Centre in Chembur. However, for one thing, the variety of methods available would require greater interest in Pakistan demography than in the past. For another, all these methods require some basic information (sometimes of an unorthodox nature), which is seldom available in Pakistan, partly because, with the full paraphernalia of a decennial census, the need for usable information is not immediately apparent.

## The unorthodox alternative

17. The population growith estimation experiment. The population growth estimation has been in existence since the end of 1960 . It already has a rich literature and only salient points need be repeated here. The experiment rests on the belief that it is possible to record

[^117]twice the vital events of the same population independently of each investigation. It further rests on the belief that records from the two surveys can be compared one by one, and those in respect of the same event, but coming from two different surveys, can be matched. From such a comparison, three categories of events would be obtained: those caught by both surveys and those caught by one only (say, either registration or enumeration). It is believed that from these three categories, an estimate of the fourth category (events missed by both surveys) can be made. ${ }^{9}$
18. Features peculiar to the population growth estimation. Population growth estimation involves continuing registration by fulltime registrars and quarterly enumerations by enumerators. There are twenty-four sample areas selected at random with a total population of 120,000 . The headquarters activities and the analyses require a staff of about forty. There are eight manuals of instructions in existence, and several volumes of reports are under preparation. The annual cost of the experiment is about $\$ \mathrm{US} 100,000$, of which about half is met from foreign sources ${ }^{10}$ and about half from the budget of the Central Statistical Office. Obviously, an organization of that type and size has many intricate features ${ }^{11}$ and it is not possible to summarize briefly all the population growth estimation literature. The differences with the parental blueprint ${ }^{12}$ can be listed as follows:
(a) The country-wide random sample is intended also to provide significant results for each of two provinces;
(b) There is four-fold enumeration of each vital event, once every quarter in respect of events during the preceding twelve months;
(c) Stillbirths are recorded and a pregnancy question is asked of each woman once a quarter;

[^118](d) Base population is obtained through a full census once a year, brought up to date by quarterly inquiries and linked throughout all the years of the inquiry;
(e) Each inhabited dwelling in each population growth estimation area is placarded with a unique population growth estimation number and shown on a population growth estimation map; the uniqueness of numbers is intended to prevent the confusion of names;
(f) Special steps are taken to secure independence between the two parts of the experiment (see following section).
19. The condition of independence. This condition, together with the ability to match records event-by-event, is crucial to the experiment. The two investigations are independent of each other organizationally, different in their content. Both are samples thrown on to the same population from different angles. It cannot be denied that if collusion between any enumerator and registrar were really intended, it could not be prevented, particularly when an enumerator was staying in the registrar's quarters.
20. The following features of the procedure ensure that collusion is not worth while:
(a) Enumerators are never blaned for vital events registered but not enumerated; registrars are never blamed for vital events enumerated but not registered;
(b) Field inspectors checking unmatched vital events do not know whether they deal with a registered or an enumerated event;
(c) Registrars keep registers and ancillary forms for a limited period only, so that copying by enumerators from the registers is not possible for long periods back;
(d) An enumerator is in the area four times a year, for a month on each occasion; registrars report their vital events monthly and their actual movement weekly; a flood of registrations during an enumeration month would draw the headquarters' attention;
(c) The enumerator is preoccupied with the study of household composition; the enumerating of vital events is a small and final part of his work (there would be no point in copying a small job, if the large and really exacting one must be done and integrated with small ones).
21. Matching experience. A good matching procedure will guard against two errors. It will avoid mismatches when insufficient items are compared. It will not fall into the opposite error of disregarding true matches by insisting on too vigorous a match, when differences between documents may be formal or due to faulty information.
22. In an attempt to steer the population growth estimation between the two errors, an involved series of matching procedures has been built up. Mechanical matchings of ptunch cards (several attempts on several alternative items) provide two-thirds of all the matches. The remainder are manual matches topped of with a few matches ascertained in the field, when reference back is required in the case of particularly recalcitrant events. The main cause of the matching difficulties lies in the indeterminate and changeable nature of names and their spelling.
23. Main substantive findings. Subject to confirmation, the following crude vital rates (per 1,000 population) have been obtained through the application of the formula given in a recent publication. ${ }^{13}$
${ }^{13}$ C. Chandra Sekar and W. Edward Deming, op* cit.

|  | East Pakistan |  |  | West Pakistan |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Births | Deaths |  | Births | Deaths |
| $1962 \ldots \ldots \ldots \ldots$ | 55 | 20 |  | 49 | 19 |
| $1963 \ldots \ldots \ldots \ldots$ | 56 | 19 | 52 | 19 |  |

These rates are higher in the case of births and lower in the case of deaths than most analysts would expect. If the results of the registration only were taken into account, the rates would be some 10 per cent lower in 1962 and some 15 per cent lower in 1963. Ignoring the "fourth category" would make practically no difference. It is possible that a point or two should be added for deaths in institutions,
omitted from the population growth estimation sample.
24. Main methodological findings. Subject to confirmation, there seems to be no change in rates calculated separately for homogenous sub-groups. Such apparent absence of discernible correlation between the two parts of the experiment increases faith in their indepen-
dence. Subject to confirmation, it appears that in areas (mainly urban) with low initial registrations and enumerations, the proportion of matches is also low, resulting in high second, third and fourth categories and an evening out of rates between areas. It remains to be seen whether this is a true demographic feature or an accident of inadequate matching.
25. Allowing for change in the value of money, Chandra and Deming were ready to estimate vital rates for 1 million to 2 million peoples with a standard error of 5 per cent for Rs 30,000 . The population growth estimation is doing the same for two populations of about 450 million each with, it is hoped, smaller percentage of error, for Rs 300,000 , when expenditure on activities not related to the estimation is ignored.
26. The purity of the allegedly random sample needs to be investigated. An unbiased
observer recently introduced to the population growth estimation reported that the population growth estimation areas seem to be the "most central and most populated parts". ${ }^{14}$ In spite of the high birth rates registered, the pregnancy rate is low. Another survey in Pakis$\tan ^{15}$ had somewhat better experience, but the data obtained are still far from complete. The greatest uncertainty is connected with the denominator of the vital rates, for which insufficient provision has been made in the plans. As the records of the population are built up over the years, it is hoped that even the more elusive parts of the population will participate in the surveys and strengthen confidence in the denominator.

[^119]
# Estimation of vital rates in the Indian National Sample Survey 

Murarimohan Majumdar

1. The National Sample Survey (NSS), started by the Government of India in 1950, is a continuing series of socio-economic surveys conducted in successive rounds. Its geographical coverage includes all of India. Though the emphasis in this survey has been on the economic side, lack of reliable vital data on a national scale was taken into consideration, it: the context of the defective registration system, and a small block on fertility was introduced in one of the schedtules in the second round (April-June 1951). The purpose of this block was to collect material for assessing the level and trend of fertility and it remained part of the NSS schedule in subsequent rounds through the sixth. In the seventh round (October 1953-March 1954), a revised format was introduced for collecting information on current events of births, marriages, deaths and sickness in the sample households. The sample design was multi-stage stratified with interpenetrating network of sub-samples and with households as the ultimate units.
2. Information on births, deaths and marriages was collected with reference to the year preceding the day of survey. The data on births related to all women who were members of the sample households on the day of enquiry or, if deceased, had been members on the day preceding the day of death. The data on marriages similarly related to all male members and those on deaths to all persons who had been members of the sample households on the day preceding the day of death. In the schedule, besides certain household characteristics and demographic particulars in respect of each member of the sample household, information related to the event of birth or death itself was recorded in the relevant sub-block. Various measures relating to fertility and mortality, as also to marriage, were thus available for the whole country as well as for the different regions.
3. The birth and death rates were estimated as 34.6 and 17.6 respectively for the rural areas and 33.8 and 17.0 respectively for rural and urban areas combined, the sub-sample variation being not large for either rate and estimates of
the standard error being 1.0 and 1.1 respectively for the rural birth and death rates. ${ }^{1}$ The birth and death rates estimated from the census for the decade 1941-1951 were, however, 39.9 and 27.4 respectively, the mean decennial growth rate being 12.5 per 1,000 population. ${ }^{2}$ For the succeeding decade 1951-1961, the growth rate jumped to 21.5 per cent. ${ }^{3}$ The estimates of birth and death rates obtained from the NSS seventh round were thus appreciably lower than the census estimates for the decade 1941-1951, though the estimated rate of natural increase of 16.8 per 1,000 population was much nearer the prevailing rate of population growth than what was known about the decade 19411951.
4. In the analysis of fertility based on second and fourth round data, under-reporting of number of children born had to be taken into account and the reported level of 6.1 for completed fertility was adjusted to 7.4. ${ }^{4}$ In the seventh round, though the enquiry had reference only to the preceding year, it related only to the occurrence of births and deaths and did not concern each individual couple as in the fertility enquiry of earlier rounds. The nature of the enquiry being thus different, the chances of omission could not be assessed simply from the experience of earlier rounds. Also, apart from recall lapse in regard to the event itself, there might be, due to ignorance or bias, undue inclusion or exclusion of events which had occurred near the end-point of the reference year.
5. In the appropriate portion of the schedule, the month of occurrence of the event of birth or death was recorded together with other particulars. The ages in weeks at the time of survey or of death were also noted in

[^120]respect of all live-births. The distribution of births by month of birth prior to month of survey revealed a peculiar feature-apart from an apparently erratic movement at certain
months, it represented a progressively decreasing series in moving back over the year (table 1, below). Also, though the ages of infants were recorded in weeks, there were heapings

Table 1. Percentage distribution of the number of births and deaths in month of event prior to month of survey: NSS 7th round rural, 1953-1954

Number of sample villages - 954; number of sample households - 8,235

| Month of survey - month of event |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & 0 \\ & 0 \\ & (1) \end{aligned}$ | $\begin{aligned} & 1 \\ & (2) \end{aligned}$ | $\overline{2}$ | $\begin{aligned} & 3 \\ & \text { (4) } \end{aligned}$ | $\begin{gathered} 4 \\ (s) \end{gathered}$ | $\stackrel{5}{(6)}$ | $\begin{aligned} & \hline 6 \\ & (7) \end{aligned}$ | $\begin{gathered} 7 \\ (8) \end{gathered}$ | $\begin{gathered} 8 \\ 8 \\ \hline(9) \end{gathered}$ | $\underset{(10)}{9}$ | $\begin{gathered} 10 \\ (1 I) \end{gathered}$ | $\begin{gathered} 11 \\ (12) \end{gathered}$ | $\begin{gathered} 12 \\ (13) \end{gathered}$ |
| 6.36 | 9.78 | 9.47 | 9.41 | 8.95 | 8.99 | Births 9.30 | 7.51 | 8.16 | 6.86 | 7.08 | 5.78 | 2.35 |
| 7.16 | 11.12 | 10.78 | 10.63 | 9.55 | 9.47 | $\begin{aligned} & \text { Deaths } \\ & 8.97 \end{aligned}$ | 7.01 | 7.67 | 4.45 | 3.69 | 5.93 | 3.57 |

Source: Government of India, "Vital rates", National Sample Survey, No. 54 (New Delhi, 1962).
at ages which were multiples of 4 and at age 26, obviously due to reporting of ages in months, in respect of infants surviving up to the time of enquiry-the total number reported at these ages forming 53.1 per cent of all surviving infants. Also, the proportions reported at ages of multiples of four weeks were relatively much higher for infants born during the earlier part of the reference year-the failure to report ages accurately being naturally more frequent in respect of older infants. Such errors in regard to age may not, however, have affected the distribution by month of birth. The rise in the number of births in the sixth month prior to month of survey probably reflects a bias for six months and consequent shift in the month of birth in reporting. Apart from such bias, it appeared that an appreciably large number of births were missed due, in particular, to reporting lapse with regard to infant deaths occurring during the earlier part of the reference year. ${ }^{5}$ The number reported for a short interval prior to the day of survey is likely to be free from the effect of the bias as well as from substantial omission due to recall lapse. As, however, the number pertaining to the first month was comparatively large, apart from the question of larger sampling error and seasonal effect, the aggregate for the quarter preceding the day of survey was used as the basis for assessing the level of the birth rate.

[^121]The distribution of the number of deaths by month of death prior to month of survey showed similar, though still larger, declines in moving back over the year and the same principle was followed for adjustment of the death rate as for that of the birth rate. The revised birth and death rates came to 42.2 and 23.9 respectively and the rate of natural increase to $18.3 .6,7$
6. In the fourteenth round (July 1958-July 1959), the collection of information for estimating current birth and death rates was accorded a high priority and a separate schedule was canvassed for this purpose for the first time in NSS. The enquiry was conducted only in the rural areas but it was spread over a larger number of villages in which each and every household was visited for collection of the required information. Each state was divided into a number of strata and from each stratum, two independent sub-samples of six villages were drawn systematically. The survey year was divided into six sub-rounds, each of two months' duration and the same two investigators worked in a particular stratum through

[^122]the entire survey period, each investigating a sub-sample of six villages, one in each subround. By this method two independent and interpenetrating sub-samples were obtained for each of the six sub-rounds. In the first two sub-rounds, detailed demographic particulars about each member of the sample household were collected while in the later sub-rounds only summary information on a household basis was obtained, though the block relating to births and deaths was practically the same in all the sub-rounds. Information on deaths in single-member households was sought from neighbours and responsible persons in the village as also from every tenth household surveyed.
7. The reference period for births and deaths was extended to two years in this round, so that, though in the final estimation of birth and death rates, the data relating to a shorter period like the preceding year could be used, the information relating to a longer interval
would be available for an assessment of the effect of recall lapse and timing bias. In the fifteenth round (July 1959-July 1960), the same set of sample villages were surveyed and the reference period was again taken as two years so that what was "last year" in the fourteenth round became "year before last" in the fifteenth.
8. The birth and death rates in the fourteenth round, based on events only of the last year, came to 38.3 and 19.0 respectively (table 2 , below). These estimates were higher than those obtained earlier, the birth rate, in particular, being appreciably higher than the seventh round estimate of 34.6 . As there had been, in all likelihood, a decline in morality, because of anti-malarial and other public health measures, in the period intervening between the seventh and fourteenth rounds, the reporting of deaths in the latter round could be regarded as even better than what a comparison with the seventh round would suggest.

Table 2. Birth and death rates from two interpenetrating samples in the six sub-rounds: NSS 14th round rural, 1958-1959
Number of sample villages - 2,538 ; number of sample households - 234,344

| Sub-round <br> (1) | Birth rate: sub-sample |  |  | Death rate: sub-sample |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} 1 \\ (2) \end{gathered}$ | $\begin{gathered} 2 \\ (3) \end{gathered}$ | Combined <br> (4) | $\begin{gathered} 1 \\ (5) \end{gathered}$ | $\begin{gathered} 2 \\ (6) \end{gathered}$ | Combined (7) |
| 1. | 38.37 | 38.56 | 38.47 | 18.98 | 19.62 | 19.05 |
| 2. | 38.76 | 40.45 | 39.66 | 19.50 | 19.89 | 19.70 |
| 3. | 37.49 | 35.00 | 36.36 | 19.82 | 18.81 | 19.36 |
| 4. | 41.63 | 38.65 | 40.13 | 21.57 | 19.08 | 20.32 |
| 5. | 36.33 | 37.33 | 36.85 | 20.04 | 17.24 | 18.60 |
| 6. | 38.13 | 37.65 | 37.87 | 16.28 | 17.22 | 16.79 |
| 1-6. | $\overline{38.50}$ | 38.02 | 38.26 | $\overline{19.47}$ | 18.58 | 19.02 |

[^123]9. The birth and death rates estimated for each of the six sub-rounds are presented in table 2. The birth rate in the first two subrounds in which more detailed information was collected in respect of household members came to be higher than in later sub-rounds-both the sub-sample estimates in these sub-rounds being higher than those in any other sub-round excepting the fourth. The estimates of the death rate, however, do not vary in the same manner as between the first two and other subrounds, though the rate came to be appreciably lower in the last sub-round. Also, though the variation between the two sub-samples is not large for the whole round for the birth as well as for the death rate, there is wide divergence
in the sub-sample estimates for some of the sub-rounds. These comparisons point to an element of uncertainty in the estimates obtained though these showed an appreciable improvement over earlier rounds.
10. The births and deaths reported for "the year before last" in the fourteenth round were only 69 and 45 per cent respectively of those for "the last year". ${ }^{8}$ Also, if the birth, death and natural increase rates estimated in respect of "the last year" in the fourteenth round are taken as 100 , the estimates obtained from the

[^124]fifteenth round for the same period, that is, "the year before last", come to 73, 46 and 99 respectively. ${ }^{9}$ These data provide some measure of the relative underreporting of vital events as one passes from the last year to the year preceding.
11. An idea of the errors in reporting in regard to only the events of the preceding year can be had from the distribution of the number of births in the sample, classified by interval elapsed since the time of occurrence of the events presented in table 3. Apart from a rise through the fifth and sixth months, the distribution represents a progressively declining series as the events recede from the time of the survey. The upward swing in the fifth and sixth months and the slump at the seventh is most probably due to a bias in reporting age and the corresponding month of birth. The distribution over the entire reference period of
${ }^{9}$ Ibid.
two years was found to be characterized by a sharper rise at the twelfth and thirteenth months and a rise again at the seventeenth and eighteenth. Obviously the reported frequencies reflect a bias at 6 months, 1 year and $11 / 2$ years which affected the distribution around certain months. The numbers reported for later months of the reference period do not indicate such a bias though the proportion for the same month as the month of survey may be regarded as rather unduly large. In any case, an undue preference for the first month would be balanced by the deficiencies in subsequent months if the birth rate is adjusted on the basis of the preceding quarter during which the decline, presumably due to recall lapse, is also not large. The revised birth rate comes to 42.5 compared to the unadjusted rate of 38.3 . Similar adjustment would also raise the level of the death rate but from experience of the seventh round it appears likely that the rate of natural increase would be higher than the original estimate of 19.2 per 1,000 population.

Table 3. Percentage distribution of the number of sample births in month of birth prior to month of survey: NSS 14th round rural

| Month of survey - montit of bieth |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\overline{0}$ | $\begin{gathered} 1 \\ (2) \end{gathered}$ | $\begin{gathered} 2 \\ (3) \end{gathered}$ | $\begin{aligned} & 3 \\ & (4) \end{aligned}$ | $\begin{gathered} 4 \\ (5) \end{gathered}$ | $\begin{gathered} 5 \\ (6) \end{gathered}$ | $\begin{gathered} 6 \\ (7) \end{gathered}$ | $\begin{gathered} 7 \\ (8) \end{gathered}$ | $\begin{gathered} 8 \\ (9) \end{gathered}$ | $\begin{gathered} 9 \\ (10) \end{gathered}$ | $\begin{gathered} 10 \\ (11) \end{gathered}$ | $\begin{gathered} 11 \\ (12) \end{gathered}$ | $\begin{gathered} 12 \\ (13) \end{gathered}$ |
| 4.89 | 9.30 | 9.17 | 8.90 | 8.53 | 9.11 | 9.86 | 8.05 | 7.81 | 7.27 | 6.94 | 6.37 | 3.80 |

## Estimation of population and its components in a developing economy

Burton T. Oñate

## I. Philosophy in the estimation OF POPULATION

1. Many developing countries have considered central planning by the government as a means to generate social and economic development. With central planning and development, there will exist a circular process which consists of three stages, namely: preparation, implementation, and evaluation of the plans and programmes. As a developing country goes through this circular process, the statistical system must also develop in order to keep abreast of the needs of this development. Initially, as the importance of trade decreases relative to the increase in importance of production or output, there exists a national effort to estimate national figures on population and components of the labour force; national income and product accounts, national food balance sheets, and other important statistics on the national level. At this initial stage, the statistical system will devise methods of collecting, summarizing, and tabulating statistical information at the national level. As development proceeds, the need for information will be for regional or provincial levels. In support of this new interest, the
statistical system must reorient its collections. The official statistics at the provincial level also must conform to the desired qualities of reliability, timeliness, and usefulness. Thus, there will be not only provincial figures but also interprovincial flows of people and manpower, goods and services, trades, and funds. Input-output analyses are developed in addition to the levels of living as the statistical framework. In the Philippines, the historical development in the collection of population and labour force statistics from 1956 to 1965 follows this philosophy.

## II. Sources of porulation data in the Philifpines

2. Two basic sources of data on population and labour force exist in the Philippines. These are the censuses which are conducted at $10-$ to 12 -year intervals and the current or bi-annual national sample survey of households known as the Philippine Statistical Survey of Households (PSSH). The Philippines conducted its last population and housing census on February $15,1960$.

Table 1. The sample of the Philippine statistical survey of households for May 1956

| Regiont |  | $\begin{gathered} \text { Number } \\ \text { of } \\ \text { strata } \end{gathered}$ | Ruralareas |  |  |  |  | Urban areas |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | $\begin{gathered} \text { Number } \\ \text { of } \\ \text { sample } \\ \text { mumipal } \end{gathered}$ | Number of sample pablacions | Number of sample barrios | Number of sample households |  | $\begin{gathered} \text { Number } \\ \text { of } \\ \text { strata } \end{gathered}$ | Number of sample peecincts | Number of sumple households |
|  |  |  |  |  |  | Poblacions | Barrios |  |  |  |
|  | Total | 30 | 150 | 150 | 299 | 1,086 | 2,992 | 62 | 310 | 1,815 |
| I |  | - | - | - | - | - | - | 32 | 160 c | 730 |
| II |  | 2 | 10 | 10 | 20 | 89 | 256 | 2 | 10 | 91 |
| III |  | 1 | 5 | 5 | 10 | 53 | 135 | 1 | 5 | 32 |
| IV |  | 5 | 25a | 25 | 50 | 218 | 513 | 4 | 20 | 165 |
| V |  | 4 | 20 | 20 | 39 c | 213 | 409 | 5 | 25 | 151 |
| VI |  | 3 | $15{ }^{\text {a }}$ | 15 | 30 | 96 | 304 | 2 | 10 | 79 |
| VII |  | 5 | $25{ }^{\text {b }}$ | 25 | 50 | 147 | 477 | 4 | 20 | 163 |
| VIII |  | 6 | 30 | 30 | 60 | 174 | 569 | 4 | 20 | 163 |
| IX |  | 2 | 10 | 10 | 20 | 43 | 169 | 5 | 25 | 140 |
| X |  | 2 | 10 | 10 | 20 | 53 | 161 | 3 | 15 | 101 |

[^125]3. Registration of vital events also is an important source of information about the characteristics of the population. There were as of 31 March, 1963, 56 provinces, 1,358 municipalities, and 28,714 barrios. ${ }^{1}$ By law, the collection of vital events is the responsibility of the local civil registrars (city or municipal treasurers) in each city or municipality. There are 1,368 local civil registrars but only about 87 per cent of these $(1,190)$ report vital statistics.

## III. The Philippine Statistical Survey of Households (PSSH)

4. In view of the dynamic character of the population current and up-to-date statistics on the number, structure changes, and requirements of the population must be developed and maintained. The sources of current population statistics necessarily must come from national sample surveys, such as the PSSH. Statistics from censuses conducted at 10 - or 12 -year intervals are neither sufficient nor adequate to meet the demands for a continuous assessment of the nation's needs and resources. Timely, complete and accurate population statistics are necessary as the basis of a realistic and rational programme of development. ${ }^{2}$ The PSSH was originally designed to give estimates of population and labour force at the national level and for some characteristics at the regional level only. Developments in the PSSH are described by various authors. ${ }^{3,4,5}$ It was organized initially in 1956 as a joint project of the National Economic Council (NEC) and the Bureau of the Census and Statistics (BCS). The national survey was conducted in October 1956, May 1957, May 1958, November 1958, May 1959, October 1959, October 1960, May 1961, October 1961, April 1962, October 1962, May 1963, October 1963, and April 1964, a total of fourteen rounds in nine years. The design is known as multi-stage sampling where the primary sampling units (psu's) were drawn with complete replacement.

[^126]5. The summary of the sample of the PSSH for May 1956 is given in table 1. This structure of the PSSH has remained unchanged except for an increase in the size of the sample households and other minor revisions. The estimates of the major component of the labour force and the coefficient of variability (cv) of these estimates for the $1956,1959,1960,1961,1962$, and 1963 rounds are available. For example, the cv of the estimates of unemployment ranged from 2.18 per cent (October 1960) to 14.56 per cent (October 1959) or an average cv of 7.59 per cent for the eleven rounds. Results given in table 2 indicate that, on the average, the PSSH is capable of measuring small to moderate fluctuations in unemployment rates. Similarly, the estimates for persons 10 years old and over, number of employed and number not in the labour force have, on the average, cv's of 2 to 3 per cent.

Table 2. Estimates and coefficient of variation (cv) of estimates of population ten years old and over by labour status for the Philippines: May 1956 and 1959 to 1963 a

| Labour force status | Average co per cent (11 rounds) |
| :---: | :---: |
| Persons ten years old and over. | 2.46 |
| Labour force | 2.60 |
| Employed | 2.61 |
| Unemployed | 7.59 |
| Not in the labour force | 2.60 |
| Employment status not reported | .. - |

a Source of basic data: Philippine Statistical Survey of Households.

## IV. 1960 census as the sampling frame

6. Provincial administrators have realized the importance of the concept of development as evidenced by a number or provincial development plans. Thus, there must be available accurate data on population and its components at the provincial level. By the very nature of the PSSH sampling design, these statistical requirements at the provincial level cannot be provided for by the original PSSH. With the PSSH as the vehicle for the household food consumption surveys (HFCS), conducted by the Food and Nutrition Research Center (FNRC), then the results from these HFCS may also be given at the provincial level. It is important to note that the estimation of crops and livestocks from the Crop and Livestock Survey (CLS) of the Bureau of Agricultural Economics (BAE) is given by province for each crop year. The interactions of demographic, social, and economic characteristics
from the PSSH, dietary and nutritional status from the HFCS of the FNRC and the agricultural situation from the CLS of the BAE can be obtained and studied at the provincial levels. The results of the 1960 population census were used to estimate population count by province and the relative efficiencies of various alternative designs were derived. Some of these approaches were applied earlier in selected provinces of Luzon, Visayas, and Mindanao, ${ }^{6}$ in thirteen provinces of the Visayan region ${ }^{7}$ and for the entire country. ${ }^{8}$

[^127]7. One statistical tool which is effective in the preparation of homogenous strata is the use of paper strata. This technique consists of arranging the barrios according to increasing or decreasing population count. Such arrangement will ignore the geographical affinity of the barrios within a municipality but will result in substantial statistical efficiency as shown by the results in table 3. The upper bound of the $\mathrm{cv}(\hat{\gamma})$ in percentage for the paper strata is lower than those given for the municipalities as strata. The upper bound of the $\operatorname{cv}(\hat{\tau})$ is a very conservative upper estimate. Paper strata for 100,000 population count gave comparable results as the strata with 50,000 count. One important finding in the use of paper strata is that $N_{h} S_{h}$ is approximately equal in each of the $h$ strata. This implies that
$$
n_{h}=\left[N_{h} S_{h} / \Sigma N_{h} S_{h}\right]
$$
is a constant in each stratum. Equal take in each stratum will be equivalent to optimum

Table 3. Effects of paper stratification on the variability within strata in selected provinces. Philippines, 1960 population census
(Size of strata is about 50,000 )

|  | Province | Number of strata | $\begin{aligned} & \text { Ravoge of } \\ & \text { co in } \\ & \text { per cent } \\ & \text { within } \\ & \text { strata } \end{aligned}$ | $\begin{gathered} \text { Upper } \\ \text { boused } \\ \text { co (̂) } \\ \text { in per cent } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
|  | Philippines ${ }^{\text {a }}$ | 520 | - | 1 |
| 1. | Agusan | 6 | 10-79 | 53 |
| 2. | Albay . | 10 | 5-47 | 6 |
| 3. | Bataan | 3 | 25-55 | 24 |
| 4. | Batangas | 14 | 4-41 | 4 |
| 5. | Bukidnon | 4 | 15-51 | 16 |
| 6. | Cagayan | 9 | 7-66 | 12 |
| 7. | Camarines Sur | 16 | 3.43 | 4 |
| 8. | Catanduanes | 3 | 27-54 | 24 |
| 9. | Cebu | 26 | 2-48 | 2 |
| 10. | Davao | 16 | 3-31 | 3 |
| 11. | Hlocos Sur | 7 | 7-61 | 10 |
| 12. | Isabela | 9 | 7-29 | 5 |
| 13. | Laguna .... | 10 | 8.75 | 10 |
| 14. | Lanao del Sur. | 8 | 6-45 | 8 |
| $15-$ |  |  |  |  |
| 16. | Leyte | 24 | 2-82 | 4 |
| 17. | Masbate | 7 | 7-59 | 10 |
| 18. | Misamis Oriental | 8 | $14-48$ | 13 |
| 19. | Negros Occidental | 25 | 1-43 | 2 |
| 20. | Nueva Ecija | 12 | 6-52 | 6 |
| 21. | Occidental Mindoro. | 2 | 46-47 | 33 |
| 22, | Palawan | 3 | 30-57 | 26 |
| 23. | Pangasinan | 22 | 2-32 | 2 |
| 24. | Rizal .... | 27 | 2-49 | 3 |
| 25. | Samar | 18 | 3-38 | 3 |
| 26. | Sulu | 7 | 8-44 | 8 |
| 27. | Zambales | 5 | 17-37 | 11 |
| 28. | Zamboanga del Sur....... | 15 | 4-38 | 4 |

Source: Bureau of the Census and Statistics, 1960 Poptulation and Housing Consus of the Philippines; Report by Province, vol. 1 (12 May, 1962.)
a Does not include Metropolitan Manila.

Table 4. Distribution of urban population by category: Philippines, 1960

| Category | Pobulation (thousand) | Per cent |
| :---: | :---: | :---: |
| I. (Density/ $\mathrm{km}^{2}=1,000$ persons) | 3,211 | 11.8 |
| II. (Density $/ \mathrm{km}^{2}=500$ persons): |  |  |
| Poblacion (irrespective of size) | 373 | 1.4 |
| Barrios (at least 2,500 persons) | 362 | 1.3 |
| Barrios (contiguous and at least 1,000 persons) | 131 | 0.5 |
| III. (At least 20,000 persons) : |  |  |
| Poblacion (irrespective of size) .............. | 2,128 | 7.9 |
| Barrios (contiguous and at least 2,500 persons) | 813 | 3.0 |
| IV. Poblacion (at least 2,500 persons) | 1,085 | 4.0 |
| Total urban | 8,103 | 29.9 |
| Total, country | 27,098 |  |

Source: Bureau of the Census and Statistics, The Urban Population of the Philippines: 1960 (mimeographed paper) (1963.)
allocation of the sample into the various strata. Equal allocation also has the desired element of administrative simplicity and efficiency in the conduct of the survey.
V. Revision of the PSSH for 1965
8. The Philippine Inter-Agency Committee on Survey Design (PIACSD) recommended the revision of the PSSH. The revision envisions estimate of provincial total at 5 to 10 per cent coefficient of variation for the major characteristics of the population. Each province will be divided into an urban sector and a rural sector. For national comparability, the barrios must comply with the standard definitions for urban-rural areas. ${ }^{9}$ The distribution of urban population by category is given in table 4. With these definitions, the urban population composes almost 30 per cent of the over-all population. On the basis of the results given in section 4, and the experience obtained from previous

[^128]rounds of the PSSH, the PIACSD agreed to draw 600 electoral precincts as psu's from the urban sector and 400 barrios as psu's from the rural sector. A minimum of four precincts and four barrios were set as a lower limit for each province. The raising factors were 400 for the urban sector and 1,200 for the rural sector. With these raising factors, the number of sample households (hhs) will total 3,690 for the urban sector and 3,190 for the rural sector, or a total of 6,880 households for the entire country. The expected sample size in the urban sector is 6 hhs while in the rural sector, the expected number is 8 hhs.
9. Region VI was chosen to test the results of the new with the old design. Results of this test confirm the level of precision indicated for the provinces of the region (table 3). The new design will be executed in May, 1965 for the whole country by the BCS. The results of the May 1965 PSSH survey will indicate the relative success attained in the production of statistics on population and its components from the national to the provincial level.

# The United Nations programme for improving population and vital statistics 

Nora P. Powell

## I. Introduction

1. Since 1960, the United Nations programme for improving statistics throughout the world has been focused on the promotion of development of national statistics which countries could use most advantageously in formulating and executing plans and programmes for economic and social development.
2. During the previous decade, great headway had been achieved in fact-finding and in the establishment of standards for internationally comparable statistics. With the setting of goals for the "United Nations Development Decade", ${ }^{1}$ however, emphasis shifted from specific projects, conceived and executed more or less in isolation, to a more comprehensive approach, designed to bring countries up to the level of statistical development where they will possess the basic quantitative data without which any development plan can be little more than qualitative conjecture.
3. This approach has served to emphasize that demographic statistics are basic to any plan of economic and social development. It has also focused attention on the fact that demographic statistics in a country cannot be considered solely in terms of the traditional sources of population census and civil registration. Rather, the essential nature of reliable population and vital statistics demands that they be obtained from an integrated system of data collection which may include provision for censuses, civil registers and sample surveys. Accordingly, the programme for improving demographic statistics must be viewed in the context of overall statistical development which makes use of all types of data-collection methods. Solely for convenience, the discussion is set forth under the methodological headings of (a) population census; (b) civil registers; and (c) household sample surveys.

[^129]II. Population census
4. 1970 world population census programme. Having achieved some degree of uniformity in collection in connexion with the 1950 censuses, the United Nations efforts in population statistics were next turned to encouraging an increase in the total quantity of data available for national and international purposes, through persuading as many countries as possible to complete some type of population enumeration in or around 1960.
5. Despite the auspicious achievements in census-taking which resulted from the 1960 world programme, there are still thirty-five countries which have never had a nation-wide census of population and eleven more where the latest census is now more than ten years old. Even for those which carried out a census, adequate data are not available in all cases. To stimulate these forty-six countries to take a modern census of population which will produce the statistics on characteristics of population required for economic and social programming, and, inter alia, to improve the next enumeration in countries with a history of censuses, the United Nations has undertaken a "1970 World Population and Housing Census Programme".
6. The programme will consist of a number of related activities designed to promote the improvement of census methods, organization, and operations. Principal of these is the provision of international and regional "principles and recommendations" for producing the kinds of population data which will be useful for planning development. Other aspects of the programme are provision of methodological handbooks and technical manuals, assistance in training, expert advice, and international compilation and dissemination of census results. These are described briefly below.
7. Principles and recommendations. The international recommendations for the 1970 censuses of population will define and recommend the collection of information on a number of basic topics on which data are most widely needed for both national and international use. A list of other useful topics will also be provided.
8. Basic tabulations which are considered to be of general importance and practicability and presumably of world-wide interest, will be recommended. Additional tabulations, while also of recognized value, are those considered to be of primary interest in only some of the regions of the world, of somewhat more specialized uses or involve somewhat more elaborate compilation.
9. Both the Population Commission and the Statistical Commission considered the first draft of these recommendations at their thirteenth sessions. Between May 1965 and the first part of 1966, the comments of Governments, regional bodies and specialized agencies will have been obtained on the draft. A second draft, revised in accordance with all of these comments, will be examined in early 1966 by a small group of experts in population census and demography. Accompanied by the recommendations of the expert group, the revised draft will be placed before the Statistical Commission at its fourteenth session in October 1966, with the anticipation of obtaining final approval at that time. If this time-table proves feasible, international recommendations will become available two full years earlier than those of the previous decade.
10. It is also expected that these world-wide recommendations will be supplemented by regional recommendations. The purpose of the regional adaptation will be to amend and supplement the international standards to meet regional needs by (a) more emphasis on topics which are of special regional concern; (b) formulation of more precise regional definitions within the framework of the international guidelines; (c) formulation of probing questions to be asked in respect of topics with special regional variability; (d) recommendation of tabulations designed to meet special regional needs; and (e) suggestion of ways in which sampling might be especially appropriate in the region. Thus, the international recommendations will be a core or common denominator programme, while the regional recommendations will serve to extend and refine these to promote applicability in each region. The two together will provide maximum flexibility while maintaining international comparability in respect of basic topics and tabulations.
11. Methodological handbooks and technical manuals. The Secretariat is continuing to assemble, analyse and disseminate technical information on population census methods. Results of these studies will be published in a revised edition of the Handbook of Population

Census Methods ${ }^{2}$ for (a) the guidance of countries in preparing 1970 census plans; (b) for use in training activities; and (c) as an aid to the interpretation of the results of the 1960 censuses. It is intended that the revised Handbook should be available in English, French and Spanish by 1968.
12. In addition to this general methodological work, a study of methods used in evaluating the accuracy of the 1960 population censuses, including information on post-censal field checks and other methods employed for evaluating coverage and content, will be issued in the form of a technical manual which will give guidance to countries in this important area. It is expected that this manual will be available in 1966.
13. Training of national personnel: training courses. Special consideration has been given to the form by which countries might be assisted in preparing national personnel for the 1970 census-taking operations, including organization, field work, control, evaluation and analysis. An examination of the 1960 experience has led to the belief that technical assistance should not be provided in ad hoc regional centres as was done previously but through activities at the national or, at most, subregional levels.
14. The bringing of technical training closer to the operating level is completely in accord with the principle of providing continuous statistical training on a regular basis rather than through crash programmes. For the same reason, plans are being made to promote the incorporation of intensive courses in census techniques into the regular programmes of the permanent regional statistical training centres sponsored by the United Nations and by the Inter-American Statistical Institute.
15. Assistance in organizing and conducting these national projects will be provided by advisers attached to the regional commissions.
16. Fellowships. In addition to organized group courses, United Nations fellowships will be provided for the training abroad of census officials and technicians, as well as of personnel who will be engaged in sampling and data processing.
17. Expert advice. The service of census experts for longer periods of time will continue to be provided under the United Nations Technical Assistance Programme. For the 1960 censuses, these longer-term assignments accounted for well over 700 man-months assis-

[^130]tance, and it is expected that the demand will be equal if not greater in the 1970 period. This assistance will be in addition to the regional advisers mentioned in paragraph 15.
18. International compilation and dissemination of census results. Because of the limitations of the conventional questionnaire method of collecting statistics from Governments, the General Assembly, in its resolution designating the current decade as "United Nations Development Decade," requested the Secretary-General, inter alia, ". . . to review facilities for the collection, collation, analysis and dissemination of statistical and other information required for charting economic and social development and for providing a constant measurement of progress towards the objectives of the Decade". ${ }^{3}$
19. Since the scope of demographic analysis is dependent upon the availability and comparability of basic population data, it seems appropriate to explore ways of organizing population data so as to be able to bring to bear the efficient processing techniques supplied by electronic computers. Bearing in mind these considerations, the Statistical Commission at its thirteenth session requested the SecretaryGeneral to continue to study the international collection, tabulation and analysis of population census statistics at the international level in light of the possible application of electronic data processing. It is expected that the study will demonstrate the potentialities of electronic data processing for enhancing the quantity and quality of demographic statistics.

## IIT. Civil registration statistics

20. Survey of current national systems of vital statistics. United Nations activities to improve vital statistics from civil registers began in 1950 with a survey of national procedures for producing them. As was to be expected, the systems prevailing at that time were wholly based on conventional civil registers of birth, death, marriage and divorce, some of which functioned well; others poorly.
21. In the past decade, it has become apparent that civil registers of adequate scope and reliability cannot be established fast enough to meet the current need for statistics on population growth rates in developing countries. Accordingly, a number of countries have turned to sample-household-surveys and analytical methods to obtain some measure of

[^131]population change. However, the methods do not produce data for local areas, nor do they provide all the cross-classifications and details required for planning purposes. Because of these limitations, interest in obtaining vital statistics from civil registers is reviving. It is recognized that not only can the registers produce vital statistics, but they, and they alone, can provide the legal documents which constitute proof of name and nationality, without which citizens of emerging countries are handicapped. In short, possession of a good civil registration system is rapidly becoming recognized as an essential component of good public administration. It is also recognized that development of reliable civil registers is a longterm goal and in the interim, sample surveys can be utilized to meet the immediate need for population growth rates.
22. The validity of this approach has recently been promulgated in two regions of the world on the occasion of the Inter-American Seminar on Civil Registration, held in Lima, Peru in November/December $1964^{4}$ and the Seminar on Vital Statistics held in Addis Ababa, Ethiopia in December 1964. ${ }^{5}$ In support of this approach, the Statistical Commission passed a resolution at its thirteenth session calling for support of the conclusions of the two seminars by provision of technical assistance, studies and research and for a "study of methods of developing vital statistics registration systems and of interim methods of providing vital rates by appropriate survey methods". The results of this study, together with the experience gained from the experiments mentioned in paragraph 23, will be used in promoting the development of vital records and statistics throughout the world.
23. Experimentation. For achievement of the long-range goal of establishing a reliable national vital statistics system, a plan has been drawn up for promotion of development beginning with a system limited to a sample of areas, and complemented, for evaluation of completeness, by a system of periodic surveys. Experimentation with this dual system has begun in Kenya, Senegal and Turkey, under United Nations auspices. Under other auspices, similar experiments are under way, inter alia, in Pakistan, Thailand and the United Arab Republic and similar experiments will be set up in other regions as resources allow so as to collect as

[^132]much information as possible on the techniques involved.
24. Seminars. Seminars on improvement of civil registration and vital statistics similar to those mentioned in paragraph 22 are being planned for Asia during 1966 or 1967 and for the Middle East and Europe in 1968-1969. A world-wide seminar is envisioned for a later date.
25. Professional associations. One of the best ways to improve public administration (and therefore civil registration) is to organize the staff into an "association". Association of civil registration officers are in existence in the United States and Canada, in Europe and in Latin America. Attempts will be made to obtain support for such associations and of establishing similar bodies in Asia and eventually in Africa.
26. International compilation and dissemination of vital statistics. One of the most effective ways to promote improvement in statistical series is to publish data from different countries side by side. Deficiencies are thus highlighted, gaps are made evident and the need for revision and improvement becomes obvious. Hence, inclusion in the Demographic Yearbook of vital statistics irrespective of their quality, is expected in time to have a salutary effect on the series.
27. In the past, series considered less than reliable have been set in italic type in the Demographic Yearbook and a dichotomous code of "complete" or "incomplete" has been appended. It is hoped that in the next few years, efforts to devise more sensitive measures of quality and reliability may result in more critical evaluation of the accuracy of the population and vital statistics published in the Demographic Yearbook. In this connexion, the possible use of computers as a means of testing internal consistency and overall reliability holds great promise, both for vital statistics and population.
IV. Household survey statistics
28. International work on standardizing
procedures for household surveys, in so far as they have to do with producing statistics required for measuring levels of living, began with the production of the Handbook of Household Surveys: A Practical Guide for Inquiries on Levels of Living. ${ }^{6}$ In the chapter on "Demographic Characteristics," the Handbook recognizes several contributions that the household survey method might make to the supply of demographic statistics. Where traditional sources are lacking, or where they do not produce information of sufficient reliability and promptness, household surveys may become the only available means of obtaining the demographic measures required for assessing levels of living and changes therein. This is recognition of the role the household surveys have played and will continue to play in "filling-thegap," that is, in obtaining some idea of the size of the population, its major characteristics and its rate of growth in countries which have never had a national census of population in which national civil registers have still to be established.
29. The household survey has still other roles to play, namely, to obtain information on more topics and on subjects of more complexity than is possible by traditional means, and to provide independent data for checking the quality of information from civil registers and from other household interviews.
30. These uses will be explored in depth in the "study of demographic sample survey methods," one of the projects of high priority in the work programme of the Statistical Office for the next three years. The results of this study should prove useful to countries in adapting the survey method to their needs. They will also be used in revising the Handbook of Houschold Surveys, a project scheduled for completion in 1968.

[^133]
## Use of sample censuses to increase scope of census subject coverage

## Hermann Schubnell

## I. Inadequacy of the census for highly INDUSTRIALIZED COUNTRIES

1. A census may be defective because the administration of a given country may not yet have been developed sufficiently or because the population is not able to provide precise information. Another reason may be that the information collected in the course of a census does no longer suffice to provide a quantitative description of the social and economic structure. Experience acquired in many highly industrialized countries over the last two decades has shown that the population census in its "classical" form of a periodical inquiry held with complete coverage at five to ten years' intervals is inadequate. It is no longer suited to meet the steadily increasing requirement made on official statistics. This must seem strange because during this period machine processing techniques have made great progress. In the industrialized nations all major statistical offices are equipped with highly efficient electronic data-processing machines.
2. The experience acquired in the Federal Republic of Germany in connexion with the 1961 population census is certainly not unique : the time required from beginning until the termination of machine processing could be cut down considerably as compared with former times and it has equally been possible to use a much more detailed programme of tabulations. However, the time elapsing between census date and the inception of machine processing work was at least as long as before, because the coding work was both rather difficult and time-consuming and since a reading device has not been used in the course of this census.
3. But it is not in the first place for technical but rather for organizational reasons that the census proves to a growing extent defective in a highly industrialized country. The solution can therefore not be found alone in the use of reading devices or even better and faster computers. These technical aids, though certainly important, and provided they can be put to an optimal use, are not the decisive element. This is because of the following reasons:
(a) The census, i.e., the complete coverage, is a heavy burden both on the administration and on the population. Even if it is widely publicized beforehand, it is hardly possible to subject the population to a census at intervals shorter than up to the present time;
(b) Another limitation is the scope of the inquiry: both in the case of self-enumeration and with an inquiry held in all households by enumerators, it is possible to record only the most important characteristics. This was suffcient at a time when the social and economic structures were relatively uncomplicated and hardly changed in the course of time. The highly industrialized society has however a very differentiated structure; the dynamic economy, the migration across the national frontiers, the high mobility of the population, the strong fluctuation between the various sectors of economy and social strata are the reason why the general picture is subject to a steady change. In order to observe and direct this development, administration, economy and science therefore require highly differentiated quantitative material ; this must be available at short notice and provide an answer to the most topical questions of a given period. The census proves to be a much too unwieldy instrument for this purpose.

## II. The necessity to provide for a system of statistical inquiries

4. A system of statistical inquiries has to be developed which meets these requirements. A step in this direction has been made in the Federal Republic of Germany by the introduction of the "microcensus" in the year 1957.
5. The microcensus is a quarterly sample survey of population and economic life. In April of every year 1 per cent of the population and the households are included into the sample, while the sampling fraction is 0.1 per cent for each of the other three quarters. In the course of the 1 per cent survey, 5,000 interviewers make inquiries in about 200,000 households comprising some 580,000 persons. The interviewers are in each case specially trained for their job. The random selection has been made for the 24,000 communities of the Federal

Republic in the form of a 1 per cent area sample based on the enumeration districts of the census. ${ }^{1,2,3,4}$

## III. Basic and supplementary programmes

6. As to the content, there is in the microcensus a basic and a supplementary programme:
(a) The basic programme, which is invariable for the different surveys, covers, among others, the following characteristics: sex, age, relationship to the head of household, presence or absence, possession of a further dwelling, marital status, year of marriage for married people, nationality, membership in a social insurance scheme, economic activity, source of livelihood, firm, agency, locality and branch of business in which an activity is performed, number of the hours worked during the reference week, occupational status and for selfemployed persons the number of persons occupied, amount of the net income in the month preceding the inquiry and for farmers the size of the cultivated area. It is further determined whether a second economic activity was performed during the reference week;
(b) The supplementary programme of the microcensus, on the other hand, changes from one survey to the other. During compilation, it is possible to combine the data of the basic programme with those of the supplementary programme; a large part of the data provided by the basic programme is already coded by the interviewer on the questionnaire. Since a household is included into three to six surveys and only then exchanged for another (rotation), it is possible to currently determine any changes as to size and composition of the household, the change of occupation or establishraent where the person is employed etc.
7. The current adjustment of the population. In order to understand the role of the microcensus within the system of official population statistics, it is important to know that the population data of the Federal Republic of Germany are currently adjusted every month according to sex. The basis for this adjustment is the census results for the individual com-

[^134]munities. It is a legal obligation for every person changing the place of residence to register with the police at the former and the new place of residence. The number of inhabitants for every community can thus be annually determined by adding births and arrivals and subtracting deaths and departures. The results of the current adjustment provide the basis for raising the results of the sample to the total population.
8. Statistics of vital events and migration. Current statistics recording primarily such events as births, deaths, marriages, arrivals, departures, but which also cover population groups according to number and structure, such as pupils at specific schools, students, etc., are closely interrelated in many ways both with the census and with the microcensus.

## IV. The major tasks to be jointly solved by the census and the microcensus

9. We shall now deal with the functioning of the system of various inquiries in the field of population and occupation statistics and the "division of labour" which has developed between census, current statistics of events (e.g., statistics of births, deaths, migration, of schools and institutions of higher education) and the microcensus.
10. The census supplies at larger intervals the basic information in the most detailed breakdown for communities and enumeration districts. It also provides highly differentiated material, e.g., the economically active population by sex, age and occupation according to about 440 occupational categories. The census therefore constitutes the most important basis for differentiated regional and technical data which are needed for regional planning and other purposes. It is also the basis for the current adjustment of the population according to communities, for the stratification of the communities for the purpose of a random selection to be used with sample designs, for the random selection of the enumeration districts, dwellings and households.
11. The microcensus disencumbers the census of data for which more detailed regional breakdowns are either not necessary or inexpedient. Pilot surveys for the census have shown that questions relating to the type and extent of social insurance were answered in a very unsatisfactory way because the legal situation is very complicated. The information provided by the respondents on disablement were also very incomplete. These questions were therefore included into the sample survey, because there it is possible for the interviewers
to advise the respondents and to check to some extent the information given. ${ }^{5}$ For legal reasons it was not possible to include questions pertaining to fertility (number of liveborn children according to the age of the mother, duration of marriage, etc.) into the census, while these subjects could be made part of a 1 per cent survey of the microcensus.
12. The microcensus controls the census: the census was taken on 6 June 1961. Microcensus surveys were held in April and July of the same year. In order to control major characteristics, the questionnaires of the population census and those of the microcensus survey of July were brought together and checked for consistency.
13. The microcensus supplements the census:
(a) In point of time. The most important data of demographic and occupational statistics are determined for the Federation and the Laender under the basic programme on a quarterly basis according to the latest position, and any changes are observed. For this purpose it was necessary to reconcile the wording of questions, the definitions and the classifications of the census and the microcensus with each other ;
(b) In topics. The subjects of the follow-up surveys supplement the census in topics (see section IV). It is hardly necessary to mention that administration and science submit many more subjects for such follow-up surveys than the interviewers and the population may reasonably be expected to handle. It is therefore necessary to make a selection from these subjects in close contact with the relevant agencies. The most important follow-up surveys, carried through hitherto, were the following:

| Subject | Major characteristics <br> Vacation and recreation.. |
| :---: | :---: |
| Which members of the <br> household have travell- <br> ed? Type of trip (or- |  |
| ganized tour, indivi- |  |
| dual trip), destination, |  |
| transportation used, ac- |  |
| commodation in hotels, |  |
| camping, etc, total ex- |  |
| penditure |  |

Care of children under 14 years of age of working mothers

[^135]Subject (cont.)

Vocational training.

Week-end commuters....

Holders of driving licences, utilization of the licence

Major characteristics (cont.)
age, sex of children; extent and type of care provided by individuals, nursery schools, schools, etc.
Type of vocational schools which have been attended (incl. institutions of higher education), practical vocational training, time and type of completion of training, relationship between economic activity pursued and training, duration of on-thejob training
Number of trips over the week-end from the place of work or of training to the residence of the family (during the last 12 months), distance, means of transportation used

> Type and year of issue of driving licence, utilization during preceding year (regularly, occasionally, not at all), purpose for which licence was utilized, type of motor vehicle used, etc.

The microcensus organization (selected enumeration districts, interviewers) may also be used for other sample surveys as has, e.g., been the case in a 1 per cent housing sample survey. It is intended to link the census to be held around 1970 even more closely together with the microcensus than has already been possible in 1961 and to make use of the results supplied by the follow-up surveys of the microcensus for the preparation of the census.

## V. Pattern of the system and examples FOR ITS FUNCTIONING

14. The graph shows in a schematic way the system for the recording of information in the field of demographic and occupational statistics (see next page). Both the census and the microcensus provide information on the number and structure of the population. The current adjustment using information obtained from the statistics of vital events and migration permit a permanent observation of the population development, the results of which are also made use of for raising the microcensus figures. The follow-up surveys of the micro-


System of statistical inquiries in the field of population statistics, Federal Republic of Germany
census bridge the graps which still exist in educational statistics, e.g., as far as the vocational training in an establishment is concerned, or it increases the available information on the economic activity of mothers and its consequences for the custody of their children or else it provides in excess of the number of disabled persons direct figures on illness and accidents. Migration statistics which are compiled on a current basis, as well as the collection of material on commuting according to number and structure of migrants and according to the migration flows from one community to another, compiled in the course of a census, are supplemented by the recording of week-end commuters in the microcensus.
15. The graph shows only the linkage of the survey techniques which have been referred to above in the field of population statistics. There are of course very close relationships also with economic and social statistics, as, e.g., with a quarterly observation of the economically active population in the various branches of economic activity and with the recording of the hours worked during the reference week. These are important data for determining the productivity
of national economy. The use of figures supplied by complete coverage and sample surveys involves, incidentally, also some rather difficult problems of reconciling comparable figures.
16. The system of interrelated collection techniques, as it has been described here for population statistics, must be tailored to measure and adapted to the prevailing situation. Such a system cannot therefore simply be transferred to other countries. It will of course never be quite possible to present a general picture of the demographic and social conditions with all their details, the number of the population, the structures and the various changes. If handled with skill, it will however be possible to gather statistically in such a net of different and interpenetrating survey techniques the most relevant developments. Each individual survey technique is of necessity more or less defective but it may be possible to compensate any shortcomings by mutual supplementation. It is here that the great importance of the use of sample surveys for increasing the scope of census subject coverage in population and occupation censuses become most evident, and particularly so for the highly industrialized countries.

# Use of current surveys as an aid in constructing post-censal population estimates 

Walt R. Simmons and George A. Schnack

## I. Introduction

1. Counts or estimates of numbers of persons living within a specified area usually come from one of four sources: a census or intended complete field enumeration; a continuously maintained register or roll of the population; a conventional population estimate obtained by adjusting the last previous census for intervening births, deaths, and migrations; or a sample survey of the specified area. The present discussion is concerned primarily with those situations in which no continuous register exists, where censuses of good quality are taken at regular intervals, and where at least minimum data necessary for conventional estimates are available. It is presumed further that periodic probability population surveysat say, monthly or quarterly intervals-either are taking place or could be introduced. Most of the remarks offered in this paper relate specifically to circumstances in the U.S.A., where these conditions prevail, and examples are taken from there. But with some modification, the central ideas and techniques might find application in areas of a quite different character.
2. The estimates being studied are those following one census but prior to another and in a country for which periodic censuses are expected at perhaps decennial intervals. It is not intended that the procedure be utilized for interpolation between two censuses, nor for projections for an unlimited period beyond a census date.

## II. The central thesis

3. One view of the conventional population estimation procedure identifies it as an inventory process: the estimate for the current period is the count for the previous period plus accessions (births and in-migrants) less separations (deaths and out-migrants). Logically the routine is unassailable, and if the measures of accession and separation are precise, and if the starting total is accurate, the current estimate will be accurate, and over time reflect a smooth trend. But in ordinary usage precise determination of the accuracy of accessions and separations is not feasible on a current basis.

The inventory scheme can drift away from a true figure; or it may be that totals are wellestimated, while sub-classes are not.
4. Population estimates usually are desired separately by colour and sex and by perhaps 5 or 10 -year age intervals. Contrasting with the other schemes for estimating population, the sample survey is unlikely even conceptually to produce estimates to close tolerances for these classes. This is because the sampling error of the estimate is large for small classes. A welldesigned survey that is faithfully executed does, however, have one attractive characteristic: namely, that it is unbiased and over an extended period should indicate proper population levels.
5. So there are two methods of estimation, each of which possesses a desirable character-istic-the conventional procedure yields an estimate which shows a smooth trend over time and a survey estimate which tends toward a correct level.
6. There are several estimating schemes which can incorporate the advantages of both the conventional method and survey. One method which has this advantage is termed the Link and Taper Procedure (LTP) and it can be expressed as

$$
\begin{gather*}
x_{i}=\alpha\left[x_{i-1}+\left(u_{i}-u_{i-1}\right)\right]+(1-\alpha) v_{i} \\
0 \leq \alpha \leq 1 \tag{i}
\end{gather*}
$$

where $u_{i}$ and $v_{i}$ are the conventional method and survey estimates, respectively, in the $i^{\text {th }}$ period and $\alpha$ is a constant. In this formulation $x_{b}$ is a composite estimate, being a weighted average of two independent estimates.
7. The expression in the brackets in equation (i) is a linked estimate; this step projects the previous $x$-estimate by the current growth in the $u$-series, tending thus to produce in the $x$-series a smooth trend; the current estimate is, however, tapered toward the level implied by the $v$-type statistic.
8. A graphic illustration of the LTP is shown in the figure. It will be observed that the $x$-series retains the smooth trend of the $u$-data while tapering toward the level of the $v$-data.


An illustration of the Link and Taper Procedure
III. An inittal experiment with data from the U.S. Health Interview Survey
9. The National Center for Health Statistics produces death rates by age, sex and colour for the United States. In the late 1950 's, it was observed that the estimated death rate for the nonwhite population age 65 and over was increasing. Later, when the 1960 population figures became available, it was noted that the apparently-rising death rates were really the consequence of an underestimated population. When revised population figures were introduced, the preliminary increase in death rates was transformed into a slight decrease.
10. The National Center also has conducted since 1957 a Health Interview Survey (HIS), which is a continuous multi-stage highly stratified probability sample of households yielding, each year, health data on approximately 120,000 sample persons. The data are post-stratified by official Census Bureau estimates of population obtained from the conventional method. As a byproduct, however, the HIS yields population estimates which are independent of the census controls.
11. The experience with the nonwhite 65 and over group led, in 1962, to an evaluation of the survey and conventional estimates. This review revealed a survey distribution of population that was in close agreement with the 1960 census. Of particular significance were the estimates for the nonwhite age 65-74 group. The conventional method had been, in 1960 , about 20 per cent below the census count. This situation appeared to be one in which the LTP might be studied. Of several variants of the method explored, the best produced results were about 5 per cent in error as judged by the 1960 census. That is, beginning with the conventional estimate for July 1957, the LTP produced population estimates which followed the smooth trend of the conventional series but rose toward the survey level.
12. These results suggested that survey estimates might be used to evaluate and strengthen estimates produced by the conventional technique. The above experience was not to be generalized, however, without further review. A priori the LTP in this instance was likely to be successful for it was studied in a domain in which the conventional method had been poor.

## IV. Tests using data from the Health Interview Survey and Current Population Survey

13. Two bodies of data could be used for further exploration. First was the HIS for other age-sex-colour classes; second was the Current Population Survey (CPS).
14. The CPS for over 20 years has been conducted as a monthly household interview survey which is similar in many respects to the HIS. Recently the survey has operated in 330 350 primary sampling units and over a year includes about 130,000 households. It would have been desirable to test the Link and Taper Procedure using these data starting with the 1950 census and projecting estimates through the 1960 census. Due largely to changes in sample structure and computational procedure in the CPS in 1954, it was not possible to recover the needed data for periods prior to this. Accordingly, the test was run for CPS data for the period 1954-1960.
15. There are many possible variations of the LTP. For the results presented in this paper, the chosen method consists of the following elements and calculations (in each case the estimates are for number of persons in a specified age-sex-colour domain):

$$
\begin{align*}
& x_{i}=\lambda\left[x_{i-1}+\left(u_{i}\right.\right.\left.\left.-u_{i-1}\right)\right]+(1-\lambda) \bar{y}_{i}, \\
& 0 \leq \lambda \leq 1  \tag{ii}\\
& \text { where } \overline{y_{i}}=\frac{1}{5} \sum_{j=i-2}^{i+2} y_{j}  \tag{iii}\\
& y_{i}=\frac{1}{5} \sum_{j=i-2}^{i+2} z_{j}  \tag{iv}\\
& z_{i}=R_{o} v_{i}  \tag{v}\\
& \text { and } \mathrm{R}_{o}=\left[\sum_{i=1}^{n} u_{i}\right] /\left[\begin{array}{l}
\sum_{i=1}^{n} v_{i}
\end{array}\right] ; \\
& \text { where }\left\{\begin{array}{l}
n \\
n \\
n=12 \text { for } \operatorname{CPS}
\end{array}\right\} \tag{vi}
\end{align*}
$$

The quantities $v_{i}$ and $u_{i}$ are defined in equation (i), above. $R_{o}$ is a base-period calibration factor
intended to place the survey and the conventional estimates at the same level at the beginning of a period of comparison-this would be a period including the most recent census date if both series were available at that time. Thus $z_{i}=R_{o} v_{i}$ becomes a ratio estimator. The $R_{o}$ quantity could be a constant for all age-sexcolour cells, or could vary with colour, age, or sex. For the HIS tests, partly because true baseperiod census data were not available, the $R_{o}$ factor was held constant, and rounded to unity for all age-sex-colour cells; for the CPS tests $R_{0}$ was calculated separately for each of the four sex-colour groups. Equations (iii) and (iv) were incorporated in the procedure to reduce the variation in the survey results.
16. The constant $\lambda$ determines the relative weights given to the linked and survey estimates. A large value of $\lambda$ emphasizes smoothness and the conventional estimate; a small value emphasizes the current survey and tends to maximize the taper. A variety of factors could be considered in choosing $\lambda$. The choice is important. If $\lambda=1$, the survey evidence is completely disregarded. If $\lambda=0$, the conventional estimate is discarded. On a priori and experimental grounds, a value was chosen which with few exceptions makes $x_{i}$ a smoothly changing, nearly always monotonic variable over time, yet usually tapers to close approach of average survey levels within something like a 2 -year period. The value chosen is $\lambda=0.8$.

Table 1. Ratios of Link and Taper estimates ( $x$ ) and of conventional estimates ( $u$ ) to census counts, for age, sex and colour subclasses, U.S. civilian non-institutional population, age 20 and over, April 1960

| Sex and age | White |  |  | Nonwhite |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Conventional estimates 1 | LTP estimates based on |  | Conventional estimates u | LTP estimates based on |  |
|  |  | HIS | CPS |  | HIS | CPS |
| Males: 20-24 | 1.001 | 0.971 | 0.976 | 1.130 | 0.981 | 0.919 |
| 25-29 | 0.998 | 0.979 | 0.992 | 1.026 | 0.971 | 0.984 |
| 30-34 | 0.996 | 0.976 | 1.015 | 0.993 | 0.976 | 0.992 |
| 35-44 | 0.992 | 1.010 | 1.022 | 0.972 | 0.945 | 1.035 |
| 45-49 | 1.006 | 0.992 | 1.004 | 1.009 | 0.977 | 1.051 |
| 50-54 | 1.009 | 1.034 | -1.020 | 1.010 | 1.032 | 1.018 |
| 55-64 | 0.995 | 0.968 | 1.004 | 0.971 | 0.947 | 1.002 |
| 65 and over | 0.955 | 0.956 | 1.011 | 0.872 | 0.969 | 1.027 |
| Females: 20-24 | 1.011 | 0.985 | 0.990 | 1.029 | 0.999 | 0.950 |
| 25-29 | 0.998 | 1.008 | 1.004 | 0.972 | 0.991 | 0.980 |
| 30-34 | 0.994 | 1.011 | 1.026 | 0.978 | 1.000 | 1038 |
| 35-44 | 0.996 | 1.025 | 1.021 | 0.979 | 0.991 | 1.013 |
| 45-49 | 1.021 | 1.027 | 1.031 | 1.056 | 1.076 | 1.018 |
| 50-54 | 1.024 | 1.035 | 1.043 | 1.024 | 0.944 | 1.064 |
| 55-64 | 1.010 | 0.996 | 1.008 | 0.976 | 0.928 | 1.043 |
| 65 and over | 0.973 | 0.969 | 1.013 | 0.878 | 0.927 | 1.050 |

17. Table 1 displays ratios of the conventional method and LTP estimates to census counts on 1 April 1960. Ratios based on the conventional estimates are excellent in all but a few cells. Of the thirty-two presented, most are within 3 per cent of the census count; only four are off by 5 per cent or more. But of the latter, three are in error by more than 12 per cent. Relatively fewer of the sixty-four ratios based on the LTP estimates are within this 3 per cent error interval, but for those outside only one is as much as 8 per cent off. Thus the LTP, while generally less precise, avoided the more extreme errors of the conventional procedure.

## V. Evaluation and commentary

18. For several reasons, it is difficult to judge the effectiveness of the technique. We note especially ( $a$ ) the test could not be begun at a known census benchmark; (b) the ratio adjustments $R_{0}$ were not ideal; and (c) the criterion estimates are themselves faulty.
19. Further, it had been our impression at the outset that the $x$-series is likely to be less satisfactory than the $u$-series when they are close together (because the $x$-series is more erratic), but that the $x$-series has special value when the two differ considerably (on the grounds that the $u$-series probably has drifted
from the correct level). So evaluation must focus especially on the performance of those age-sex-colour cells in which the $x$ - and $u$-series are markedly different.
20. The data in table 1 suggest by this standard that the technique accomplishes at least a part of its objective. Review of detailed calculations not presented here suggests further that more satisfactory results might be obtained if modifications are introduced in the procedure. One such modification is mentioned below.
21. In the present study, there are available for each age-sex-colour classification two LTP estimates, one from the HIS and one from the

CPS. It is reasonable to expect that a linear combination of these two estimates in the estimator

$$
\hat{x}=A x_{1}+(1-A) x_{2}, \quad 0 \leq A \leq 1
$$

where $x_{1}$ is the HIS estimate, $x_{2}$ the CPS estimate, and $A$ a constant proportional to the reciprocal of the estimated variance of $x_{j}$, will have a smaller variance than either $x_{1}$ or $x_{2}$. Ratios of the $\hat{x}$-estimates to the census counts are shown in table 2. The agreement is good; now there is no error as large as 6 per cent, and only three of the thirty-two cells show errors of more than 3 per cent.

Table 2. Ratio of combined link and Taper estimate a to census count, for age, sex and colour subelasses, U.S. civilian non-institutional population, age 20 and over, April 1960

| Age | White |  | Nonwwhite |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Male | Female | Male | Female |
| 20-24 | 0.974 | 0.988 | 0.944 | 0.970 |
| 25-29 | 0.987 | 1.005 | 0.979 | 0.985 |
| 30-34 | 0.999 | 1.020 | 0.986 | 1.023 |
| 35-44 | 1.018 | 1.023 | 0.999 | 1.004 |
| 45-49 | 0.999 | 1.029 | 1.021 | 1.041 |
| 50-54 | 1.026 | 1.040 | 1.024 | 1.016 |
| 55-64 | 0.990 | 1.003 | 0.980 | 0.997 |
| 65 and over. | 0.989 | 0.996 | 1.004 | 1.001 |

a The combined estimate is $\hat{x}=0.4 x_{1}+0.6 x_{2}$.
22. It should be emphasized that this is a report on preliminary explorations. Although many facets deserve further investigation, attention is directed to five areas: (a) development of technical features of the Link and Taper Process to secure a most efficient form of the procedure, with optimum choice of constantswhich might vary from one situation to another; (b) analysis of weaknesses in the censuses, and of the interaction of these weaknesses with the Link and Taper Process; (c) review of the concept that the process should have as its target the prediction of the next census, as distinct from the "best" estimate of level; (d) determination of most effective boundaries for domains to which the basic process should be applied: e.g., should the current survey "control" be exercised at 10 -year-sex levels without regard to colour, finer age and colour breaks being secured by other means: or should the process itself be applied at finer age-sexcolour levels; (e) provision for introducing
modifications into the process to take account of improvements which occur in conventional projections.

## VI. Conclusion

23. Early investigation indicates that evidence from current probability population surveys can be used to improve or evaluate conventional population estimates for periods following a census and pending the availability of a subsequent census. The recommended process results in an estimated population series which follows the trend of conventional estimates, while approaching the level of the current survey. Called the Link and Taper Procedure, the resulting series might possibly be used as official population estimates but more likely should serve as a monitor series which warns demographers of probable drifts in their projections, and thus leads to study and possible improvement in the conventional procedure.

# Response biases in demographic enquiries 

Ranjan Kumar Som

## I. Introduction

1. Response errors. In censuses and sample surveys, the non-sampling errors and biases introduced at the stage of the collection of data are called response or observational errors. Such response errors have often nullified the results of otherwise well-designed demographic enquiries.
2. Statistical model. ${ }^{1}$ Assume that the survey is either a complete enumeration or an equi-probability sample and denote by $\bar{y}(t G)$, the simple mean of the variate under study on the $t^{\text {th }}$ trial (the subscript $G$ designates the general conditions of the survey). The expectation of $\bar{y}(t G)$ is: $E\{\bar{y}(t G)\}=\bar{Y}+B(G)$ where $\bar{Y}$ is the unknown, true value and $B(G)$, the bias of the estimate.
3. Response bias and response variance. While the response bias, $B(G)$, leaves the sampling variance unaffected, other response errors, even with the expectation zero, would increase the variance, their contribution to the total root mean square error being termed response variance.
4. In this paper, our objective will not be a study of the response variance, but of detection, correction and minimization of the response biases by methods that may be built into the design of the enquiry: we shall not consider the use of demographic models, and the emphasis will be on field enquiries, rather than registration systems. These methods should preferably be used in combination, those operationally prohibitive being on a sub-sample basis.

## II. Methods of detection and correction of response biases

5. The response errors can be of two types: (a) the "coverage" errors, e.g., the under or over-reporting of population; and (b) the "classification" or "content" errors, e.g., the

[^136]mis-classification of economic activity and age. These and other instances of the general errors have been adequately dealt with elsewhere.
6. Re-survey. A sub-sample of units in the original survey is surveyed again using the same (or preferably a more detailed) schedule, and, in a personal interview, better staff, either as a post-enumeration check or as a regular part of the original survey.
7. The statistical model in a re-survey is $E\{\bar{y}(t G)\}=\bar{Y}$ on the assumption that the bias element $B\left(G^{\prime}\right)=0$, where $G^{\prime}$ refers to the general conditions of the re-survey. The difference $\left\{\bar{y}(t G)-\bar{y}\left(t G^{\prime}\right)\right\}$ gives an estimate of the bias element $B(G)$ in the original survey.
8. Inter-penetrating networks of sub-samples: the sub-division of the total number of units in the survey (sample or census) into a number of parallel, random groups enables one to test the differential effects of investigators and of other factors, e.g., variations in the field schedules and methods of collection. This technique of Mahalanobis ${ }^{2}$ has been used in sample surveys in India, ${ }^{3}$ the Philippines, and Rhodesia (1948), ${ }^{4}$ to provide a check on the accuracy of the field work.
9. In the above model, the bias element $B(j G)=B^{\prime}(G)+B^{\prime}(j G)$, where $j$ refers to the investigator, $B^{\prime}(G)$ is a constant bias that affects all investigators alike, and $B^{\prime}(j G)$ that affects " $j$ "-the investigator. The $F$-ratio of "between investigator" variance/the relevant "error" variance test the hypothesis $B^{\prime}(j G)=$ constant, i.e., non-existence of any differential bias of the investigators.

[^137]10. The net bias common to all investigators, $B^{\prime}(G)$, passes undetected by this method: ${ }^{5}$ this has to be controlled by improvement in survey methodology, and adoption of special analytical techniques.

## III. Recall lapse ${ }^{6}$

11. In retrospective demographic enquiries, the response errors can often be expressed as a function of the recall period, i.e., the period elapsed between the date of occurrence of the event and the date of enquiry, and may, therefore, be termed recall lapse. A tabulation by the recall period or a related item often reveals the recall lapse, which may otherwise lie hidden in the over-all estimates. Recall lapse was detected by Mahalanobis and Das Gupta ${ }^{7}$ in Indian fertility data and has been observed or suspected in a number of demographic, morbidity and household consumption enquiries. The lapse may include both the total omission of events as well as a net uni-directional shift in reporting the dates of the events ("boundary effect"), resulting either in a "telescopic" or a "receding" effect.
12. Current vital data. ${ }^{8}$ In a survey on current vital data, where the survey units move uniformly over the survey period of one year and the reference period for recording vital data is the preceding twelve months, let $y(i k t G)$ be the (estimated) number of events reported in the $i^{\text {th }}$ month of survey ( $i=1,2, \ldots, 12$ ) to have occurred in the $k^{\text {th }}$ preceding month $(k=1,2, \ldots, 12)$. The average number of events reported in the $k^{\text {th }}$ preceding months is:

[^138]$\bar{y}(k t G)=\Sigma y(i k t G) / 12$, the expectation of which is: $E\{\bar{y}(k t G)\}=\bar{Y}+B(k G)$, where $B(k G)$ is the bias, a function of $k$. The cumulative average of $\bar{y}(k t G)$ up to and including the $k^{\text {th }}$ preceding month is: $\bar{y}(k t G)=(12 / k)$ $\sum_{k=1}^{k} \bar{y}(k t G)$ and gives the estimated annual number of events for the recall period of $k$ months, the expectation of which is: $E\{\bar{y}(k t G)\}=$ $12 . \bar{Y}+(12 / k) \sum_{k=1}^{k} B(k G)=Y+\bar{B}(k G)$, say, where $Y$ is the true annual number of events and $\bar{B}(k G)$ the average recall bias for the $k$ preceding months. If there were no recall bias, i.e., if $\bar{B}(k G)=0$, then $E\{\bar{y}(k t G)\}=Y$. The $\bar{y}(k t G)$ 's may be smoothed by a curve $f(k)$, from which $\hat{\bar{y}}(o G)$ can be estimated (at $k=0$ ), and taken to be equal to $V$ on the assumption that $\bar{B}(o G)=0$. In physical terms, $\hat{\bar{y}}(o G)$ would indicate the (expected) annual number of events were these to be recorded at the exact moment of occurrence.
13. In the Indian National Sample Survey on current births and deaths (1953-1959) and the Upper Volta Survey on current deaths (19601961), the following curve gave a good fit to the data: $f(k)=c \cdot \exp \left(-a k^{2}\right)=\hat{\bar{y}}(o G) \cdot \exp$. ( $-a k^{2}$ ), from initial conditions. Some vital rates are shown in the table.
14. Boundary effect. If the net boundary effect (either telescopic or receding) for the $k^{\text {th }}$ preceding month, due to a shift in reporting the dates of events, denoted by $C(k G)$, is a function of $k$, it can be included in $B(k G)$. If it is a constant, $C(G)$, the net boundary effect will be inextricably mixed up with the true number of events. Further studies are required on this point.
15. Historical fertility data. ${ }^{9}$ In the Indian data, for the most recent marriage cohort " $o$ ", the infant death proportion, $q(r o)<q(s o)$, where $r$ refers to registration and $s$ to survey, but for the older marriage cohorts " $c$ ", $q(r c)>$

[^139]Unadjusted and adjusted (for recall lapse) rates in demographic surveys

|  |  |  | Rates/1,000 persons |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Survey | Item | Unadjusted | Adjusted |

$q(s c)$; also $q(r c)>q(r o)$, but $q(s c)<q(s o)$. Assuming $q(s o)$ as free from any bias and a uniform standard of registration over the period, the corrected proportions for the older marriage cohorts " $c$ " were obtained as: $q$ ' $(r c)$ $=q(r c) \cdot q(s o) / q(r o)$.
16. In the same data, for the reported sexratio at birth (female/male), $f(c)<f(o)$. The ratio $f(0)$ was taken to be most reliable and not to have altered basically over the period.
17. Assuming the independence of these two assignable causes of recall lapse, the correction (multiplying) factor for the reported number of children born for the $c^{\text {th }}$ marriage cohort was: $1 /\{1-p(1 c)\}\{1-p(2 c)\}$, where $p(1 c)$ $=$ probability of missing a birth due to recall lapse in infant deaths $=\left\{q^{\prime}(r c)-q(s c)\right\} /$ $\left\{1+q^{\prime}(r c)-q(s c)\right\}$; and $p(2 c)=$ probability of missing a birth due to sex-selective recall lapse $=\{f(o)-f(c)\} /\{1+f(o)\}$.
18. Comparison of total number of children born and current fertility rates by age of mother: ${ }^{10}$ if for any age-group $x, F(x)$ is the total fertility rate (centred at the mid-point of the age-group) and $f(x)$ the current fertility rate, the successive sums of which, $F^{\prime}\left(x^{\prime}\right)$, can be plotted at ages $x^{\prime}$ (the terminal ages minus one-half the interval covered by the reported), the graphs for $F(x)$ and $F^{\prime}\left(x^{\prime}\right)$ should be identical statistically if all the data were correct. From the graph of $F(x)$, valued can be read off at the ages $x^{\prime}$. Let these values be $F^{\prime \prime}\left(x^{\prime}\right)$, and for the next group, $F^{\prime \prime}\left(y^{\prime}\right)$, etc. Then an estimate of $f(x)$ is provided by: $F^{\prime \prime}\left(y^{\prime}\right)-\mathrm{F}^{\prime \prime}\left(x^{\prime}\right)=f^{\prime \prime}(x)$ say. Assuming that the derived rate $\mathrm{f}^{\prime \prime}(x)$ is more reliable for the younger women (age-group " $o$ "), no association between fertility and mortality, and that the errors in current reporting on births are proportionately the same for women at different ages, the observed current rates are corrected as: $f^{\prime \prime}\left(x^{\prime}\right)=f(x) \cdot f^{\prime \prime}(o) / f(o)$, and the summation of $f^{\prime \prime}\left(x^{\prime}\right)$ would give the corrected estimate of total fertility. An estimate of the birth rate is obtainable on application of the same adjustment factor $f^{\prime \prime}(o) / f(0)$ to the total number of births during the preceding year.
19. The implicit assumption of stable fertility may, however, be examined in view of the confliciting trends observed in some recent studies.
20. Morbidity data: recall lapse in morbidity data has been revealed by Logan and

[^140]Brooke ${ }^{11}$ in England and Wales (with underreporting in the "month before last" as compared to the "last month"), by Linder ${ }^{12}$ in the U.S. and by Das and Som ${ }^{13}$ in India (with under-reporting in the different weeks prior to the interview within the preceding month). In the U.S., the reported hospital discharges were seen to decrease systematically with recall period within the preceding year. ${ }^{14}$

## IV. Methods of minimizing response bias

21. Survey design: estimates of birth and death rates can be provided by retrospective methods as also by periodic enquiries with person-by-person matching, information of infants born and dying during the interval being collected by retrospective method: such periodic enquiries are most desirable, though costly and presenting some operational difficulties.
22. In the Indian National Sample Survey, 1958-1959 ${ }^{15}$ and the Moroccan Multi-purpose Survey, 1961-1963 ${ }^{16}$ for the rural sector, retrospective and periodic enquiries with per-son-by-person matching (in the former in one sixth of the original sample) were used in combination. In Morocco, the combination of the two methods gave more precise results than the use of a single method.
23. External checks. In a survey where it is possible to have matching of the survey and the registration data (after allowing for differences in definition and migration), Chandra Sekar and Deming, ${ }^{17}$ assuming that the underreporting in the survey and in the registration operated independently, have devised the correction (multiplying) factor for the total number of events reported by either or both the agencies: $1-\{1-p(1) \cdot p(2)\}$, where $p(1)$
${ }^{11}$ W. P. D. Logan and E. M. Brooke, The Survey of Sickness, 1943-1952 (London, General Register Office, 1957).
12 F. E. Linder, "National health surveys as a source of morbidity data for genetic and radiation studies", The Use of Vital and Health Statistics for Genetic and Radiation Studies (United Nations publication, Sales No.: 61.XVII.8), p. 213.
${ }_{13}$ N. C. Das and R. K. Som, A Preliminary Note on Morbidity Pilot Study (Calcutta, Indian Statistical Institute, 1962).
14 W. R. Simmons and E. E. Bryant, "An evaluation of hospitalization data from the health interview survey," American Joumal of Public Health, vol. LII (1962), pp. 1638-1647.

15 Som, et al., op. cit.
16 Ahmed Ben Souda, Utilisation par le Maroc du recensement (1960) et de l'enquête à objectifs multiples (1961-1963) pour déterminer la natalité et la mortalité (Commission Economique pour 1'Afrique), E/CN.14/CAS.4/VS/13 (1964).
17 C. Chandra Sekhar and W. E. Deming, "On a method of estimating birth and death rates and the extent of registration," Journal of the American Statistical Association, vol. XLIV (1949), pp. 101-115.
$=$ probability of an event not being reported in the survey $=y(s r) /\{y(s r)+y(\bar{s})\}$, and $p(2)=$ probability of an event not being registered $=y(s \bar{r}) /\{y(s r)+y(s \bar{r})\}, s$ and $\frac{s}{s}$ denoting whether the event was reported in the survey or not; and similarly for $r$ and $\bar{r}$. Operationally prohibitive except on a small scale, this method has found important applications in India ${ }^{18}$ and Pakistan. ${ }^{19}$
24. Schedule design: screening questions and probes. A broad question without crosschecks and fully detailed probes is likely to lead to biased responses. Such cross-checks

[^141]and probes are included in the demographic surveys in India. ${ }^{20}$ In the U.S. Health Survey, only half of the chronic conditions were reported in response to the initial probe question. ${ }^{21}$ In India, it was observed that about one fourth of the sickness spells were missed by an initial question. ${ }^{22}$
25. Proxy- and self-intervieves. One methodological problem in interview surveys is the possibility of differential reporting in proxyand self-interviews. About one fifth of the minor non-chronic conditions were missed in the U.S. Health Survey due to the acceptance of proxy-interviews for adults. ${ }^{23}$

[^142]
## New concepts in census methodology

## Conrad Taeuber

1. The new elements in the conduct of censuses are primarily matters of philosophy and emphasis. They include a professionalization of the entire task, critical evaluation of all phases of the operation, and an approach which seeks efficiency in the use of the resources that are available. There has been increased recognition of sources of error in any census operation, as well as of the advantages and limitations of census-taking in meeting the needs for data. There have been changes in emphasis and content as the requirements for demographic data have changed. Collecting information on births and deaths in the census has largely given way to statistics based on registration of vital events or sample surveys. A technique that appears to be very modern may actually have been foreshadowed long ago, but the present day use and emphasis may be different. For example, a sample inspection of card punching was applied in the very first census which used punched cards. Such inspection today is only one of the procedures used in the increasingly effective application of quality control procedures in a census.
2. Reports of census procedures reveal clearly an accelerating application of modern statistical tools to the task of taking and processing a census. There is also a growing awareness that a census needs to take advantage of social science research in data collection, advanced statistical procedures, administrative management techniques, and the modern equipment and techniques for handling large masses of materials. There has been a growing awareness of the utility of census results for public, as well as private purposes, and with this has come a growing demand for clarification of concepts, some new items of information, speed in issuing results, and more complete analysis of the results. Increasingly there is an appreciation of the need for critical analysis of coverage and subject matter. With greater emphasis on quality of the results has come the recognition that the user of data is served best if he is given some information about possible sources of error or bias, and that confidence in the integrity of the census operation is actually enhanced rather than diminished by
a frank appraisal of the quality of the census results.
3. The growing emphasis on international comparability has not led to a stifling uniformity, but has recognized the fact that a census serves important national needs and should be adapted to the situation in which it is conducted. There has also been increased effort to spread the idea of census-taking. The International Statistical Institute campaigned for a census of the civilized world for 1900 ; the Inter American Statistical Institute took the lead in promoting a 1950 census of the Americas; the United Nations urged worldwide censuses of population in 1960, and is at work on a similar programme for 1970.
4. It is generally recognized that the value of a census is enhanced if the results can be compared with those of an earlier one. The traditional pattern that a 10 -year interval is desirable is no longer adequate. Some countries are shifting to a quinquennial census programme. Others are using sample enumerations as a means of updating information secured at the last census, including large scale quinquemnial surveys for this purpose.

## I. Electronic computers

5. A little more than half a century after punched cards were first introduced into census activities, the electronic computer appeared. Its use has spread rapidly, though some of the applications at present do not take full advantage of the fact that this equipment is not limited to speeding up the work which was done by the card handling equipment of an earlier period. Effectively used, the computer also promises much greater accuracy in the processing of the results. It substantially reduces the need for large numbers of temporary and untrained clerical workers at the time of a census. It makes for greater uniformity in editing and simplifies the use of information from the current census for editing and for imputation for missing or erroneous entries. The computer can keep a record of the actions that have been taken. While the objective in its use is largely to make human intervention in the mass handling of the data unnecessary,
it can also identify those cases for which human review or intervention seem desirable, and, thus, make it easy to apply the expert knowledge of the census staff in the most economical manner. It facilitates analyses of data for families or households, as well as their individual members. Its ability to perform complex operations aids in the application of sampling procedures in the census, as well as in the preparation of detailed analytical tables.
6. Auxiliary equipment has been developed to facilitate the input of information without the intervention of punched cards, and further improvements appear to be on the horizon, Similarly, there have been significant developments in the capacity of electronic equipment to prepare output copies for multiple reproduction at relatively high speeds, and further improvements are in sight. The ability to transmit information in the form of computer tape, rather than through the intermediary of the printed page, promises significant increases in the use of census results.
7. None of the advantages of the computer come easily and there have been some disappointments in the first application of this type of equipment to the processing of census results. With growing experience and technical improvements, some of these "growing pains" are likely to disappear. What at one time appeared to be a problem in the effective utilization of this equipment may in the long run turn out to be one of its advantages. It calls for earlier and more complete planning of all phases of the census than appeared necessary under other systems.

## II. Quality of census results

8. Three quotations from reports of the U.S. census may serve to illustrate that concern with the quality of census results is not new, but that the emphasis has changed:
(a) "...... it would seem to be the duty of those charged with the publication of these statistics to indicate in respect to each class the degree to which the figures may be relied upon, and, as nearly as may be practicable, the proportion of omission or error ${ }^{3 \prime}$ (1871);
(b) "All tabulations made in the Census Office are verified; they are not permitted to leave the producing division until their accuracy has been fully tested, and the names of clerks responsible for verification indicated upon the manuscript.... The absence of serious errors in the Census publications is remarkable and gratifying" (1908);
(c) "It has become a generally accepted principle among professional statisticians that
a compiling agency has responsibility for furnishing adequate information regarding the limitations of the data which it collects and publishes. The present policy of the Bureau of the Census is to provide as consistently as possible measures of the accuracy of all censuses and surveys which it conducts" (1953).
9. The growing attention to quality of the census data is applied to all phases of the operation, the field canvass, the processing of the data and measures to evaluate the completeness and accuracy of the returns. Pretests of census schedules and procedures have become a standard aspect of census planning. The need for training of the field personnel, as well as other personnel receives a great deal of attention. Programmed learning in the training of temporary field personnel is one of the newer techniques which hold substantial promise for improvement of the training of these persons.
10. In the control of the enumeration there has been increasing attention to the use of lists of housing units which are established prior to, or at the time of the census if they are not otherwise available. Where a population register is available, it can effectively aid in the control of the enumeration. In a significant number of countries, a pre-listing is undertaken and numbers are affixed to housing units; which then serve as controls for the enumeration. The requirement that people stay at home on census day until they have been enumerated is not generally accepted, though used in some instances. In some countries enumerators give a certificate of enumeration, or place. an ink mark on the hand of persons who have been enumerated. In Hong Kong a helicopter was brought into service to control the listing of boats, as well as the deployment of enumerators on the ground. Aerial photographs have provided necessary maps in many countries. Operations analysis has shown that a relatively small number of enumerators contribute a disproportionately large share of the errors, and means have been developed to identify them early and correct the situation. Workioad norms have been used to control the work in the field, as well as later work in the office. The Union of Soviet Socialist Republics reported a complete field check subsequent to the enumeration to help assure the correctness of the returns and the coverage.
11. The wording, as well as the content, of the questions has received a great deal of attertion in recent years. There is clearly increasing emphasis on avoiding questions which would be embarrassing to the respondent and on recognizing the possibility of memory biases and other sources of erroneous responses. Ques-
tions which can be answered objectively are favoured, though it is recognized that some other types of questions may be required in order to meet the needs for census data. It is no longer considered appropriate to ask whether persons in the household are defective in mind, sight, hearing or speech, or are physically impaired, or whether the household includes prisoners, convicts, or paupers. Canada has used an objective test to secure answers to the question on blindness. Efforts to reduce the misreporting of age have been reported from many countries. Some extraordinary steps have been taken to secure age reports in cultures which do not share the western concept of age.
12. The definition of the enumeration unit has been the subject of considerable attention. Problem areas or groups are increasingly identified in advance for special handling. Census reports are concerned with the procedures for dealing with such special groups as street sleepers, boat dwellers, persons afloat, wayfarers by land, personnel on merchant ships, or those temporarily present or absent. They are also concerned with the most appropriate treatment of nomads, prisoners, persons in institutions, the military, university or college students, persons maintaining two or more residences, and others who do not readily fit the classic dichotomy of de facto or de jure population.
13. The evaluation of the results has become an accepted part of a census. The United Nations reports that twenty-six countries expected to conduct some form of post censal evaluation of the results in the censuses taken in or about 1960. These frequently involve re-enumeration of a small sample of the households or individuals, using the work of highly qualified enumerators to set a standard for measuring coverage or accuracy of returns. This procedure is limited, for problems in the original enumeration may well be repeated in the reenumeration as well. In a number of instances it has been possible to compare census returns with those from a current survey. Comparisons on an aggregative as well as on an individual basis have been made with other sources of information, such as vital statistics, administrative records, and previous censuses. Internal analysis of census results, or the comparison of cohorts enumerated in successive censuses have sometimes led to important findings. The United Nations has held a number of seminars on the evaluation of census results, and published a number of country case studies.
14. With the growing recognition that the census is a statistical operation, there has been increasing acceptance of the view that the
results are subject to errors. In turn, consideration has been given to the most effective allocation of resources to reduce preventable errors. There has also been growing concern with methods of evaluating the census results. Experience has shown that making the results of these investigations generally available contributes to public confidence far more than the vain attempt to claim infallibility for the results.

## III. Sampling

15. There may be some statistical offices which view sampling and censuses as competitive, but their number is rapidly diminishing. The application of sampling to the census operation has grown rapidly. Sampling procedures are applied to pretests; they may be used to secure a part of the information that is required, and thereby reduce the burden on the public and perhaps gain other advantages. A limited census may be taken to provide small area statistics and a sample used to provide the more detailed information which is needed only for larger areas. Sampling plays an important role in the quality control of all steps of a census. Samples of schedules have frequently been drawn to provide preliminary results significantly in advance of the final results. Samples have also been used to provide the basis for detailed analytical tabulations which are not required on a complete count basis. In some instances emergency conditions have arisen during the processing with the consequence that only sample tabulations could be prepared. The selection of a sample of the returns to be retained for later tabulations has permitted analytical tabulations after the pressure of the main census work has been completed.
16. Post census surveys to gain additional information or to provide a basis for evaluation of the census returns almost universally depend on the use of sampling procedures.
17. Annual or more frequent sample surveys are increasingly in use to provide up-to-date information in the period between censuses. "Micro-censuses" make effective use of this principle in a growing number of countries.

## IV. Speed

18. Perhaps at one time a country was prepared to wait years for the results of the census, but that is no longer the case. National planning, programmes for economic development, and a host of administrative uses by Government and the private sector of the economy have brought increasing pressure for prompt returns. Hand tabulation or a preliminary
tabulation based on a sample of the returns is frequently used to meet the need for early reporting of at least part of the returns. More rapid tabulating equipment has played a role, and perhaps of equal importance has been more adequate advance planning of the entire census operation. There are indications that substantial advances in reducing the time between collection and publication of the data are within reach. Developments in printing technology have also made significant contributions.

## V. Comparability and meeting national needs

19. One of the early and continuing programmes of the International Statistical Institute was the promotion of censuses and of international comparability among them. More recently this work has been carried on by the United Nations and its regional organs, and in the Americas by the Inter American Statistical Institute. These organizations have developed standards, reviewed experience, and provided a forum for the exchange of views concerning improved ways of meeting newly developed needs. The objective has been comparability, recognizing that censuses must be adapted to the national needs and that conditions vary among countries and regions.
20. The established standards have generally provided for a core of items and tabulations which are recommended to all countries, and suggestions for meeting special needs in a way that provides for comparability. In this framework, attention has been given to special needs for new items or for modification of items. Thus, while there is a growing preference for questions on educational attainment rather than the traditional question on illiteracy, a number of countries which continue to use the question on illiteracy have developed more objective questions than the standard one on ability to read and write. Ability to read a newspaper or to write a letter may be the basis for the classification. Yugoslavia developed a test which was administered to a small sample of the population and which served as a basis for evaluating the returns which had been received in reply to the census questions on illiteracy.
21. There has been a growing emphasis on securing information on the economic activity of the population, and a number of efforts to develop labour force concepts which recognize the special situation in countries with limited industrialization. In some countries attention is being given to the scientific and technical qualifications of the nation's manpower.
22. Increasing attention is also being given to family statistics, including fertility, economic
dependency, and family composition. The term "inherited widows" is found in a report from an African country where the levirate is still practised. Family income has not yet been included in many censuses. In some instances where it has been included, special provisions have been made to give the respondent additional assurance that this item would be treated in confidence.

## VI. Informing the public

23. Although censuses generally are taken under laws which compel replies, there is a growing recognition of the need to enlist the cooperation of the public if the census is to be successful. The use of radio, television, the press, and other means of mass communication makes the public aware of the census and may help allay fears and mistrust. Local councils, public advisory committees, and advisory committees of professional and other users help keep the public informed and also aid in the plans for the conduct of the census in the light of local conditions and needs. The schools have played a major role in providing awareness of the census, and in some situations the teachers and older students provide a major share of the enumerators.
24. Procedural reports in which the census office reports in some detail how a census was taken are not yet sufficiently frequent, but their number is growing. One such report on a 1961 census contained an apology for the length of the report, pointing out that it had been thirty years since such a statement had been prepared. If there is a trend in these reports, it is to present an operational approach to the census under discussion. The classical arguments over de facto and de jure concepts, or over the enumerator versus the householder approach, are relegated to the background in favour of a discussion of the ways of meeting the specific situation of the country. There is a clear preference for reliance on the direct report of the householder, rather than dependence on the intermediary enumerator wherever conditions make this feasible, but a recognition that a combination of the two methods may be the most effective procedure.
25. It is taken for granted that census results are to be published and thereby placed in the public domain. With tabulating equipment and computers in growing use, publication needs to be viewed not only in the traditional sense, but attention needs also to be given to publication in the form of punch cards or magnetic tapes which are usable on the equipment available to the analysts.
26. To facilitate the use of census data, attention has been given to the areas for which such data are to be reported. Stable statistical areas have been established in some instances and data are presented for these, as well as for the administrative units within the country. Statistical areas within cities and metropolitan areas contribute significantly to the utility of census results. If they retain the same boundaries from one census to another, they contribute to the analytical uses of the data.
27. As census offices are put on a permanent basis, and staffed by professional workers, there has been increased emphasis on census reports which provide more analytical treatment of the data than is possible in the normal census volumes. In an earlier and more leisurely day, census directors often included lengthy reports with observations on the data, the trends revealed by them, and their import for the nation. Census monographs provide a more systematic treatment of the trends and bring to bear the expert knowledge of the census staff in the analysis of the data. The presentation contained in such reports extends the information to a wider circle of readers than can be reached by the publication of the tabular material alone. Censuses have benefited from the increase in the number of qualified users of their data. Efforts at collation of census data with data from other sources has often increased the utility of the census materials and has led to needed improvements.

## VII. Conclusion

28. A brief report necessarily omits many details and exceptions. The attempt to identify new items may convey an idea of general acceptability which would be incorrect. Census methodology has improved substantially since the beginning of the twentieth century. The best census offices today include a high degree of self-criticism and an evaluation of their
work and experience. Some of the poorest offices, on the other hand, tend to accept methods and results with little criticism. As Governments and other users of census data acquire more experience and greater technical competence, there is a growing appreciation of the need for a continuing search for methods that reflect an awareness of the needs as well as the possibilities of improvements.
29. Any forecast in this field may well be wrong, but at the risk of misjudging present and future trends, some indications of possible future developments may be set down. The census of the future will more often be the work of a permanent staff of professionally trained persons, and less often an ad hoc project, hastily developed by a staff with little training or experience for such work. It will be an important element in an integrated programme of national statistics. It will give a great deal of attention to the methods of collecting data, to the quality of the data that are collected and tabulated, and to the most effective methods of providing the data that are needed. It will combine complete coverage with sampling in ways deemed to provide the most effective use of available resources. Considerable attention will be given to speed of putting the results into the hands of the users. Increased attention will be given to the needs of users and to ways of making the results most useful. Growing attention to training of census workers at all levels, and increased sharing of experience internationally will aid in bringing about these developments. This will also lead to greater experimentation with new methods which are adapted to the needs and resources of individual countries. With growing awareness of the role of statistics, it can be anticipated that there will be recourse to a greater variety of sources of data and less need to assign to the census tasks which could better be performed by other means.

## Testing deficiencies and analytical adjustments of vital statistics

V. G. Valaoras

## I. Universality of the problem

1. Logic and experience demonstrate that no quantitative measurement is ever 100 per cent accurate, because of the conglomeration of a multitude of factors (probable error due to small numbers, adverse physical conditions, or faulty techniques, involved in the measurement, personal equation, etc.), which falsify the final result. This is particularly evident in the study of biological, social or demographic phenomena which, with the now existing knowledge, seems to defy exact measurement. For example, in the population censuses and the systems of vital registration, errors of omission or duplication, and misstatements of the sex, the age or other characteristics, are common, even among the most advanced countries. However, the magnitude of the error varies widely, and only when it exceeds a desired margin of confidence, the need arises for a proper rectification of the deficient data.
2. In the analytical phase of population statistics, the demographer had first, to locate the areas of deficient returns, and, second, to adjust the data to its maximum likelihood of accuracy. Several methods have so far been proposed, and tried more or less successfully, in this respect. For obvious reasons, none of these methods is universally applicable, perhaps because the origin and the peculiarities of the errors are too diverse to be accounted for in a single systematic way. The following paragraphs summarize the experience recently gained in Greece during the analysis of its post-war fertility, mortality and population trends, on the basis of the vital registration records, for the years 1956 to $1962^{1}$ and its last two population censuses, taken on 7 April 1951 and 19 March 1961.

## II. Areas of deficiencies and adjustment of data in birth-statistics

3. Three main types of errors can be easily located in the registration of births in Greece of recent years:

[^143](a) Delayed registration;
(b) Negligence in reporting exactly the sex of the newborn; and
(c) Omission of reporting the fact of a live or a dead birth.
4. Delayed registration was found to be practised, systematically, for live births occurring in November and in December, the declaration of which is postponed until the early months of next calendar year. Evidence of this is found in the monthly rhythm of live births (frequencies rectified to months of 30 days each, see table 1), in which the number of births belonging to November was about 10 per cent less than expected and that to December by 25 per cent less than expected, on the assumption that there is a regular variation of the frequency of births, with a high point in winter, and a low one during the summer months. The residual of the missing live births is being charged mostly to January, but also to the subsequent months of early spring. The motivation for this practice is, perhaps, the desire on the part of the parents to have their child officially recorded as younger, by one calendar year.

Table 1. Live births registered in Greece, by month of occurrence (average numbers, in thousands, for 1956-1960; months equalized to thirty days each)

| Months(30 days) |  | Live births (per 1,000) |  |
| :---: | :---: | :---: | :---: |
|  |  | Observed | Expected |
| January |  | 15.7 | 14.0 |
| February |  | 15.1 | 13.6 |
| March |  | 14.1 | 13.0 |
| Apri! |  | 12.9 | 12.4 |
| May |  | 11.9 | 11.9 |
| June |  | 11.8 | 11.8 |
| July |  | 12.0 | 12.0 |
| August |  | 12.1 | 12.1 |
| September |  | 12.8 | 12.7 |
| October |  | 13.6 | 13.5 |
| November |  | 12.6 | 13.9 |
| December |  | 10.4 | 14.1 |
|  | Year | 155.0 | 155.0 |

5. Omission or misstatement of the sex of the newborn are found to be closely related with incomplete registration of live births, which is more pronounced in rural areas. During the six-year-period 1956-1961, among almost 1 million registered live births in Greece there were 1,668 records in which mention of the sex of the newborn child was missing. In rural areas (towns with less than 2,000 inhabitants), the frequency of omission was twice as high as in the cities having a population (in 1961) of over 2,000. Improvements are rapid (see table 2) and it seems that

Table 2. Non-declaration of sex, per 100,000 registered live-births in Greece (1956-1961)

| Period | Rural | Urban |
| :---: | ---: | ---: |
| $1956-1959 \ldots \ldots \ldots \ldots \ldots$ | 302 | 152 |
| $1960-1961 \ldots \ldots \ldots \ldots \ldots$ | 95 | 53 |
| $1956-1961 \ldots \ldots \ldots \ldots \ldots$ | 232 | 118 |

this type of inexcusable error, in the official registration of births in Greece, may disappear soon. It applies more often to female than to male live-births, and it is certainly related with the poor registration of the vital facts in the small villages of rural Greece. Evidence for this assumption is offered by the still high proportion of registered male sex to total live-births, in the rural areas, and the grossly deficient stillbirth-rate, which, contrary to the expectation, in rural areas is almost one third of what it is in urban centres.
6. Both these indices may be used to evaluate a first approximation of the size of error committed in each case. From a cursory examination of these characteristics, on the international level, it appears that a percentage of around 51.5 males per 100 live births of both sexes, and a stillbirth-rate of about 20 (per 1,000 live births), as found in the urban centres of Greece, are compatible with those found in countries reputed to have a complete registration of vital facts. On the assumption, therefore, that registration, in urban Greece, is complete or nearly complete, the amount of female live births which escape registration in the rural areas amounts to about 2.3 per cent per year, and that of non-declared stillbirths to 270 per cent over those now registered.
7. The size of the suspected incomplete registration of live births may also be investigated, by using the survival ratios among the population born during the five years prior to the last census (19 March 1961). The result

Table 3. Per cent males, among total registered live-births, and stillbirth-rates, in rural, urban and total population of Greece

| Population | Percent males to all births | $\begin{aligned} & \text { Stillbirths } \\ & \text { Rer } 1,000 \\ & \text { Rve-births } \end{aligned}$ |
| :---: | :---: | :---: |
| Rural ${ }^{\text {a }}$ | 52.06 | 7.17 |
| Urban ${ }^{\text {a }}$ | 51.48 | 19.33 |
| Total ${ }^{\text {a }}$ | 51.78 | 13.10 |
| Total ${ }^{\text {b }}$ | 51.65 | 14.22 |

a Average of period 1956-1959.
${ }^{6}$ Average of period 1960-1963.
can then be compared with the population enumerated in the age group under five years, as follows:

| Recorded live-births (April 1956 to March 1961).... | Males | Female |
| :---: | :---: | :---: |
|  | 406,3 | 378,7 |
| Survivors, expected in March 1961 | 379,76 | 356,52 |
| Census population, less than 5 years of age. | 388,21 | 366,7 |
| Deficit in number of survivors | 8,45 | 10,2 |
| Deficit in registered live- births . .................. | 9,045 | 10,8 |
| Per cent completeness of birth-registration | 97.8 | 97.2 |

The result obtained by this comparison is that incomplete registration of life births affects both sexes, by a proportion of between 2 per cent and 3 per cent, and that, in actual numbers, some 3,600 live births ( 1,500 males and 2,100 females) escape registration every year. However, the validity of this finding depends on the following three assumptions, that (a) the census returns are accurate; (b) migration in this age group is nil; and (c) survival ratios, based on the 1955-1959 life table of Greece, are applicable in this population group. Only the first assumption carries some reasonable doubts, as to its applicability, for it is known that census enumerations often understate the population at the young ages here concerned. In such a case, the number of live births escaping registration in Greece can very well be greater than the 2 to 3 per cent mentioned above. Since both elements here compared (census population and registered live births) may err in either direction and by an unknown quantity, a better assessement of the errors involved may be obtained, when deficiencies in death statistics are also examined, in combination with the above.

## III. Areas of deficiency and adjustment OF DATA IN DEATH-STATISTICS

8. In death statistics, three main areas of weak registration can also be discerned, as follows:
(a) Incomplete registration of infants who die immediately after birth;
(b) Unconventional sex differentials in mortality, during infancy and early childhood; and
(c) Misstatement of the age at death among those dying at old ages.
9. Incomplete registration of early infant deaths is, by far, the most serious of the above weaknesses. As in the case of live births, it is more pronounced among the rural areas of the country (towns of less than 2,000 inhabitants each), and it is intermingled with errors in the statement of the sex of the deceased infant. This may be seen in the following comparison (table 4) derived from the four years' experience between 1956 and 1959.

Table 4. Age and sex characteristics of infant deaths, in rural-urban population of reece. Based on total numbers registered during 1956-1959

| $\begin{gathered} \text { Age at asath } \\ \text { (days) } \end{gathered}$ | Per cent deaths, by age at death |  | Per cont males to all deaths |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Rural | Urban | Rural | Urban |
| 0-6 | 22.1 | 31.7 | 52.2 | 57.7 |
| 7-27 | 20.1 | 20.2 | 50.2 | 53.7 |
| 28-365. | 57.8 | 48.1 | 50.5 | 52.3 |
| 0-365. | 100.0 | 100.0 | 50.8 | 54.3 |
| Age (days) | Tufant death-rate |  | Sex-ratio in death-rate |  |
| 0-6 | 9.4 | 12.2 | 101 | 129 |
| 7.27 | 8.6 | 7.8 | 93 | 109 |
| 28-365. | 24.6 | 18.6 | 94 | 104 |
| 0-365. | 42.6 | 38.6 | 95 | 112 |

10. During this period there were, in the rural areas, 13,732 infant deaths among 322,783 registered live births, while, in the urban centres, the corresponding numbers were 11,849 and 306,918 . The infant death-rate was 42.54 and 38.61 respectively, or 10.2 per cent higher in rural areas. However, and contrary to the expectation, the neo-natal death rate was 10.5 per cent lower in the rural areas over that of urban centres. A similar discrepancy is found in the comparison of sex-differentials, and of the proportion of deaths occurring during the neo-natal period (up to four weeks after birth), which are conspicuously smaller than those derived from an overall analysis of international experience, in this respect. All these evidences point to a substantial underregistration of infant deaths, especially among those dying during the first week after birth, which is heavier among the rural population, but affects also the urban centres. The nondeclaration of an early infant death presumably means, also, omission of declaration as a live birth. Moreover this under-registration seems to be selective, the death of a male infant being
more readily omitted than that of a female infant. The existence of these weaknesses in the registration of infant-deaths in Greece are clearly indicated in the comparisons of table 4. The question now arises as to the ways by which such weaknesses may be rectified, so that the data will approach the best likelihood of their true occurrence.
11. It is helpful, in this respect, to draw on the experience of international demography, as is shown in the example of table 5 and figure 1 . The data presented (totals of the five-year period 1955-1959 for all items, except for live births, which are for the period 1953-1957), show that infant and early childhood mortality are closely related between themselves, and that the proportion of neo-natal deaths to all infant deaths, as well as the proportion of males to total infant deaths, are inversely related with the size of infant, or early childhood mortality-rates. In the resulting patterns of these variables, among countries with low and high infant or childhood mortality, the case of Greece, marked by an asterisk in figure 1


Note: Patterns of variation of infant and early childhood mortality, of the sex-fatio in live-births, and of the constituents of infant mortality, in thirty countries (see sable 5 ).

Figure 1

Table 5. Age and sex characteristics in live births and in infant deaths, among thirty countries, with varying intensity of mortality rates. Average of $1955-1959$ (live births, average 1953-1957), or as indicated

| ${ }_{(1951959)}^{\text {Countrips }}$ | Infant $m_{*}$ |  |  | $\underset{\substack{\text { Live } \\ \text { ber cens } \\ \text { males }}}{\substack{\text { nem }}}$ | Per cent infant deaths |  | Per cent mate infant deaths |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \text { Learn } \\ & \text { rate } \\ & \text { yeaurs } \end{aligned}$ | Rate | $\begin{aligned} & \text { Execess } \\ & \text { per cent } \end{aligned}$ |  | days | ${ }_{\text {days }}{ }^{27}$ | $\underset{d a y s}{7}$ | $\overbrace{\text { days }}$ | 28.365 days | Year |
| 1. Sweden | 0.92 | 17.0 | 12.5 | 51.54 | 66.9 | 76.0 | 59.1 | 58.9 | 55.2 | 58.0 |
| 2. Denmark | 0.94 | 23.7 | 14.6 | 51.61 | 61.2 | 71.1 | 60.1 | 59.5 | 57.8 | 59.0 |
| 3. England-Wales | 0.94 | 23.4 | 12.2 | 51.44 | 60.4 | 71.2 | 58.7 | 58.2 | 56.3 | 57.7 |
| 4. United States of America | 1.10 | 26.5 | 12.0 | 51.25 | 63.8 | 72.3 | 58.2 | 58.1 | 55.8 | 57.4 |
| 5. Scotland | 1.10 | 28.7 | 12.2 | 51.40 | 57.6 | 67.2 | 59.6 | 59.2 | 54.6 | 57.7 |
| 6. New Zealand. | 1.14 | 21.4 | 11.9 | 51.42 | 60.1 | 69.7 | 58.4 | 58.4 | 55.5 | 57.6 |
| 7. Norway | 1.14 | 20.2 | 11.9 | 51.31 | 52.4 | 62.3 | 59.4 | 58.8 | 55.4 | 57.5 |
| 8. Netherlands | 1.24 | 18.1 | 12.6 | 51.46 | 59.3 | 69.8 | 59.0 | 58.9 | 55.8 | 57.9 |
| 9. Australia | 1.32 | 23.9 | 10.9 | 51.34 | 62.2 | 71.2 | 57.4 | 57.4 | 55.7 | 56.9 |
| 10. Canada |  | 30.5 |  | 51.37 | 53.3 | 63.8 | 58.0 | 58.0 | 55.9 | 57.2 |
| 11. Belgium | 1.36 | 35.5 | 13.0 | 51.41 | 47.1 | 59.6 | 59.4 | 58.5 | 57.4 | 58.1 |
| 12. Switzerland | 1.44 | 23.9 | 12.1 | 51.28 | 63.7 | 72.6 | 57.1 | 57.0 | 57.3 | 57.2 |
| 13. Germany, Federal Republic of | 1.48 | 37.4 | 11.1 | 51.45 | 57.9 | 67.5 | 57.9 | 57.6 | 57.0 | 57.3 |
| 14. France | 1.58 | 33.9 | 12.4 | 51.19 | 38.2 | 51.3 | 58.5 | 58.2 | 56.8 | 57.5 |
| 14. Finiand | 1.66 | 26.3 | 11.7 | 51.22 | 53.1 | 63.0 | 57.4 | 57.4 | 56.8 | 57.2 |
| 16. Austria | 1.74 | 42.7 | 11.8 | 51.35 | 50.4 | 61.0 | 57.6 | 57.5 | 57.2 | 57.4 |
| 17. East Germany | 2.00 | 45.2 | 11.2 | 51.69 | 43.4 | 52.0 | 58.1 | 57.7 | 57.1 | 57.4 |
| 18. Hungary | 2.00 | 58.5 | 10.9 | 51.77 | 38.4 | 52.4 | 58.1 | 58.1 | 56.7 | 57.4 |
| 19. Cyprus | 2.40 | 30.8 | 3.1 | 51.12 | 29.4 | 52.2 | 48.7 | 49.2 | 50.6 | 49.9 |
| 20. Greece | 2.48 | 41.4 | 1.7 | 51.98 | 26.5 | 46.7 | 55.2 | 53.8 | 51.2 | 52.4 |
| 21. Italy (1957-1958) | 2.55 | 48.7 | 8.1 | 51.32 | 37.7 | 51.8 | 58.2 | 57.2 | 53.6 | 55.5 |
| 22. Poland (1955-1957) | 2.83 | 74.6 | 10.2 | 51.64 | 25.6 | 40.8 | 57.9 | 57.6 | 56.5 | 56.9 |
| 23. Japan | 3.46 | 37.7 | 7.7 | 51.39 | 32.9 | 55.7 | 57.0 | 56.1 | 54.4 | 55.3 |
| 24. Singapore | 3.80 | 42.5 | 7.8 | 51.59 | 32.2 | 45.2 | 59.5 | 59.3 | 55.0 | 56.9 |
| 25. Trinidad-Tobago | 3.82 | 62.6 | 10.0 | 50.66 | 34.1 | 46.2 | 58.7 | 57.5 | 55.1 | 56.2 |
| 26. Bulgaria | 4.16 | 65.8 | 8.4 | 51.50 | 21.6 | 41.6 | 60.3 | 58.0 | 54.1 | 55.7 |
| 27. Yugoslavia | 7.80 | 98.2 | 3.9 | 51.64 | 19.6 | 38.2 | 57.3 | 55.8 | 52.4 | 53.7 |
| 28. Portugal | 8.93 | 87.7 | 7.2 | 51.50 | 16.9 | 32.1 | 57.2 | 56.8 | 54.3 | 55.1 |
| 29. Chile (1954-1958) | 12.10 | 118.4 | 7.9 | 50.70 | 18.8 | 31.5 | 56.6 | 55.8 | 53.4 | 54.2 |
| 30. Egypt | .. | 130.0 | .. | 51.55 | 7.5 | 16.9 | 58.9 | 56.8 | 50.0 | 51.1 |

[^144](as well as of some other countries), deviate conspicuously from the expected position, thus indicating an incomplete registration of the vital facts concerned.
12. The most obvious weakness is the incompatibly low proportion of infants dying during the first week after birth, which amounts to 22 per cent among all infant deaths in rural areas, and to about 32 per cent in urban centres of Greece. According to international experience, such proportions would correspond to infant death-rates of 85 and 65 respectively, instead of the recorded ones of 42 and 39 (see table 4). If, as a first approximation, the num-
ber of infant deaths occurring during the first week after birth is progressively increased, its percentage to all deaths, and the total infant death-rate, will obviously increase simultaneously, until they both meet at a central point of gravity, indicated by the international experience. This corresponds to an infant deathrate of about 48 for the urban and 56 for the rural population. Further refinements can be applied to these first approximate results. In the first place, the number of unregistered infant deaths, as derived by the above method, should also be added to the number of livebirths, for it is highly improbable that, in the short time interval involved, they were regis-
tered as live births but not as infant deaths. Secondly, sex differentials should also be brought into conformity with the international patterns. At the termination of all possible adjustments, the under-registration was found to
affect not only rural but, also, urban mortality, and the infant death-rate for the country was raised by 25 per cent over its recorded level. The detailed results of these corrections are given in tables 6 and 7.

Table 6. Observed and rectified numbers of live births and of infant deaths in Greece (urban-rural and total, 1956-1959) and estimated completeness of registration

| Population |  | Corrected |  |  | Original |  |  | Per 100 complete. ness |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Males | Females | Total | Males | Females | Total |  |
| Live births (in thousands) |  |  |  |  |  |  |  |  |
| Rural <br> Urban |  | 170.3 | 160.6 | 330.8 | 168.0 | 154.8 | 322.8 | 97.6 |
|  |  | 159.3 | 150.2 | 309.5 | 158.0 | 148.9 | 306.9 | 99.1 |
|  | Total | 329.6 | 310.8 | 640.4 | 326.0 | 303.7 | 629.7 | 98.3 |
| Infant (under one week) deaths |  |  |  |  |  |  |  |  |
| Rural |  | 4,068 | 2,946 | 7,014 | 1,580 | 1,446 | 3,026 | 43.1 |
| Urban |  | 3,712 | 2,666 | 6,378 | 2,165 | 1,587 | 3,752 | 58.8 |
|  | Total | 7,780 | 5,612 | 13,392 | 3,745 | 3,033 | 6,778 | 50.6 |
| Infant (under one year) deaths |  |  |  |  |  |  |  |  |
| Rural |  | 10,234 | 7,991 | 18,225 | 6,977 | 6,755 | 13,732 | 75.3 |
| Urban |  | 8,182 | 6,293 | 14,475 | 6,435 | 5,414 | 11,849 | 81.9 |
|  | Total | 18,416 | 14,284 | 32,700 | 13,412 | 12,169 | 25,581 | 78.2 |

Table 7. Rectified characteristics of infant death-rate in Greece (1956-1959)

| Population | Per cent deaths under 1 week |  |  | Infant death-rate |  |  | $\begin{gathered} \text { Per } \\ \text { centin- } \\ \text { crease } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Males | Females | Total | Males | Femates | Total |  |
| Rural | 39.8 | 36.9 | 38.5 | 60.1 | 49.8 | 55.1 | 35.3 |
| Urban | 45.4 | 42.4 | 44.1 | 51.4 | 41.9 | 46.8 | 21.1 |
| Total | 42.3 | 39.3 | 41.0 | 55.9 | 46.0 | 51.1 | 24.8 |

13. Finally the erroneously high age at death, as reported for those dying at very old ages, is being brought into light in the example of table 8 . In this, the number of deaths at the age group of 85 years and over was growing rather smoothly, over the period 19511963, in conformity with the known rate of aging of the population of Greece. By contrast, the death-rate grew precipitously between 1951 and 1960, and then dropped sharply, resuming its slow rate of increase comparable to that observed in the number of deaths. The element of this disturbance is located in the estimated population in the age group $85+$, which, undisturbed as it is by migration, was being reduced each year by a disproportionately large number of persons alleged to have died in this age bracket, but actually being at a younger age when death occurred. The 1961 census

Table 8. Mortality at very old ages (85 years and over) in Greece, 1951-1963

| Year | Number in thousands |  | Death |
| :---: | :---: | :---: | :---: |
|  | Population | Deaths |  |
| 1951 | 30.9 | 5.6 | 180 |
| 1952. | 31.2 | 5.6 | 181 |
| 1953. | 31.6 | 6.9 | 217 |
| 1954. | 31.5 | 7.4 | 235 |
| 1955. | 32.0 | 6.7 | 211 |
| 1956. | 32.5 | 8.1 | 248 |
| 1957. | 32.5 | 8.3 | 255 |
| 1958. | 32.4 | 8.1 | 250 |
| 1959. | 31.9 | 8.6 | 268 |
| 1960. | 31.4 | 8.8 | 281 |
| 1961. | 48.0 | 9.6 | 200 |
| 1962. | 47.4 | 9.9 | 209 |
| 1963. | 46.3 | 10.1 | 218 |

brought back this population to its true level, thus reducing sizably the corresponding death rate. This anomaly, which begins in Greece at the ages beyond 60 and affects more heavily the female sex, can be rectified with the analysis of the constituents of the mortality, in the light of the returns of the last two censuses, 1951 and 1961.
14. It may therefore be concluded that defi-
cient data in vital statistics, which are common in many countries, may be adjusted to approach their true levels, provided that, first, there are available supporting data from recent censuses and the registration system and, second, use is made of the vast amount of international demographic data, which demarcate specific patterns, joining together the various but intrinsicly related demographic elements of human fertility and mortality.

# The United Arab Republic project for measuring vital rates in rural areas 

## G. Vuкоvich

## I. Background of the project

1. The lack of adequate information on basic demographic parameters is one of the greatest obstacles to proper economic, social and health programmes in developing countries. Because of the acute need for demographic data, attempts have been made in many countries to improve the registration system, if any, or to establish a new registration apparatus which may provide necessary information on population statistics. In spite of the efforts already made, registration in these countries is far from being complete and accurate, and vital statistics published are seriously deficient. As to the censuses taken in those countries, in most cases they also can be considered as inaccurate both from the quantitative and qualitative points of view. To make up for this shortcoming, different methods, aiming at the adjustment of deficient statistics and calculating failing parameters from the existing ones have been developed. This latter procedure is generally based on stable and quasistable population models. Besides, the importance of developing sample surveys has gradually gained ground and these, if properly designed, can serve as substitutes for deficient registration and census. Sample surveys have been carried out in a number of developing countries providing valuable information on population parameters. And since both registration and census have a long way to go before they can be brought up to the required standard, sample surveys can be considered as the cheapest and most suitable method of getting statistical information on the population of developing countries.
2. A thorough investigation of population data of the United Arab Republic easily reveals their shortcomings. The registration system had been established in Egypt as far back as 1917, and the statistical processing of vital events has also been established a long time ago. The quality of population data, however, is being seriously influenced by the fact that health bureaux, which assume the responsibility of reporting vital events, are serving less than the half of the population of the country (47.3 per cent in 1960). Out of the popu-
lation served by health bureaux the ratio of those belonging to urban areas amounted to 79 per cent in 1960 , which means that about 84 per cent of all rural areas were not covered by the network of health bureaux in 1960. Because of the efforts made by the Government this percentage shows a continuous decrease; nevertheless, it will be years before all rural areas will be served by health bureaux. The completeness of registration in urban and rural areas that have health bureaux shows a remarkable improvement-fluctuations however, often occur. It was considered to be over 90 per cent for the average of the years 1959-1960. On the other hand, rural areas without health bureaux show serious underregistration, as suggested by the data of table 1. It can be seen from the table that these areas have "lower" crude birth and death rates, and a more "favourable" pattern of age specific mortality than any of the other areas included in the table. Since crosstabulated data of vital statistics cannot be taken apart according to the three areas figuring in table 1, analysis of vital statistics based on published data seems to lead to erroneous results. Similar difficulties arise when analysing census data.
3. The weakness of vital statistics and the growing need for accurate data were subjects of successive discussion at the North African Demographic Centre, and resulted in a decision to carry out a research project devoted to the measurement of correct vital rates and a thorough analysis of fertility, mortality and migration in rural Egypt. As cities and towns have a nearly complete vital registration, the project was suggested to be limited to rural areas only. It has also been agreed that the project should be carried out in two steps, the first being a survey of Lower Egypt, and the second of Upper Egypt. The Lower Egypt survey is expected to be started in the first half of 1965 , while the Upper Egypt survey will be carried out about a year later. Our report refers to the preparatory stage of the Lower Egypt survey, but it should be pointed out that the same methodology will be adopted for the second stage, and the dividing of the project into two parts is only due to the lack of ade-

Table 1. Vital rates calculated from unadjusted data, by different areas of the United Arab Republic (1960)

| Item | Urbanareas | Rural areas having health <br>  | Retral areas wothowt hewlin bureau: |
| :---: | :---: | :---: | :---: |
| Crude rates (per thousand): |  |  |  |
| Crude birth rate | 43.9 | 48.5 | 41.6 |
| Crude death rate. | 17.6 | 22.1 | 15.6 |
| Rate of natural increase. | 26.3 | 26.4 | 26.0 |
| Age-specific death rates (both sexes): |  |  |  |
| Infant mortality rate. | 0.1425 | 0.1336 | 0.0791 |
| Central death rates: |  |  |  |
| 1-4 | 0.0345 | 0.0501 | 0.0331 |
| 5-14 | 0.0019 | 0.0023 | 0.0019 |
| 15-39 | 0.0032 | 0.0031 | 0.0026 |
| 40-59 | 0.0090 | 0.0078 | 0.0077 |
| $60-$ | 0.0701 | 0.0748 | 0.0684 |

quate, highly qualified personnel to be employed on the field. The costs of the projects are granted by the U.S. National Center for Health Statistics and the North African Demographic Centre has taken the responsibility of designing and carrying out the surveys, and of their final analysis. The field work itself will be carried out by the Department of Statistics and Mobilisation of the U.A.R., on the basis of a subcontract between the North African Demographic Centre and the said department. A joint committee including staff members of the Statistical Department and the North African Demographic Centre has been formed in order to design and supervise the field work.
4. The project includes three enumerations of population of a sample of villages, the continuous registration of vital events in the sample villages, a special fertility survey, and the processing and final analysis of data obtained by the surveys. The project is based on approximately 1 per cent sample of the total rural population of the United Arab Republic. It should be mentioned that the North African Demographic Centre, which is serving the Arab countries of North Africa and the Middle East, has launched two more research projects in 1964. One of these will provide demographic parameters for Arab countries, while the second will be a comparative study on fertility of developed and Arab populations. The project reviewed in this paper is expected to be of basic use for both projects mentioned, since it will help, among others, to establish typical fertility and mortality patterns of a rural Arab population, which may be helpful when analysing demographic conditions of other Arab countries.

## 11. The selection of sample units

5. The sample had to meet the requirement of being representative for the rural population of Lower Egypt. A systematic, stratified sample was drawn by the following method:
(a) The villages of Lower Egypt were grouped according to their size and ten strata were thus formed, and they were finally drawn together into three broad strata, which are as follows: villages with (a) less than 2,000; (b) 2,000-4,999; and (c) 5,000 and more inhabitants. The median population of each stratum was $1,215,3,200$, and 6,930 , respectively. The lower and upper quartiles of the distribution obtained by forming the three broad groups nearly equals the upper limit of the first, and the lower limit of the third group interval. All calculations referring to the sample design were based on the data of the 1960 population census of the United Arab Republic. As mentioned before, the sample fraction has been agreed to be about 1 per cent of the total rural population of Lower Egypt, as of September 1960. A greater sample fraction would surpass the available financial resources and would not permit the concentration of qualified staff on the field operation. The 1 per cent sample, however, satisfies the requirement of representativeness, and the population included amounted to about 95,000 in 1960 and certainly exceeds 100,000 in 1965;
(b) The number of villages to be sampled from each stratum has been calculated by dividing 1 per cent of the population of the stratum concerned by the median population of
the stratum. Equal sample fractions were thus obtained within each stratum, the number of selected villages being eight in the first, eleven in the second, and six in the third stratum. The selection of sample villages was based on a list containing the names of all villages in Lower Egypt, and grouped according to the group intervals of the strata. A systematic sample has been drawn up from the list, the results of which can be seen in table 2. The
sampling fraction for the total population is 1.08 per cent, and as it appears from the table, the middle group (villages with $2,000-4,999$ inhabitants) is slightly over-represented, while the third group seems to be somewhat underrepresented. The value of the first group equals the average sample fraction. No corrections of the sample have been made and the fractions obtained by systematic sampling were considered as final.

Table 2. Sample fractions for the Lower Egypt survey
(Based on 1960 population census data)

| Stratum | Population number |  | Number of willages |  | Sample fractions |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total tural | Sample | Total rtral | Sample | $\begin{gathered} \text { Villa- } \\ \text { ges } \end{gathered}$ | Popu <br> lation |
| Under 2,000 | 912,690 | 10,873 | 767 | 8 | 1.04 | 1.06 |
| 2,000-4,999 | 3,343,306 | 40,723 | 1,024 | 11 | 1.07 | 1.20 |
| 5,000 and over. | 4,519,104 | 43,100 | 567 | 6 | 1.06 | 0.95 |
| Total | $\overline{8,775.100}$ | $\overline{94,696}$ | $\overline{2,358}$ | 25 | 1.06 | 1.08 |

## III. The population at risk

6. The determination of the population at risk always raises delicate problems, and different methods have been adopted in surveys carried out so far. As to our problem, since the sample population is sufficiently large (over 100,000 ), and arrangements were made to employ trained staff in the field, as interviewers and supervisors, it was possible to work out a plan which may minimize the effects of uncertain factors when determining the population at risk. Making use of the relatively high number of expected staff members at disposal, the taking of three successive censuslike enumerations has been decided. It is hoped that the enumerations, if carried out properly, will provide the highest possible degree of accuracy. The first enumeration will take place one week before the first day of the one year period of continuous registration of vital events. The second enumeration is planned to be carried out at the mid-period of the registration year, while the third one will be on the last day of the survey, i.e., the last day of continuous registration. The census-like enumerations will cover all sample villages and will be carried out on basis of general rules of census taking. Because of the limited area involved and since some of the villages show a certain extent of migratory movements, it has been agreed that better results can be obtained by adopting the de jure method both in enumerations and vital registration.
7. The enumerations will be carried out by the so-called household method, and a house-
hold questionnaire similar to that used in the 1960 census of the United Arab Republic has been adopted for the survey. The main difference between the questionnaire adopted for the survey and that of the 1960 U.A.R. census is that the former will be supplemented by a question referring to the length of the stay in this village, and that the question concerning the number of children ever born will be raised to all ever married women, instead of the married women only. Single females are not to be asked for their children, but since in a rural Arab society illegitimate childbearing is rather exceptional, the omission of eventual illegitimate children will have a negligible effect on the fertility pattern of the population under study.
8. The questionnaire of the census-like enumerations will be filled in by household units. The tabulation, however, will be based on individual punch-cards. The tabulation programme of the enumerations will be so determined as to give sufficient information on the distribution of population by basic demographic items. Detailed cross-tabulations will be made by sex, age and marital status, and special tabulations are planned in order to permit deeper analysis of the population and to serve as denominators when calculating different demographic rates. The enumerations are considered to be not only devices when calculating the population at risk, but their data, as those of general censuses, will be analysed since they are expected to have a higher accuracy than the 1960 census had. Data of the second enumeration (carried out at
the mid-point of the one year registration period) will serve after certain corrections as the population at risk. Both the first and the third enumerations have the primary purpose to check on the completeness of the second one, and some tabulations will be made from the data of these two enumerations for checking.
9. The third purpose of the enumerations is to help the registrar when registering vital events in the village. Some items to be entered in the register are being taken from the household questionnaire of the first enumeration, which offers a possibility of improving the quality of both the registration and enumeration.

## IV. The fertility survey

10. Based on the continuous registration of births, a special fertility survey will be carried out by the help of an extension of the birth questionnaire. This survey will be the first attempt to get detailed information on fertility histories of a sample of rural females in the U.A.R. All mothers giving birth to a child during the registration period will be included in the survey and interviewed by the registrar, the number of females thus interviewed will amount to about $5,000-5,500$. The survey obviously excludes females having no delivery during the registration period. But since the fertility in rural Egypt is believed to be constant, fertility histories of females of different ages during a period of a year may not substantially differ from the so-called longitudinal fertility pattern of a cohort of females, or at least, some basic patterns, which are characteristic to a rural Arab society can be obtained by this way. Besides the routine questions referring to the present child and the female's previous fertility history, the survey is hoped to provide some information on the family planning experience of the mothers. The fertility survey will be carried out by completing a special questionnaire which is an amendment of the statistical report on births. The questionnaire will be divided in two parts, the first referring to the social and economic conditions of the mother and her husband, the age at marriage, number of previous marriages of the wife, and the previous pregnancies and deliveries, while the second part will ask for knowledge on family planning and eventual experience in that field. Considering the difficulties in collecting this type of information from a relatively large number of females living in a traditional rural society, the registrars (who are females) will be specially tramed in this field. The fertility survey will permit the analysis of fertility by duration of marriage, occupational and educa-
tional differences, and may contribute to the knowledge on the influence of age at marriage on fertility, the fertility of first and subsequent marriages by age at marriage, and the influence of accidental birth control experience on fertility.

## V. The continuous registration of vital events

11. All vital events occurring during the registration period will be registered, irrespective of whether or not they are registered by an administrative or health authority. As stated before, the registrars will be females, preferably full time employees. They will be appointed to the sample villages for a period of fourteen months and their number will depend on the number of inhabitants of the village in question. Their duty will be not only the mechanical registration of vital events, but also of visits to families living in their area of action, in order that they make themselves socially acquainted with the population. This method is hoped to reduce the omissions to minimum, and to improve the quality of answers.
12. The following events are to be registered: births, deaths, marriages, divorces, immigration, and ernigration. All events will be entered into special registers, designed to suit statistical processing, and monthly reports are expected to be submitted to headquarters. Special methods are being developed in order to secure the proper book-keeping of all events. The registrar will be provided with a copy of the first census-like enumeration, which will serve as a benchmark when visiting the families and entering answers in the register. The registration forms have many items in common with the enumeration questionnaire, and this offers a possibility of thorough checking and is expected to improve the quality of both registration and enumeration. At the same time, this method may reduce the errors in the data caused by the inconsistency of numerators and denominators of rates.
13. By the end of the registration year, and after the necessary corrections and eventual amendments, the registered material will be centrally coded and converted to individual punch-cards. The registration and the censuslike enumeration will permit the calculation of several demographic parameters for the rural population of Egypt, such as life table, fertility and reproduction rates, nuptiality tables, migration tates and others. The first publication of the results of the project will be made available by the end of 1966 .

## SUMMARIES OF PAPERS

## Attempt to estimate the under-registration of children of less than one year in the Iranian census of 1956

## M. Amani

In the population censuses of the developing countries, the group of children of less than one year is one of those most liable to underregistration. Our study is designed to show how this phenomenon appeared in the Iranian census of 1956 .

As a basis for our estimate, we took the ratio between the group of children of less than one year and the group of those from one to four years divided by four.

In the case of most populations, the number of children from one to four years divided by four will be less than the number of those of less than one year. If it turns out otherwise, it can be considered that the group of less than one year has been under-enumerated. For example, according to the Iranian census of 1956 the number of children of less than one year in the rural areas was 364,537 and one quarter of the number of those from one to four years was 514,391 - a higher figure than that of those of less than one year.

In order to obtain a registration index, we calculate the ratio of those of less than one year to one quarter of the group of one to four years multiplied by one hundred.

There is no doubt about the under-enumeration of the children of less than one year in the 1956 Iranian census. The application of the index cited above gives 77 , which shows that 77 per cent of the children of less than one year were registered in 1956. In a population of the type of the Iranian population, this index should be about 118. Consequently the real number of children of less than one year in 1956 should be 827,521 .

## Method of life table construction for populations for which vital statistics are lacking

Eduardo E. Arriaga

In the past, there has been under-registration in the statistics of certain countries that make their utility for the construction of life tables
hazardous, if not impossible. A method for the construction of life tables, based on the proportional distribution of the population by age groups, and an estimate of the annual growth rate, is presented here. The importance of this method lies in the fact that deaths are not needed for the calculation of the probabilities of survival. Moreover, even though the method requires estimation of the birth rate, this estimation is obtained by the same procedure of adjustment, and therefore, it is not necessary to use birth statistics. On the other hand, since the method uses the proportionate distribution of the population between certain ages (in general between 10 and 55 years old), the common percentage omission in the registration in all age groups does not affect the calculations, and the effect of the differential omission by age is considerably reduced. The method has limitations, and its application is advisable only in those cases where fertility has not varied very much or has experienced minor variations. Another requirement of the method is that migratory movements should be meaningless. The method proves to be useful in the case of populations where the utilization of vital statistics is impossible, but its main value lies in the fact that it is possible to estimate with some accuracy the mortality levels in the past when registration did not exist or was incomplete.

## Problems of evaluating and locating census data as preliminary stages in the analysis of internal migration

## K. M. Barbour

The study of internal migration, particularly of rural-urban migration, demands the satisfactory definition of urban and rural settlements. These may be classified according to their size or function, or a combination of the two. For effective international comparisons, agreed criteria are necessary, so that migration sources and destinations may be observed.

Maps are a useful tool in the study of the direction and distance of migration, as well as in the classification of the areas of the depopulation and growth. Maps also provide a base for the study of inter-censal change. The paper describes various studies undertaken in Sudan,

Ghana and Nigeria and their utility for subsequent surveys of many kinds as well as for rural administration.

## Repeated demographic observation in a rural area in Senegal: method and first results

## Pierre Cantrelle

A continuing demographic observation was undertaken for the first time in two areas of the groundnut-growing region of Senegal, one having a population of 33,000 and the other of 17,000.

An individual card index was established for these 50,000 persons. It is brought up to date annually by visiting each family and recording the events that have occurred since the original census (births, marriages, deaths, emigrants, immigrants).

The data collected by this procedure are much better than those provided by the official register of births, marriages and deathswhich has many gaps in this rural area and are also superior to those collected by visiting the villages every three months.

The method used also seems to be preferable to the surveys based on a single recapitulatory questionnaire, which had previously been used in Senegal.

The rates calculated for the resident population observed during the first year of the survey (1963) in the two areas are, respectively: birth rate, 48 and 54 per thousand; fertility rate, 212 and 218 births per thousand women between the ages of 15 and 49; death rate, 32 and 25 per thousand. These results seem reasonable bearing in mind the factors affecting the death rate, which could be observed.

The present survey will be continued for at least three successive years with a view to ascertaining the annual variations in the birth rate, which have not yet been established for Africa.

## Research and data collection techniques for developing areas

Joseph A. Cavanaugh

Demography, vital, health and other types of statistics vary greatly in respect to the degree of their reliability in developing areas. Lesser developed countries are often unable to utilize research and data collection techniques employed in economically advanced countries. The major purpose of this paper is to indicate that
the quality of statistical data can be improved substantially and the quantity of such data can be increased by developing and implementing special techniques adapted to the resources and capabilities of developing areas.

Special techniques are needed for a variety of reasons. Biological conditions in lesser developed areas do not lend themselves to the easy collection of statistics. Communication and transportation facilities are poor and economic resources for the collection, processing and publishing of statistical data are limited.

A number of techniques may be used to improve the efficiency of the administration of research and data collection systems. To avoid duplication of statistical activity by various governmental components, a central coordinating council may be established. The collection of vital statistics and the estimation of parameters may be performed by assuming that births and deaths are a function of population size. Future need for manpower and facilities can be estimated by assuming that the need is a function of population increase and the necessity to erase a present deficit. Hospital statistics may be obtained easily and without excessive cost by the use of a simple schedule and final tabulation of patient characteristics based on a sample. A national sample design for low cost surveys can assist greatly in the collection of a wide variety of types of data.

Considerable imagination and initiative are necessary to adapt older techniques and invent new ones. Various international organizations, government offices and training centres are engaged in the development of special techniques. It is urgent that implementation of these techniques be accelerated in a world of nations that is experiencing an ever-increasing interdependence and need for reliable statistical data on population and related areas.

## A note on the use of birth-place-place of residence data for estimating intercensal migration streams

## D. Friedlander and R. J. Roshier

This paper attempts to demonstrate how classifications of persons by birth-place and place of residence have been modified into sets of intercensal migration streams. The method has been applied to English data, covering some 100 years. The main problem is that the classifications of persons by birthplace and place of residence refer to lifetime migration and not to any specified period. To turn lifetime migration into intercensal migration data requires an
examination of the mortality of the different groups of life-time migrants and in turn, an assessment of the influence of their age structures upon their survivorship. Thus, if the classifications of persons by birthplace and place of residence would have been further classified by age, it would be relatively easy to turn the lifetime migration data into intercensal migration data. However, this has rarely been done on a national basis.

It is shown in the paper that age distributions of lifetime migrants can be estimated with sufficient accuracy for the purpose, and hence intercensal migration streams can be calculated. The main assumption involved is that the age structure of current intercensal migrants is constant, and it is shown that this assumption is not too unrealistic.

## Non-conventional methods of obtaining data on the religious composition of the United States population: the case of Jewish population statistics

## Robert Gutman

A variety of non-conventional methods have been used over the last century in obtaining data on population characteristics and births and deaths among the Jewish population of the United States. These methods can be classified in terms of three attributes: the auspices under whose direction they were used; the portion of the total national Jewish population to which they relate; and whether or not the procedures involved personal enumeration. The combination of these attributes yields eight categories, each of which represents a distinct type of method for obtaining data. Studies of Jewish population statistics illustrate seven of these types. Each is discussed and brief comments are made regading their reliability and usefulness. Among studies dealing with population trends among Jews in the nineteenth century, Billings' survey in 1889 is outstanding. Approximately forty community surveys conducted by private organizations affiliated with Jewish denominations have been conducted in particular cities and metropolitan areas since the 1930's. These offer a rich source in depth for understanding the demography of American Jews. With the exception of one survey conducted by the Bureau of the Census in 1957, all figures purporting to show the number of Jews in the United States have been collected under private auspices through impersonal enumerations. Plans are now under discussion among Jewish organizations to conduct their own sample surveys.

## A method of using census data for measurement of fertility

Ivo Laif

Census data generally contain among other quantities the numbers of women in single ages $L_{x}$ and the corresponding numbers of liveborn children $K_{x}$. From these quantities without taking into consideration vital sta-tistics-fertility rates can very easily be computed.

The empiric cumulative fertility $F_{o}(x)$ must be analytically graduated beforehand. "The force of fertility" is defined by $\mu_{x}$. In the lowest fertile age this force is $\mu_{a}=+\infty$, in the highest fertile age it is $\mu_{\omega}=0$. A differential equation meets these conditions and contains, besides that, a parameter characterizing the typical properties of the fertility in question. Other parameters are added and the generalized formula for the analytical graduation of empirical cumulative fertility $F_{o}(x)$ is given. The parameters $\alpha_{v}$ are to be calculated by least squares method, which leads to a system of normal equations.

For the sake of facilitation and acceleration of the computation the values of the function $\eta^{\text {p }}$ are given.

A numerical example of this theory on the basis of Yugoslav census data from 15 March 1948 is presented.

Mutatis mutandis, this theory can be applied on the computation of nuptiality, divorciality and other demographic tables too.

## Population data and the Indian National Sample Survey

## D. B. Lahirp

The paper discusses the data collection experience of a developing country like India under conditions of extremely limited resources and pressing need for reliable data for national economic and social planning.

Indian National Sample Survey (NSS) is a multi-subject, continuing survey organization which collects comprehensive population data using improved survey-design procedures for controlling non-sampling errors. The National Sample Survey collects data by villages and/or urban blocks so as to establish relationships between demographic variables and the regional characteristics of the particular villages and/or towns.

Three broad principles are followed in the collection of the population data: first, introduction of only a few demographic variables
even in subjects which are primarily demographic; second, introduction of non-demographic variables likely to illuminate population problems; and finally, the use of an integrated approach where data on the various socioeconomic aspects of the households, standard of living etc. are coilected on a continuous basis to study various demographic situations. Integration of different types of data-variables in a single round of survey is considered economical not only because of technical reasons but also because of savings in overhead costs.

## Techniques to measure population growth: survey of population change in Thailand

Patience Lauriat and Anuri Chintarananda

The paper discusses the experience of the National Statistical Office of Thailand in carrying out a sample survey to establish reliable estimates of growth of population over a period of time. The specific purposes of the survey are:
(a) To obtain reliable estimates of the total birth and death rates;
(b) To obtain reliable estimates of the annual birth rates by age of the mother;
(c) To obtain reliable estimates of annual death rates by age and sex;
(d) To measure under-registration of births and deaths;
(e) To investigate age and sex biases in vital registration data.

This is a continuing survey, to be undertaken over a period of five years from 1964 to 1969. The first round was begun in July, 1964 and as of May, 1965, the fourth round of interviews was under way. The survey is a stratified twostage probability sample consisting of geographically definable areas which could be identified in the registration documents. Bangkok and environments with over 2 million people were excluded from the universe of the survey, but the feasibility of adding the registered data for Bangkok to the findings of the survey is being planned.

On the basis of the data collected so far, the first approximation of the crude vital rates for Thailand are estimated to be 46.0 per 1,000 for births and 12.9 per 1,000 for deaths. The relative sampling error is expected to be about 1.5 per cent for birth rates and at a slightly higher level for death rates. These estimates will also be subject to non-sampling errors, of which the most serious is expected to be underreporting of vital events by the respondents.

Forthcoming data from the continuous rounds of the survey will allow for the precise estimates of growth rates. The experience, so far, has confirmed the idea that sample survey techniques can be applied to measure population growth in the absence of reliable vital statistics.

## The graduation of age-specific fertility rates by order of birth of child

Denis Peter Mazur

This report is concerned with mathematical concepts in the approach to fertility rates for those situations where basic data are scant and erratic. It should therefore be of special interest for work on most of the non-industrialized regions where censures are not as yet administered efficiently. A general solution to the problem of graduating age-order specific fertility rates is presented here in the form of equations applicable to data situations where only the rates of total fertility by order of birth of child are available, or where the data are gathered in broad age categories. Theoretical considerations presuppose knowledge of certain basic parameters such as, the initial, terminal, and modal age of fertility in a population of women. The graduation of rates to any desired degree of specificity by age of woman and up to the sixth and higher orders of birth can best be done on the basis of period-type rates and, under certain conditions, with generational measures as well. In addition, projections of incomplete cohort fertility rates by age of woman and order of birth of child can be made in a similar fashion with the use of the model.

## An index to measure digit preference error in age data

## K. V. Ramachandran

Single and even quinary year of age data are of immense value in planning. Unfortunately, many times, the data have gross digit preference errors. An idea of this error can be had by using one of several techniques. The graphical method is easy but is subjective and cannot quantify it. The Digit Preference Index is easy of calculation but suffers from the effect of mortality. The Myers Index takes account of this but does not consider the varying incidence of the error of the non-stability of the population. Carriers Indices to a large extent take account of all these but still leave much to be desired. For comparing groups of populations especially these have less value.
A new index called the Preference Pattern Index is given here for this purpose and is
defined below: ten pattern matrices are formed starting with an age with end digit $r(r=0$, $1, \ldots, 9)$. The pattern matrix starting with an age ending in digit $r$ is obtained by taking percentages of ages ending in digits $0,1, \ldots, 9$ in each of the age segments $r$ to $r+9,10+r$ to $19+\mathrm{r}, \ldots, 10(n-1)+r$ to $10 n-1+r$. The percentages in all the ten pattern matrices at each digit $r$ are then pooled to form the blended percentages ( $r=0,1, \ldots, 9$ ). The ratios expressed as a per cent of these blended percentages to their grand total give an idea of the preference for the digits and the sum of their absolute deviations from 10 provides an index of digit preference.

The performance of these indices on the single year of age data for Greater Bombay, India is made and the advantage of the new index over the others especially for comparisons of groups is brought out.

An evaluation of the use of retrospective questionnaires for obtaining vital data: the experience of the Moroccan multipurpose sample survey of 1961-1963
Georges Sabagh and Christopher Scott
The objective of this paper is to show the sources and extent of errors of observation in the different methods that were used to collect birth and death data in the 1961-1963 multipurpose sample survey of Morocco carried out by the Moroccan Central Statistical Service.

All data in this paper are based on 131 of the 146 rural primary units (mostly villages) of the survey (population 55,788). The survey involved three rounds with exactly one year between the 1 st and 3 rd rounds and a mean interval of 197 days betwen the 1st and 2nd rounds. The following survey items were used:
(a) List of household members (1st and 2 nd rounds and roll-call at 3rd round);
(b) Retrospective death (1st, 2nd, and 3rd rounds) and birth questionnaires (3rd round);
(c) Date-of-birth questionnaire ( 2 nd round);
(d) Household check-sheet explaining differences between 1st and 2nd round lists (3rd round).

In 84.6 per cent of births and 59.0 per cent of deaths that could have occurred between the 1 st and 3 rd rounds, there was agreement between all documents. When documents disagreed a number of rules had to be established to specify which evidence was overriding. The analysis of error pertains to the period between the 1 st and 2 nd rounds.

If vital data were collected with a singleround retrospective procedure, the gross error
(over-enumeration+under-enumeration) would be 17 per cent for births and 36 per cent for deaths. There is a net error of over-enumeration of 3 per cent for births and 10 per cent for deaths. If two rounds are available thus making possible a combination of household composition follow-up and a retrospective mortality questionnaire, over-enumeration is almost entirely eliminated and under-enumeration is noticeably reduced.

Most of the remaining errors of underenumeration were attributed to (a) an estimated number of infants born and deceased between the two rounds and missed by all questionnaires; (b) matching failures due to the absence of adults at the 1 st round; and (c) matching errors.

## Census data and urban planning requirements

## Dawlat A. Sadek

The importance and need of reliable population data for the purposes of physical planning needs hardly any emphasis. It is inconceivable to think of planning and designing the future growth of an urban area without the help of this basic information on people. This is even more true in the case of planning redevelopment of existing towns and cities. Since cities are concentrations of people in a relatively small space, it is only appropriate that an urban planner and geographer should know all the relevant facts and characteristics of population for which an area has to be planned. In the absence of reliable population data, planners and geographers are left to rely on more or less vague notions about the size, needs and resources of a given community.

It is, therefore, essential that the census should provide as much of the relevant demographic data on our cities as possible. The proposed city census handbooks together with certain basic maps visualizing the demographic information on the cities could be of great assistance not only to urban planners, but to administrators, social workers, and research students as well.

## Estimates of birth rate and expectation of life in India on the basis of quasistability

## G. B. Saxena

Indian population for the last two to three decades has been behaving in a quasi-stable form, i.e., mortality has slowly declined while
fertility is fixed at a constant level. In the absence of any significant migration, these factors have resulted in a constancy of age distribution which would have approximately resulted from the stable conditions of fixed age schedules of fertility and mortality.

An application of the stable population theory reveals that the birth rate in India during the years 1901-1921 was 53 per 1,000. In 1931 it was 45 per 1,000 and during the period 19411961, it was about 43 per 1,000 population. Estimated life-expectancies at birth are 20, 22, $19,28,35,35$ and 37 years for females and $20,22,18,29,35,35$ and 42 years for males in 1901, 1911, 1921, 1931, 1941, 1951, and 1961 respectively.

As these rates are based on the assumption that age distribution under perfect stability is exactly identical to that under quasi-stability, these estimates require a correction. The corrected birth rates in 1941 work out at 47 and during 1951-1961 at 46. The corrected estimates of expectation of life for females are 28, 33 and 37 years in 1941, 1951, and 1961 respectively. The corresponding estimates for the males are 29,34 , and 42 years.

On the notions and measures of overpopulation and under-population

## Wilhelm Winkler

The author finds the usual definitions of overpopulation vague, and proposes to replace them with the following definitions:
(1a) Relative over-population: over-population in relation to the present standard of living of the population (formula 1);
(b) Theoretical absolute over-population: over-population in relation to the physiological (and cultural) minimum of (cultural) existence (formula 2) ;
(c) Practical absolute over-population: overpopulation as described in $b$ above, but with allowance for the distribution of income (formula 3).
(2a) Actual over-population: over-population according to (1c) above, with allowance for the resources already developed by the population.
(b) Potential over-population: over-population with allowance for the capacity of the territory to support with its resources the
number of inhabitants by which it is underpopulated.

A territory may be actually over-populated and potentially under-populated if the population has not yet reached a degree of education and organization to enable it to use the territory's economic possibilities. The contrary, potential over-population and actual underpopulation, prevails today in many countries in Europe.

Some figures are attached to illustrate these cases.

## An estimate of the birth rate in Pakistan through the application of quasi-stable population techniques

## Melvin Zelnik

This paper presents the results of an attempt at estimating the current (i.e., 1962) birth rates in East and West Pakistan through the application of quasi-stable population techniques. The two parameters used in the estimation process are the proportionate age distributions for East and West Pakistan, by sex, available from the 1962 Population Growth Estimation (PGE) survey and the (1951-1961) intercensal annual rates of growth (for East and West Pakistan, by sex).

Application of the stable population model requires, or assumes, constant age schedules of fertility and mortality. It is quite likely, however, that mortality has been declining in Pakistan in recent years. It was necessary, therefore, to introduce an adjustment for the effect on the estimates of the bias introduced by the assumption of stability. The results indicate a birth rate (in 1962) of around 61.0 for East Pakistan and 48.0 for West Pakistan.

An attempt was made to determine whether fertility has in fact remained constant over time by comparing the gross reproduction rates estimated by stable age techniques for 1911 age distributions with those estimated from the 1962 PGE age distributions (after adjusting the latter for the bias introduced by declining mortality). The results are close enough to confirm the hypothesis or assumption of constant fertility. On the basis of these estimates, East Pakistan appears to have a GRR of around 4.3 and West Pakistan of approximately 3.4 .

Meeting B. 7

# NEW DEVELOPMENTS IN MEASUREMENT AND ANALYSIS OF FACTORS OF POPULATION GROWTH AND STRUCTURE 

PAPERS<br>Sampling techniques in the elaboration of demographic statistics<br>G. R. Chevry<br>[Translated from French]

## I. Introduction

1. The use of samples representative of larger units is now a matter of general statistical practice in all countries. But before describing how sampling techniques are employed in the elaboration of demographic statistics, it may perhaps be useful to recall the reservations with which they were regarded for many years by economic and social statisticians.
2. The theoretical principles of the method have been well known since the time of Poisson (first half of the nineteenth century) if not since that of J. Bernoulli (second half of the eighteenth century). Yet, it was not until 1895 that the International Statistical Institute took up the question of the use of representative samples. It then waited eight years (1903) before expressing timid approval of the technique, and another twenty-two years (1925) before defining the term "representative method" and approving two techniques for obtaining a sample of such a kind that the results of a partial inquiry based on the sample may be validly extended to the population from which the sample was taken. ${ }^{1}$ Nevertheless, although Professor A. L. Bowley applied the technique as early as 1913 in surveys of social statistics, ${ }^{2}$ it was not until later, in the work of R. A. Fisher (1932) and J. Neyman (1934 and 1938), that sampling techniques were systematically utilized in demographic and sociological inquiries.

[^145]3. The resistance thus shown for many years to the use of a method which nevertheless had valuable advantages was undoubtedly due to the fear of orthodox statisticians that innovators would initiate inquiries based on insufficiently representative samples, and to the difficulty of finding satisfactory sampling frames.

## II. Sampling techniques for fact-finding

## A. Censuses

4. In developed countries the periodic population censuses carried out provide complete coverage. Nevertheless, sampling is sometimes used to simplify the operation, in the following way: the basic questions are addressed to all persons covered by the census, and certain additional questions are addressed only to a sample. This technique may be illustrated by two examples:
(a) In the 1940 United States census a certain number of questions were addressed to only one person out of twenty. They included:
(i) Place of birth of father, of mother?
(ii) Are you a veteran, the wife or widow of a veteran, the child (under eighteen years) of a veteran?
(iii) (For married women, widows or divorcees) Have you been married more than once? Age at first marriage? How many children have you had? ${ }^{3}$
(b) The individual schedule for censuses carried out in France up to 1946 contained the following questions for all persons covered:

[^146](i) In what year were you married? (Give, where appropriate, the years of successive marriages).
(ii) How many live-born children have you had?
(iii) Age in completed years of surviving children?
5. For the 1962 census, all the questions relating to marriage and the birth of children were removed from the general individual schedule and transferred to a special questionnaire addressed only to married women, widows or divorcees born after 1891 (i.e., aged under seventy on 1 January 1962) and resident in a sample of census communes and districts selected in advance.
6. In the developing countries a reasonably adequate population census is the first operation to be carried out before a development plan is drawn up. Unfortunately, in such countries a complete census is often impossible for many years precisely because of their lack of development. Owing to the high proportion of illiterates, particularly among the rural population, the census has to be carried out by specialized enumerators whose work is rendered very difficult by the people's ignorance, their often primitive mentality and the taboos which have to be taken into account. Owing to the extent of the territory to be covered, few developing countries are capable of providing the number of competent enumerators a census would require. Apart from this basic consideration, the developing countries are eager to complete census operations within reasonable time-limits, because of their urgent need for demographic information and because of the slender financial resources available for such operations. For all these reasons, they are obliged to resort almost exclusively to the technique of representative sampling.
7. In the main, this takes two forms:
(a) A census limited to a demographic sample survey carried out in a selected number of villages or hamlets. Such an operation requires lengthy preparation for:
(i) The compilation of calendars for determining the age of persons on the basis of their statements;
(ii) The assembling of the geographical maps necessary for carrying out the survey;
(iii) The sociological research which is essential if the questionnaires are to be well adapted to the population of the survey and the results are to be correctly interpreted;
(iv) The compilation of lists of villages and hamlets constituting the sampling frame.
This method is the one favoured in the Frenchspeaking African countries.
(b) The English-speaking African countries, on the other hand, have tended to use a technique similar to that already described in connexion with the developed countries. It consists in carrying out a general census based on a restricted number of questions, then a sample survey for additional more complicated questions. This technique has two definite advantages: it establishes a sample frame which can be used later for various other enquiries and it provides a sample check of the restricted general census. ${ }^{4}$

## B. Movement of the population

8. In countries where vital records are kept regularly in every administrative district, all the local registration offices usually have registers in which declarations of births, marriages and deaths are entered. On registering such declarations, the local offices also complete individual statistical transcripts corresponding to each declaration (or compile lists by type of declaration: birth, death, etc.). These are transmitted periodically to a regional or national office responsible for compiling statistics of population movement.
9. It is the preparation of these individual transcripts or lists which strictly speaking constitutes the statistical recording of vital events. To our knowledge, sampling is not used in this operation in any country except Sweden.
10. In Sweden, every registration office enters in a special register, known as a "sample" register, births which occur on the fifteenth day of each month, which represent $12 / 365$ ths or roughly 3 per cent of the total number of births. For these births more data are entered than for births on other days. The processing of these sample registers, or rather of the birth reports based on them, provides more complete data than those obtained from the routine processing. ${ }^{5}$
11. For a country whose registration system is not yet operating satisfactorily in all areas and which has a fair degree of racial homogeneity, one way of improving national statistics of population movement is to select

[^147]from its administrative sub-divisions a sample which at least (in so far as vital statistics are concerned) is fully representative of the whole country and to concentrate its efforts on the improvement of the registration and reporting of vital events in those selected areas.
12. But this, of course, can only be a temporary expedient; the ultimate goal is the full and accurate registration of vital events throughout the country. ${ }^{6}$
13. The systematic registration of births, marriages and deaths is generally non-existent in the developing countries; or it may exist in theory but in practice be very incomplete. In order nevertheless to obtain data for calculating current demographic rates with reasonable accuracy, the authorities resort to the sample survey method described above for censuses, framing the questionnaires to obtain the following information (for example):
(a) For each family, the sex and age of the children, and births and deaths which occurred during the twelve months preceding the survey;
(b) For each adult woman, the number and sex of live-born, surviving and deceased children.
14. To obtain data on the natural movement of the population outside the periods in which demographic surveys are held, a procedure known as itinerant registration may be used. This consists in sending an official at regular intervals, say every two months, to a random sample of villages. He interviews the inhabitants and records births and deaths which have occurred since his last visit.
15. Finally, the field tours made by teams of medical personnel may be used as an opportunity for questioning the women examined on their age, their marital status, and the number and sex of their live-born children. ${ }^{7}$

## C. Specific inquivies by sampling

16. Specific surveys of households or individuals, which would certainly not be attempted if they had to provide complete coverage, may be carried out quickly and cheaply by the sampling method, particularly when a recent general census offers a sound basis for the selection of the sample. Of course, surveys of this kind may cover very different topics, but we may mention in particular-because they are carried out with slight variants in many countries-the periodic surveys made of the employment of the labour force. These reveal the evolution and structure of the economicallyactive population between censuses and also

[^148]yield valuable data on the marginal econo-mically-active population-i.e., persons who during a census generally state that they are economically inactive but who nevertheless work either irregularly or for only a few hours a week.

## D. Special studies

17. The sampling method may be used not only for censuses and specific inquiries, but also for special studies which would otherwise present unsurmountable difficulties. The scope for such studies is of course enormous, and may be illustrated by a recent and probably little-known example.
18. In all countries mortality rates by occupation or social class, which are of great significance, are very difficult to calculate, and unreliable, because the denominator of the rates is provided by a census whereas the numerator is obtained by extraction from the death transcripts; and the chances are high that a person will be classified in a different occupational category on his death from that in which he was placed at the census.
19. To calculate correct rates the demographer must be certain of assigning to the sub-population made up of a group of individuals in the given social status category all the deaths of its members, and those alone. A possible method is to establish such sub-populations and keep track of all their members in order to ascertain on certain dates whether they are living or dead. It is here that the sampling method is of great value, for there can be no question of keeping track until death of all the population enumerated, or even of the adult population. That would be an enormous task, and the work must therefore be limited to a sample.
20. French statisticians have been able to undertake such a study by following chronologically until death a sample of more than a million persons enumerated in 1954 and classified at that time in twelve well-defined sociooccupational categories.
III. Sampling techniques in data processing

## A. Censuses

21. After a population census the responsible authorities are always confronted with a mass of documents relating to millions of different statistical units (individuals, households, dwellings, apartment buildings). The processing of these documents, even with the most modern electronic equipment, always takes time; for it is still essential to check the completed forms,
code the replies and possibly mark the documents for mechanical reading, and indeed to prepare conventional punch cards and transcribe them on magnetic tape; all operations, except the last, which must be done by human beings and therefore take time. It would therefore be a serious mistake to believe that modern processing machines reduce to any large extent the time needed to obtain results-particularly in view of the fact that the demands of users of the processed statistics tend to grow even more rapidly than the possibilities offered by the equipment employed. We can only say that with electronic equipment many more results are obtainable in roughly the time formerly taken with more primitive methods.
22. In addition to becoming more demanding, however, the users of data are now in a great hurry. Fortunately, the sampling method permits their being given partial satisfaction by making possible a preliminary processing operation confined to a random sample of the census documents (for example, one document out of a hundred or one out of twenty). Thanks to this procedure only a reasonably short time need be taken to produce results-though these cannot of course be highly detailed-and, in particular, marginal distributions for the country as a whole or for extensive regions.
23. Later, when the exhaustive processing of all the assembled documents is carried out, the statisticians will be entirely at liberty to refrain from recalculating these basic distributions: the sample processing will have yielded an adequate approximation. They may limit themselves to establishing either more detailed distributions or distributions for geographical districts too small to have yielded valid results by the sample method alone.
24. Of course, this type of processing of a sample representing all the questionnaires collected may relate either to all the questions asked or to only some of them.

## B. Population movement

25. Statistics of population movement may be obtained more rapidly with the help of the method currently used for censuses, namely, the priority processing of a random sample comprising a certain percentage of all transcripts of vital events collected. For example, in the United States a national sample representing 10 per cent of death transcripts is taken to obtain very rapidly general information on various causes of death. This is a preliminary processing by the sampling method which does not rule out subsequent processing of all the transcripts collected.
26. However, in order to save time and reduce the total cost of vital statistics, the demographer may give up the idea of complete processing and limit himself to processing a large sample of the transcripts collected-for example, one out of two or three. At the national level and for fairly extensive geographical areas, samples of this size would yield results almost as reliable as those obtained by complete processing.
27. We confess that we are completely unaware whether such a procedure has actually been used anywhere, but probably some countries have considered it. In France, statisticians at one time considered the idea of conducting only a partial processing of certain types of transcripts, but they dropped the idea for the following reasons:
(a) Vital statistics are compiled for fairly small geographical units, and the figures involved are small in terms of absolute numbers. Moreover, the process of tabulation distributes the aggregate data among a very large number of items, and each item therefore has a low frequency. A sample analysis (even of the order of one out of two) would reduce all these numbers still further and, in particular, would raise their deviation coefficient to an unacceptable level;
(b) Over the last twenty years a growing proportion of births have occurred in maternity hospitals or clinics situated in a commune other than that of the mother's habitual domicile. Thus, for France as a whole, the proportion of hospital births rose from 24.5 per cent in 1948 to 52.4 per cent in 1962, the percentages being respectively 28.4 per cent and more than 65 per cent for mothers domiciled in rural communes. Since under French Civil Code births must be declared in the place where they occur, the National Statistical Institute has been compelled to process birth transcripts twice, first according to the place of birth and secondly according to the mother's domicile. This dual operation, which moreover produces statistics by communes, does not lend itself to the sampling method.

## IV. The use of sampling techniques in the verification of complete inguiries

28. Ever since statisticians have conducted censuses and inquiries, they have been obsessed with the need to know the degree of approximation of their results. They are aware, of course, that a census which is intended to give complete coverage never does so entirely, that it certainly contains omissions and probably also duplications, and that mistakes may have been made in carrying out instructions and in
the declaration or notation of the characteristics presented by the persons enumerated. Sampling offers a means of checking the order of magnitude of these errors at a relatively low cost.
29. Inquiries of that kind will not be examined further here, however, since they are to be discussed in a special paper by Mr. G. Vangrevelinghe.

# Longitudinal recording of vital events (total longitudinal analysis) 

J. Condé

[Translated from French]

## I. Transverse anazyses and longitudinal ANALYSES

1. Vital events are events which depend on current conditions. It is commonplace to state that the number of deaths depends on the temperature, the number of marriages on the economic situation, and so forth. However, vital events are also events which form part of an individual history. Consequently, they are also affected by the past and by the anticipated future.
2. In order, therefore, to understand the causes of a demographic phenomenon and to predict how it will develop, account must be taken both of current conditions and of the conditions experienced in the past and to be experienced in the future by those participating in the phenomenon; hence the two ways of analysing population statistics: transverse analysis and longitudinal analysis.
3. Transverse analysis consists of treating vital events recorded during a calendar year as deriving from a hypothetical group of persons who experience such events throughout their lives. These events depict the demographic behaviour of the hypothetical group, which is said to be the current behaviour of the population in question. Transverse analysis, by summing the figures, provides current indices which are inevitably subject to fluctuations of all kinds and to current irregularities.
4. Longitudinal analysis places every vital event in a chain of which it is merely one link. The vital events observed during a calendar year are then related to the individuals who experienced the events. Thus, for instance, the successive births to a couple are related to that couple. Couples having certain characteristics in common are then grouped and the effect of those characteristics on behaviour with respect to family formation is studied. The couple is taken here, of course, only as an example. Nuptiality, mortality, migration, and so forth, can be studied in the same way.
5. Both types of analysis are obviously of value. Longitudinal analysis makes it possible
to eliminate ephemeral features of a given situation, and it is therefore suited more particularly to forecasts.

## II. Individual longtrudinal analysis and total longitudinal analysis

6. When each individual vital event is related to its author, longitudinal analysis is easy. However, the relating of events to their individual authors is usually difficult to organize. Mr. M. Croze's paper deals with this problem. However, since persons possessing common characteristics must in any event be grouped at a later stage, it is often possible to avoid the trouble of establishing individual relationships and to carry out a mass operation instead. Let us consider, for instance, the deaths occurring in 1963 among persons born in 1900. Each death certificate can be related to the corresponding birth certificate, and if this is done every year one can, eventually, study the mortality of all the persons born in 1900, according to the various characteristics which they possessed at birth.
7. Instead of establishing the relationships individually, however, one can classify deaths in 1963 according to the year of birth of the deceased, and if the classification is done each year one can study the mortality of all the persons born in 1900 . It is, of course, much easier to establish mass relationships than individual ones, but the opportunities for analysis are much reduced. If, in the example taken, individual relationships are established, the group of persons born in 1900 can be subdivided into sub-groups corresponding to the characteristics which it is customary to record when a birth is reported-ages of mother and father, social and vocational status of the parents, number of brothers and sisters, duration of the parents' marriage, and so forth. None of this can be done if mass relationships are established. In theory, it is true, the information given in the birth certificate can be obtained at the time of death, but where similar information is sought on different dates which may be very far apart, there is a danger of
many errors which very quickly restrict this theoretical possibility. Total longitudinal analysis therefore emerges as the result of a compromise between the ease of establishing relationships and the restricted opportunities for analysis.

## III. Need for a dual classification

8. Although total longitudinal analysis is easy, it must nevertheless comply with a number of requirements. In the first place, it calls for the classification of vital events according to the year in which the events to which they are related occurred. For example, as mentioned above, deaths may be classified by year of birth of the deceased. However, there are other possibilities, including the classification of births, by year of birth of the mother or of the father, by year of marriage of the parents or, by year of birth of the preceding child. Marriages can be classified by year of birth of the wife or of the husband. Another possible classification is by year of birth of the wife and year of birth of the husband. Remarriages can be classified by year of widowhood or year of divorce.
9. Such classifications suggest opportunities for longitudinal analysis, but they are not sufficient, since vital events are usually studied in terms of the interval between such events and the phenomena to which they are related-age at death, age of the mother at birth of her children, duration of the marriage, age of the spouses at the time of marriage, duration of widowhood, and so forth.
10. Vital events must therefore be classified according to this interval also. One example will show the need for such dual classification. Let us consider the vital event, birth, in relation to the vital event, marriage, plotting a graph with calendar-years as the abscissa and a scale of duration as the ordinate. A birth will be affected by two co-ordinates-the date on which it occurs (the abscissa) and the duration of the marriage from which it results (the ordinate). Let us consider the births registered in 1962 which result from marriages solemnized in 1956. The sixth anniversary of such marriages will fall in 1962. Where a birth takes place before the sixth anniversary, the duration of the marriage will be less than six years and the points representing such births will be inside the triangle $A B C$. Where a birth takes place after the sixth anniversary, the duration of the marriage will be more than six years and the points representing such births will be inside triangle ABD (see the Lexis diagram).
11. In order to relate all the 1962 births to the 1956 marriages, we must have the total

number of the points inside the parallelogram $A B C D$; but to be able to study the fertility of 1956 marriages by duration of the marriage, we must have separate figures for the number of points inside triangles $A C B$ and $A B D$ respectively. We therefore need the dual classification of 1962 births by year of marriage and duration of the marriage.
12. Table 1 gives, as an example, a dual classification of this kind with respect to legitimate births registered in France in 1962 resulting from marriages of less than twenty years' duration.

It often happens that the dual classification is not available; the two following cases are encountered:
(a) Births are classified by duration of marriage;
(b) Births are classified by calendar year of solemnization of marriage.
The problems arising in the first case are discussed below.

## IV. Single classification by individual year of age

13. In table 1 , births classified by duration of marriage are shown in column 4. Each figure in column 4 is the sum of the two figures in column 3. The problem, then, is how to obtain the figures in column 3 from the figures in column 4. A study of table 1 immediately provides the answer. Where the number of marriages does not vary greatly from year to year, the figures in column 3 are obtained simply by dividing those in column 4 by 2 . This rule ceases to apply if the number of marriages varies greatly.

Table 1. Legitimate births registered in 1962 and classified by calendar year and duration of the marriage of the parents

| Year of marriage (1) | $\begin{gathered} \text { Nuquber of } \\ \text { maryiages } \\ \text { (in thotsands) } \\ \text { (2) } \end{gathered}$ | Dual clussification of births (3) | Births by duration of marriage (4) | Duration onarriage (5) | Annual <br> decline <br> in <br> ( 6 ) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1942 | 267 | $\frac{1,871}{1,713}$ | 3,564 | 19 | 0.946 |
| 1943 | 219 | $1,981 \text { 1,806 }$ | 3,787 | 18 | 0.677 |
| 1944. | 205 | $2,450 \quad 3,142$ | 5,592 | 17 | 0.516 |
| 1945. | 393 | $\frac{4,921}{5,912}$ | 10,833 | 16 | 0.787 |
| 1946. | 517 | $\begin{array}{r} 7,552 \quad 6,218 \end{array}$ | 13,770 | 15 | 0.955 |
| 1947. | 427 | $\frac{7,764}{6,657}$ | 14,421 | 14 | 0.924 |
| 1948. | 371 | $\frac{8,252}{7,358}$ | 15,610 | 13 | 0.856 |
| 1949. | 341 | 9,441 8,929 | 18,370 | 12 | 0.856 |
| 1950. | 331 | $11,527$ | 21,469 | 11 | 0.895 |
| 1951. | 320 | $12,523$ | 23,975 | 10 | 0.858 |
| 1952 | 314 | $\frac{14,801}{13,168}$ | 27,969 | 9 | 0.858 |
| 1953. | 308 | $16,928$ | 32,595 | 8 | 0.842 |
| 1954. | 314 | $\frac{20,172}{18,521}$ | 38,093 | 7 | 0.885 |
| 1955. | 313 | $\frac{23,180}{20,561}$ | 43,741 | 6 | 0.802 |
| 1956. . | 293 | $\frac{25,311}{25,429}$ | 50,740 | 5 | 0.829 |
| 1957. | 311 | $\frac{31,530}{29,662}$ | 61,192 | 4 | 0.837 |
| 1958. | 312 | $\frac{37,224}{35,858}$ | 73,082 | 3 | 0.854 |
| 1959. | 321 | $\frac{43,424}{42,101}$ | 85,585 | 2 | 0.847 |
| 1960... | 320 | $\frac{50,279}{50,816}$ | 101,095 | 1 | 0.800 |
| 1961... | 315 | $\frac{84,461}{41,848}$ | 126,309 | 0 | - |

${ }^{*}$ This is the number of marriages registered during the year indicated in the preceding column. As a result of migratory movements, there were in France in 1962 couples whose marriages had not been registered in France (a large number of married repatriates from North Africa). There are also couples whose marriages were registered in France and who were no longer in France in 1962. There are many more of the former than of the latter. This phenomenon is disregarded here, since it is of no significance when explaining an analytical method. If, however, it was intended actually to carry out the analysis, the number of the marriages would have to be corrected.
14. Let us take, for example, the 13,770 births resulting from marriages with a duration of fifteen years. Some of these births result from the 517,000 marriages in 1946 and the rest from the 427,000 marriages in 1947. By dividing 13,370 proportionately to 517,000 and 427,000 , we arrive at 7,540 and 6,230 births respectively, and this is a good approximation to the figures in column 3.
15. The procedures indicated here for dealing with births as related to marriages are entirely general. If the phenomenon ander study varies greatly with the duration factor, a divisor other than 2 may have to be used, but the principle will remain the same. One objection comes to mind. This divisor 2 which has been used was arrived at precisely because the dual classification which it was desired to reconstruct already existed. Is there not some illusion here? It is quite true that the divisor cannot be selected unless there is a dual classification. However, it is sufficient to have such a. classification for a single year and for a sample of births; it is then assumed that the divisor thus determined applies to other years and to the whole population. If there is no dual classification for a given country, even for a single year, use may be made of the dual classification for another country with similar sociological, cultural and climatic conditions.

## V. Single classification by age group

16. It has been assumed that the figures for births classified by year of duration of marriage were available, but often only groups of years
of duration are known. Let us imagine, for instance, that in table 1 only the total number of births for five to nine years' duration of marriage is known. This number is 193,738 (the sum of the figures in column 4 for the durations of five to nine years). From this figure, it is proposed to reconstruct the corresponding figures in column 4. In this case, the decline in fertility according to the duration of the marriage must be taken into account. An examination of the factors in column 6 of table 1 shows that the number of births declines by approximately 15 per cent each year when the number of marriages annually does not vary greatly. This means that if, in the absence of variations in the number of marriages, 1.00 represents the births resulting from marriages of five years' duration, those resulting from marriages of six years' duration will be represented by 0.85 , those resulting from marriages of seven years' duration by $0.85^{2}=0.72$, those resulting from marriages of eight years' duration by $0.85^{3}=0.61$, and those resulting from marriages of nine years' duration by $0.85^{4}=0.52$.
17. The 193,738 births in table 1 resulting from marriages of five to nine years' duration are related precisely to a period when there was little variation in the number of marriages annually. Consequently, the figures in column 4 will be obtained by dividing 193,738 proportionately to the five factors $1.00 ; 0.85 ; 0.72$; $0.61 ; 0.52$. The validity of the reconstituted figures thus obtained may be judged from table 2.

Table 2. Reconstitution of the figures in column 4 of table 1 for durations of $5-9$ years

| Protortionality factors a |  | Reconstituted figures | Observed births | Duration of the marriage |
| :---: | :---: | :---: | :---: | :---: |
| 0.52 |  | 27,260 | 27,969 | 9 |
| 0.61 |  | 31,978 | 32,595 | 8 |
| 0.72 |  | 37,745 | 38,693 | 7 |
| 0.85 |  | 44,560 | 43,741 | 6 |
| 1.00. |  | 52,362 | 50,740 | 5 |
|  | Total | 193,905 | 193,738 | 5-9 |

${ }^{a}$ These factors are computed on the basis of an annual decline in births of 15 per cent.
18. If there is a variation in the number of marriages annually, account must be taken of this new factor. Let us take, for instance, births registered in France in 1956 resulting from marriages of five to nine years' duration.

Table 3, which is presented in exactly the same form as table 1, shows that these births are related to a period when there were considerable variations in marriages from year to year (the figure in column 2).

Table 3. France. Legitimate births registered in 1956 classified by calendar year and by duration of the marriage of the parents (duration of 5 to 9 years)

| Year of marriage (1) | $\begin{gathered} \text { Number of } \\ \text { (marriages } \\ \text { (in thousands) } \\ (\text { (2) } \end{gathered}$ | Dual classi- <br> fration <br> of bithths <br> (3) | Birthe by duration of marriage <br> (4) | $\begin{gathered} \text { Duration } \\ \text { of } \\ \text { maryase } \\ (5) \end{gathered}$ | Births for the duration of marriage <br> (6) | Reconstitutced (7) | Reconstituthed (8) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1946. | 517 | $\frac{21,291}{16,672}$ | 37,963 | 9 | - | 38,700 | $21,200117,500$ |
| 1947 | 427 | $\frac{20,262}{17,309}$ | 37,571 | 8 | - | 38,400 | $\xrightarrow{20,600}$ |
| 1948 | 371 | $\frac{21,162}{18,649}$ | 39,811 | 7 | 213,719 | 40,300 | 21,000 19,300 |
| 1949. | 341 | $\xrightarrow[23,988]{21,870}$ | 45,858 | 6 | - | 45,000 | $22,800$ |
| 1950. | 331 | $\xrightarrow{28,081}$ | 52,516 | 5 | - | 51,300 | 26,100 25,200 |
| 1951. | 320 | - | - | - | - | - - | - |

It is assumed that only the total number of births resulting from marriages of five to nine years' duration is known-the figure is 213,719 -and it is proposed, from this total, to reconstruct the figures in column 4. These figures are still proportionate to the factors mentioned above: $1.00 ; 0.85 ; 0.72 ; 0.61 ; 0.52$, but it can be taken that they are proportionate also to the original number of the marriages from which the births result. The marriages of five years' duration resulting in births include the marriages in 1951 and 1950, the sum of which is: $331+320=651$. The marriages of six years' duration resulting in births include the marriages in 1949 and 1950, the sum of which is: $341+331=672$; and similarly with respect to births resulting from marriages of
seven years' duration ( $371+341=712$ ), eight years' duration $(427+371=798)$ and nine years' duration $(517+427=944)$. Lastly, the figures in column 4 will be reconstructed by dividing 213,719 proportionately to the factors: $1.00 \times 651 ; 0.85 \times 672 ; 0.72 \times 712 ; 0.61$ $\times 798 ; 0.52 \times 944$.
19. Table 4 gives the results of such a computation. The reconstituted figures have been inserted in table 3 (column 7). The validity of the method can be judged by comparing columns 4 and 7 of that table. From the reconstituted figures in column 4, the figures in column 3 are obtained by the procedure indicated above. These are the figures in column 8 of table 3.

Table 4. Reconstitution of the figures in column 4 of the table

| Year of marriage | Marriages (in thousands) | Proportionality factors: | Product of the two praceding columns | Births reconstituted | Observed births | Duration of the marriage |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1946-1947 | 944 | 0.52 | 491 | 38,700 | 37,963 | 9 |
| 1947-1948 | 798 | 0.61 | 487 | 37,400 | 31,571 | 8 |
| 1948-1949 | 712 | 0.72 | 512 | 40,300 | 39,811 | 7 |
| 1949-1950 | 672 | 0.85 | 571 | 45,000 | 45,858 | 6 |
| 1950-1951 | 651 | 1.00 | 651 | 51,300 | 52,516 | 5 |

a These factors are computed on the basis of an annual decline in births of 15 per cent.
20. The same objection as previously comes to mind. The factor 0.85 , which measures the decline in births according to the duration of the marriage, was obtained because precisely that classification which it was desired to reconstitute was already available. Here again,
the answers given above are valid. It is sufficient to determine this factor for a single year and from a sample of the population. In this case, however, the factor can be determined even if births are classified only by groups of five years' duration.
21. Let us suppose, for instance, that for table 1 only the following figures are available:

|  | Births | $\begin{gathered} \text { Declime } \\ \text { frome } \\ \text { one } \\ \text { group } \\ \text { to } \\ \text { the } \\ \text { next } \end{gathered}$ |
| :---: | :---: | :---: |
| 0-4 | 447,263 | - |
| 5-9 | 193,738 | 0.433 |
| 10-14 | 93,865 | 0.482 |

The births resulting from the marriages of less than fifteen years' duration are related to a period when there was little variation in the number of marriages annually. If the decline in births is constant for each year of duration, the annual decline is the fifth root of the decline for each five-year group. Thus, we have for this annual decline: $K_{1}=\sqrt[5]{0.433}=0.846 \mathrm{in}$ comparing the first two groups, and $K_{2}=$ $\sqrt[5]{0.482}=0.865$ in comparing the second and third groups, which is quite in line with an annual decline of approximately 15 per cent.
22. We shall limit ourselves to these examples. It will be easy to imagine the method to be used when births are classified by calendar year of solemnization of marriage (or by groups of calendar years). We will simply repeat that all these methods are quite general and apply to any total longitudinal analysis.
23. All the foregoing gives an example of total longitudinal analysis carried out with statistics of population movement only. The same principles can also be applied in the case of longitudinal analyses using only population census statistics.
VI. Total longitudinal analysis in popuLATION CENSUSES
24. In theory, a population census makes it possible to carry out individual longitudinal analyses. When a person is interviewed, he is
asked for information on the vital events in his past life, and these events are automatically related to the person who experienced them. When tracing phenomena through a number of successive censuses, however, it would be necessary, if an individual longitudinal analysis was desired, to relate each person's census schedule to the schedule completed at the preceding census. This is an operation which is not impossible in theory, but which nevertheless presents great difficulties. A mass relationship is therefore often established instead of individual ones, and all the principles of total longitudinal analysis apply.
25. The best-known example is the construction of mortality tables by comparing the numbers of a group of generations throughout a series of censuses (India has for long been constructing its tables in this way). The same method may be used, however, for studies of family size, nuptiality, remarriages, and so forth.
26. There again, we find the need for a dual classification-by interval elapsed and by calendar year of occurrence and in the event that no such dual classification exists, methods similar to those, the theory of which has been given above, are used. The same problems have to be resolved when censuses are presented by groups of duration or groups of years.
VII. The combining of population cenSUSES AND STATISTICS OF pOPULATION movements
27. A third opportunity for longitudinal analysis is available to the research worker when statistics of population movement are combined with population censuses. A classical application of this third kind of analysis is in estimating migratory movements between two censuses. However, many other examples can be thought of.

# Method of comparing several observations relating to the same person 

Marcel Crozé

[Translated from French]

1. For several years statisticians have been developing observation procedures which consist in assembling, for each person of the population studied, various facts which have been observed or have occurred on different dates. After showing why this method has been considered necessary, we shall examine the different ways in which it is applied and shall discuss their advantages and disadvantages. For reasons of brevity, we cannot hope to deal with the subject in depth; our basic aim will be to put forward a few points for reflection and pave the way for a fruitful discussion.

## I. Need for the method

2. To understand the raison d'être of this method we must first consider the aims of demographic analysis and then consider whether the traditional methods of observation enable them to be attained. ${ }^{1}$

## A. Aims of demographic analysis

3. The first demographers, who were generally statisticians by training, were infiuenced by statistical methods and the calculus of probability. For that reason, the initial techniques of analysis consisted basically in the calculation of frequencies (rates, quotients, etc.) relating to facts taken in isolation.
4. These methods gave satisfaction for a long time, particularly in the field of mortality. However, the demographic events affecting each individual are not independent; they take place in a certain order during a person's lifetime, and some of them may even be repeated (births of children, for example). It therefore appeared desirable not to isolate all these events but to reconstitute the "demographic history" of the populations studied, along the lines of the curriculum vitae used to gain knowledge of an individual. By integrating the results of such longitudinal studies we can also calculate total rates analogous to averages (average number of children, average ages, etc.), which are more

[^149]specific and more useful than probability calculations.
5. Finally, whatever the technique of analysis used, in any attempt to explain demographic behaviour many different criteria must be combined, and consequently many different events relating to each individual must be assembled.

## B. Methods of observation

6. The traditional method of observation consists in the compilation of separate collective statistics, the principal forms of these being census statistics and vital registration statistics.
(a) Whether we are calculating frequencies or making longitudinal analyses, we are usually required to combine sets of statistics of different origins: two sets of current population statistics, or one set of current population statistics and one set of population movement statistics, or again several sets of movement statistics. These methods are often satisfactory even for longitudinal studies. ${ }^{2}$ However, they present the following disavantages: the longitudinal study of renewable events is difficult-the criteria which can be used are limited both in number and accuracy to those included in the most summary form of inquiry (for example, the information on occupations in transcripts of vital events), and, above all, it is impossible to be certain that the same person is classified in the same way in the two sets of statistics, a fact which makes differential studies very imprecise;
(b) In certain cases a single observation (census or special inquiry) provides information which meets the needs of the analysis, particularly if the questions relate to the past (retrospective inquiries). Nevertheless certain disadvantages remain: distortions may be introduced by selection due to mortality and migration; the number of criteria studied, especially in censuses, is bound to be limited; and the statements collected may lack precision, particularly through deficiencies of memory.
${ }^{2}$ The technique of global longitudinal analysis is dealt with in another paper.
7. From the foregoing it is clear that the customary methods have disadvantages which sometimes vitiate the whole operation. It may therefore be useful and even essential to assemble for each individual several particulars obtained from different sources or observed on different occasions. For methods of this kind enable us to make correct longitudinal analyses while avoiding the drawbacks of retrospective inquiries (effect of selection), and to increase the number of usable criteria. Also, from a practical point of view, they ensure uniformity of classification and greater accuracy of observations.

## II. The different techniques

8. The collection of various data relating to a single individual may be done a posteriori, using documents already available, or may be organized in advance so as to facilitate any type of specific study, foreseen or unforeseen. Since the same system may be used, depending on the circumstances, for past or future studies, we shall not deal with these two procedures separately but rather examine the different techniques of data collection.

## A. Utilisation of a single registration system

## General registration

(a) A theoretically conceivable method would be to consolidate systematically in a single document or single file, if not all possible data, then at least the most extensive possible collection of data about each individual: vital records, successive residences, education, occupational record etc. Such a system, which was contemplated in France, for example, in 1940, should at the same time meet administrative needs and allow the compilation of statistics by the mechanical processing of available data;
(b) Actually, systems of such ambitious scope have never been put into practice and probably never will be, for they have numerous disadvantages:
(i) The cost of keeping the card indexes up to date is considerable, particularly because the number of different data is higher; it may be recalled that many countries have given up the idea of introducing population registers because of their high cost;
(ii) In order to limit the cost and to avoid the accumulation of enormous records, the range of particulars of each type extracted has to be limited, so that it may prove inadequate for either administrative or statistical purposes;
(iii) In any case, the range of data assembled is necessarily restricted: as has just been pointed out, the bulk of the files has to be limited; certain particulars cannot be obtained easily, or are too difficult to keep up to date; and, finally, once the particulars to be collected have been selected, some, whose usefulness may not be appreciated until later, may have been left out.

## Special registration systems

(a) While systems of such generality do not appear to be acceptable, consideration may be given to using special registration systems limited to certain subjects, such as are already, in many cases, in current use for administrative purposes. The records or individual documents may be kept up to date either by the organizations concerned or by the persons themselves;
(b) Here are some examples;
(i) The livret de famille issued in France to each couple on marriage, in which are recorded the particulars of the spouses and the dates of the births and deaths of their children;
(ii) The health booklets issued at the birth of each child, in which health data such as growth, illnesses, vaccination, special medical examinations, etc., are recorded;
(iii) The records of persons covered by Social Security;
(iv) The personnel records kept by some enterprises.
(c) The use of these documents for statistical purposes presents certain advantages: as they are often kept for administrative reasons, the marginal cost of using them for statistical purposes is low, and in their own field the data which they contain are more detailed than in a very general file;
(d) On the other hand, they have the inherent disadvantage of being limited to a special field and giving little or no information, even where it would be very useful, on other subjects; for example, the lizret de fanille and the health booklet give little or no information on occupation or residence.

## B. Combination of several registration systems

9. Since it is impossible to collect all usable information in a single registration system, and since special systems limit the possibilities of studying and combining different data, we can attempt to establish a link among various ad-
ministrative or other documents, so as to be able to draw on the sources best adapted for each particular study, without necessarily creating a new system.
10. In certain cases, data relating to a single person are compared within the same system of registration. For example, differential studies of infant mortality in France are made by comparing the death transcripts relating to children under one year of age with the corresponding birth transcripts, by reference to name, date of birth and place of birth. The methods used in historical demography (extraction from parish registers) are also of this kind.
11. Usually, however, recourse must be had to several sources, which may be organized according to different methods and may be under the control of different organizations. Here are some examples:
(a) In the United States, mortality by social category is being studied by comparison of the death transcripts for four months of 1960 with the census schedules for 1960. This method permits the calculation of correct mortality rates, since it makes available the additional data contained in the census schedules;
(b) In France, on the other hand, the same subject is being studied on the basis of a sample taken from the 1954 census, periodic observations being made, with the help of a system derived from registration, of survivals or deaths (first observation 1 January, 1961; subsequent observations every five years) ;
(c) By a similar procedure, observations are made to determine whether persons treated in cancer hospitals whose progress the doctors have not been able to follow are still alive after a specified lapse of time;
(d) In Canada, Newcombe has used similar methods of comparing data on members of family groups for studies of genetics.
12. The main problem involved in this method is to find a practical and effective procedure for comparing the various documents pertaining to each individual. In particular, the number of cases where the comparison cannot be made must be limited; if the proportion is too high, the results may be distorted because the persons left out may be different from the rest of the population. Thus, the main difficulty which arose in the United States survey of mortality by social category was caused by the fact that for 20 per cent of the deaths no corresponding census schedule was found. To permit or facilitate comparison several systems may be used:
(a) Newcombe codified the names and used the date and place of birth;
(b) In France, we are able to use an instrument created for administrative purposes nearly twenty years ago: the identification register. The National Institute of Statistics and Economic Studies keeps for each commune a register in which persons born in the commune are entered consecutively. Each person is assigned an identification number made up of components indicating sex, year and month of birth, department and commune of birth, and order of birth in the commune. This number may be substituted for the name, and lends itself particularly well to machine processing. Its essential aim is to provide a link between different records systems. The date of death is also entered in the register, thus making possible the studies described above. If an index of addresses listed in the order of the register were kept, direct inquiries could be made of individuals;
(c) A similar system has been proposed by Twisselmann in Belgium for the purpose of genetics studies. Consideration is being given to the possibility of supplementing the number assigned to each individual by the numbers of his parents, so that family groups can be reconstituted.

## III. Disadvantages of the method

13. All these systems for using or comparing documents have common disadvantages of varying importance.
14. Usually, the documents utilized have been devised for an administrative purpose and are under the control of the competent authorities. As a result, they are often unsuitable for sound scientific study. In the first place, the data collected are intended to meet the needs of the administration, and are ill-adapted to, or inadequate for, the research undertaken. Furthermore, the procedures of administrative management which obviously have priority, do not make for convenience of processing; and the administrative staff responsible are not always ready to give their help in work which is of no direct concern to them.
15. Even where, technically, the comparison of a number of different documents is relatively easy, the amount of data available remains fairly limited. In the French studies of mortality by social category or of the survival of patients treated for cancer, only the fact of death or survival is recorded, and yet the work is relatively costly. To obtain fuller information the number of comparisons would have to be
multiplied; but the technical difficulties would then become very great and the cost prohibitive.
16. Furthermore, whether we are considering administrative documents or records intended specifically for the compilation of statistics, the information collected systematically may be inadequate or of mediocre quality. Thus, particulars entered in health booklets by the holders themselves are often useless for precise scientific study, since they are entered by laymen. Unless the system is a rigorously compulsory one, documents or records may not be kept perfectly up to date, and certain facts may be omitted. In point of fact, there are a number of topics which can be studied accurately only by means of special inquiries.
17. Finally, mention must be made of a political and moral objection to this type of method. Some fear that it may encroach upon individual freedom, that systems elaborated for purely scientific studies may be used for other purposes by totalitarian régimes, or even that research workers may place their desires for scientific progress above certain ethical principles which are thought to constitute true values of civilization.

## IV. Conclusions

18. In certain cases the comparison of different documents relating to a single person is the only means of obtaining reliable results. Admittedly, such operations may be costly, but it has to be accepted that serious studies will involve expenditure; otherwise it is better not to undertake them. Only methods analogous to those employed in France and the United States can provide unimpeachable data on mortality by social category.
19. In order to reduce the cost of these methods and improve their effectiveness, studies of the best ways of cross-referencing the different sources are needed. Systems similar to the identity number will certainly prove very valuable in the future. This device appears preferable to the systematic compilation of voluminous records, which are difficult to keep up to date and not necessarily satisfactory.
20. These methods are not a panacea, and they have limits, due in particular to the limited number of data available and to their frequent lack of accuracy. Special inquiries, carried out by qualified researchers, particularly retrospective surveys, will often provide information that no standard document could supply. The cost of such inquiries may in any case be less high than that of administering a complete registration system. Moreover, the procedures used to compare documents can be used to carry out longitudinal surveys: for example, persons in a given category can be selected from the census and interviewed several years later, when their addresses have been found by means of the records cross-referencing system.
21. However, this method must be approached with caution, because of the political objections which have already been discussed. Perhaps the wisest course is to use existing systems without pressing for the creation of new ones.
22. Finally, there is no doubt that all the techniques used in statistics must be employed, particularly the sampling method and mechanical and electronic techniques.
23. To sum up, to determine the best method of carrying out a given scientific study, we must take into account scientific, economic and ethical factors alike.

# Methods of using old documents to study population trends in the past 

T. H. Hollingsworth

## Introduction

1. In 1830, Sadler calculated the proportions of the British nobility whose families had become extinct, ${ }^{1}$ but his methods were crude and his reasoning faulty. Four years later, a Berlin doctor estimated the expectation of life of the medical profession. ${ }^{2}$ In 1841, de Chateauneuf studied the members of the three academies of France. ${ }^{3}$ He had a clearly defined group, with the age at entry to it and the age at death for each member, covering more than two hundred years. Yet his analysis was weak; he did not construct life tables, and did not seem to be interested in possible changes in mortality over a period of time.
2. During the next hundred years, demographic techniques slowly improved, and Peller was able to do a really worth-while study in 1943. ${ }^{4}$ It is now realized that heavy preliminary work usually must be done in order to use the old material properly.
3. Longitudinal analysis normally is used. If the dates of birth and of death have been found for a large number of individuals, it is easy and more logical to construct mortality tables by the cohort of birth. The results thus appear in this slightly unfamiliar form. Normal tables, in effect, are compled by cohort of death. Over a long period, moreover, the longitudinal method yields in principle a true demographic history, whereas an attempt at making up cohorts from age-specific death rates at different dates is bound to involve assumptions about migration.
[^150]
## I. Parish registers

4. Before there were regular national censuses, parish registers were kept in most parts of Europe. Dates of baptisms, marriages, and burials were recorded in them. Besides these, there were various taxation returns, some lists of householders in towns, and occasional censuses in limited areas.
5. The best of these sources of data are the parish registers. Almost every inhabitant should be included. In parts of England in the eighteenth century, there were considerable numbers of nonconformists, and Jews were excluded everywhere, but the parish registers give a direct means of measuring precisely those demographic trends which one wishes to measure.
6. Taxation returns are the chief source of information on population in Europe for the Middle Ages, for levies were intermittent and we rarely know how many people were too poor to be taxed. The information often is merely a count of households or of hearths, and fertility and mortality can be inferred only from taxation returns and cannot be measured directly. Other sources are even less regular than taxation returns. If a full census was taken in a limited area, we still have only information for that area at that particular date, which is not enough to give a general view of the population.
7. The difficulties in using parish registers are formidable. Many old registers have been lost and some are illegible. Even if we find a district where all the registers are good, there is still one serious problem: we do not know the base population. We can tell easily which were the years of exceptionally high mortality, caused by famine or disease, but we cannot easily estimate the level of this mortality. Fertility levels will equally difficult to estimate.
8. There is only one general way to overcome this difficulty: to reconstruct the base population from the registers themselves. The names of the persons baptised in the parish are given. We may hope to match these with the names of the persons married and dying
there. In practice, this cannot be done for everyone, chiefly because of migration. A less common difficulty is similarity of names. Failure to register an event at all seems to have been rare. Since many marriage registers, especially in the eighteenth century, record the ages of each party, the names of their parents and their parish of usual residence, almost all baptismal registers give the names of both parents; since burial registers often give the age of the deceased, reconstruction becomes a practical, if laborious, possibility.
9. The chief task in the reconstruction is family reconstitution, which is necessary to measure fertility properly. Children born to a couple who were married in the parish must be looked for in the baptismal register. If all the children can be found for a fairly high proportion of marriages, we shall have an excellent base from which to calculate the level of fertility by any method we may choose.
10. The pioneer work in reconstituting families has been done in France, notably by Henry, In 1956 a manual was published, describing in detail how to exploit a parish register. ${ }^{5}$ This now has become the standard method in France, and has been used in several studies. ${ }^{6}$ A very large sample study of all the parish registers in France was begun in 1959. A similar sample in England was begun in 1964.
11. Sutter and Tabah generalized the problem of reconstituting a family to finding the relationship between various members of a population. They have given an example of how they did this by means of punched cards. ${ }^{7}$ Steinberg has an electronic computer programme for doing the same thing. Most of the reconstitution work is, in fact, done by hand, using the coloured slips on which the information was extracted from the registers.

## II. Genealogies

12. Full genealogies over a long period have been compiled for a few special groups. The hard work of reconstruction thus has been done, and the proportion of families which are reconstituted approaches 100 per cent. Any inquiry which requires knowledge of a person's relatives can be done from such data. In other

[^151]instances, such information would be almost impossible.
13. Nevertheless, there are many limitations to the use of genealogies. Those that do exist are most often for peculiar populations: physically isolated, socially very elevated or a religious sect. The earliest genealogies give very little information about exact ages and dates. It is rare, moreover, to find a set of genealogies containing more than a few hundred individuals, which is not a sufficient number to be worth studying.
14. The most severe limitation, however, is the difficulty of defining the universe one is to study. A genealogy may often omit those people who left no children. Some genealogies were no doubt begun in order to trace the descendants of a couple when it was realized that there were numerous descendants. Clearly, some rigid criterion is needed to define the universe. This is often a difficult task.
15. A comparatively early study of a genealogy was done by Yuan. ${ }^{8}$ He did not consider fertility, and did not think his data were good enough to give reliable mortality rates under the age of twenty; it is an interesting piece of work, however, and some knowledge of fertility and the age at marriage might be gained by reworking the same genealogy. Peller's studies on the ruling families of Europe have already been mentioned. ${ }^{9} \mathrm{He}$ alone, of those who worked on old records, had almost no difficulties because of missing information. "When beggars die, there are no comets; the heavens themselves blaze forth the death of princes". ${ }^{10}$ In French Canada, records of more than a million baptisms, marriages and burials between 1621 and 1800 were collected into a genealogical record toward the end of the nineteenth century. These were sampled by Henripin in his study, ${ }^{11}$ but he considered only 1,131 families and kept to the period 1700-1730. Henry's study of 3,079 members of the old Genevan bourgeoisie living between 1550 and 1947 devoted some space to a discussion of the

[^152]demographic shortcomings of data originally collected for a genealogy. ${ }^{12}$
16. Children who die in early infancy well may seem unimportant to a genealogist. Fertility and infant mortality both, therefore, may have been higher in reality than they seem on first analysis. When the apparent birth intervals are long, one cannot be certain that all the fertility, in fact, was recorded. A second weakness of genealogies is that when there is a marriage with a person outside the defined universe, the date of birth of the outsider is usually unknown. The children born of such a marriage are often omitted completely. Mlegitimate children are generally ignored by genealogists. This fact, however, is unimportant, because in reality relatively few illegitimate children are likely to have been born.

## III. The British nobility

17. The nobility of the British Isles have been studied many times by those interested in demography. Recently, a large systematic study has been made of their levels and trends of marriage, fertility and mortality from the end of the sixteenth century to the beginning of the twentieth. ${ }^{13}$ For the entire period, the noble families remained at the highest social level.
18. The data are good after about 1750 , but many dates were missing between 1600 and 1750. It was assumed that the records for some children who died in early infancy were altogether missing. The numbers of such omissions were estimated by a method to be described later.
19. The primary universe was defined as all peers and eldest sons of peers who died between 1603 and 1938. The peerages of England, Scotland and Ireland were taken all together. The secondary universe consisted of all the legitimate children of the primary universe. The group studied was really the secondary universe. The tertiary universe consisted of all the legitimate children of the secondary universe. These three universes overlap to some extent. The total number of persons included was about 70,000, and dates of birth and death were sequired for all of them. Dates of marriage and of birth and death of the marriage partner were required for the first two universes. On the whole, records of some 225,000 births, marriages and deaths were required.

[^153]20. The data were gathered from more than five hundred volumes, many of them collections of information about the members of the peerage and their families. Further reference books were used to trace the husbands and wives of the secondary universe, for marriage outside the nobility was frequent, always more common than marriage within it. Six clerks took six months to code the bulk of the information on nearly 32,000 forms especially printed. Another year was spent by four skilled. clerks in searching for missing dates and in completing the records.
21. The whole of the information on the forms was put on 37,000 punched cards. After verification, the cards were tested by means of a computer programme for logical inconsistencies. More than two thousand of these were found, chiefly clerical errors, such as absurd ages and marriages between persons of the same sex. A magnetic tape was made of the data and it was run on a computer with four successive analysis programmes, providing four sets of tables. These tables were the basis of the analysis.
22. It was clear at an early stage that some method would be required for dealing with missing or uncertain dates. In many studies (not mentioned here), the rash expedient of simply omitting people for whom any dates were missing, was adopted. This method is almost certain to introduce bias. In a previous paper, ${ }^{14}$ a method of estimating the unknown dates was adumbrated. This method is now made more elaborate. Every missing event was given both an exact date and an estimate of the accuracy with which that date was known. The correct dates (only about two thirds of those required) were distinguished appropriately, and the guessed dates were assigned to one of eleven levels of accuracy. These were zero to three weeks, three to six weeks, six weeks to three months, three to six months, and so on, doubling the length of the interval successively. The last level was thirty-two to sixty-four years. It was assumed that every date was known within a period of thirty-two years on either side. The procedures for guessing dates and assigning levels of accuracy were empirical, but they worked quite well in practice. The great advantages are that no person need be ignored, and it is always possible to check at a given point in history how good the data are for studying any particular topic.

[^154]23. The accuracy of dates of birth improved steadily until after 1750, when almost all the secondary universe had completely accurate dates of birth. The males, however, were recorded better than the females at all periods. The accuracies of date of birth were used to estimate how many children dying in early infancy might have been omitted. By assuming that the two were linearly related, and that the true sex ratio at birth was roughly constant, an implied number of omissions was calculated for each period. This procedure is not ideal by any means, yet it seems fairly rational and does give likely values for infant and child mortality, as well as for the sex ratio at birth.
24. A similar correction was made to the numbers of the tertiary universe, needed for analysis of the family size of the secondary universe. Here some difficulty arose over families of unknown size. Some had a positive, but unknown size, others were completely unknown. About one third of the latter were assumed to have been childless, since this made better sense than assuming that they were representative of all families, of which only about one sixth were childless.
25. The cost was considerable. The computer programme did not allow the study of several interesting topics, for example, the
spacing of births and the propensity of members of a particular family to marry.

## IV. Conclusions

26. The methods described above must be applicable to other populations. Wherever good parish registers exist, there is the possibility of reconstructing the whole demographic life of the parish. A good genealogy would save most of the work, but nothing short of family reconstitution is wholly satisfactory.
27. The information must be collected carefully and the preliminary reconstitution must be done systematically. The method of Fleury and Henry has been proved to be widely applicable. ${ }^{15}$ It at least can be used as a starting point and, if necessary, adapted to suit local conditions.
28. There also may be genealogies which are worth exploiting. No person once mentioned should be excluded, and all unknown dates should be guessed intelligently, assessing the reliability of the guess each time. The greatest amount of useful knowledge can be gained only by such careful work.
[^155]
## Demographic simulation models with the aid of electronic computers

## Hannes Hyrenius

1. In recent times, the word "model" has come to be employed in rather varying senses, which may at times give rise to some misunderstanding.
2. The vaguest and most meaningless way of interpreting the idea of a model is to take it as representing merely a theory. The meaning becomes more precise when we refer explicitly to the variations of a phenomenon or to the relations between two or more phenomena.
3. The next stage in making the concept even more precise is to look at the phenomena as variables. The variation may then be imagined in the form of functions, and we are faced with the task of clarifying the meaning of these functions.
4. Furthermore, it may be possible to express the functions in a mathematical form or otherwise. If the functions can be given specific forms, including certain parameters, problems of estimation appear.
5. The preceding observations are of a general nature, but they clearly apply to what is understood by "demographic models".
6. A distinction has been made between "macro-models" - or "aggregate models" on the one hand and "micro-models" on the other.
7. The former are understood to be based on average or aggregate conditions. If, for example, we take a life table and a series of age-specific fertility rates, it is possible, as was first shown by Lotka, to derive the relative age distribution corresponding to constant mortality and fertility rates. We may then say that the stable age distribution is a model which shows what would happen in real life if the age-specific mortality and fertility remained constant over a sufficiently long period.
8. It should be observed that the result, the relative age structure, is obtained directly through a mathematically derived functional relation. The intermediate events, births and deaths, do not appear in the picture. If we were to apply the word "simulation" to this general property of our model, this could refer
only to the model's capacity to depict the population structure as implied in the assumption of constancy in the two demographic change factors; however, it does not seem correct to use the word "simulation" in this way. In what follows, we shall therefore restrict the use of the word "simulation" to models which deal with the events themselves, or in other words, with the discrete changes in a population caused by happenings to the individuals. This is, at the same time, what is meant by the expression "micro-model". The two different expressions do have separate values; there may, for instance, appear elements of a macrotype in a simulation model.
9. The words "macro" and "micro" may suggest that the former deals with large populations while the latter is limited to small populations or subgroups. From what has been said in the previous paragraphs it follows that this is not the case.
10. A micro-model can very well be based on the average properties of demographic change factors in the Chinese population. On the other hand, we might derive the stable age structure (a macro-model) corresponding to observations of births and deaths in the small isolate of a few hundred people on the island of Tristan da Cunha.
11. The way in which a micro-model is obtained, mainly by use of a computer, evidently makes it possible to increase the model population to any size which seems suitable; and in fact, for a detailed description of the family formation in a model, it might be desirable to have a fairly large model population.
12. The purpose of developing models is generally to obtain schematic but realistic pictures of the main factors involved. As far as demographic models are concerned it would be possible to include not only demographic factors in a narrow sense (i.e., the change factors of mortality, fertility, nuptiality and migration, together with the corresponding structural factors). It can be expected that a step-by-step procedure would enable different semi-demographic and socio-economic phenomena and variables also to be introduced. To
the extent that this can be done, we shall then obtain instruments for studying the interrelations between population trends and structure, economic development, social conditions, health factors, etc.
13. The main reason our knowledge of demographic-economic-social-health interrelations is unsatisfactory is the fact that we are concerned with situations and changes of a non-experimental character. Human activities, behaviour and relations cannot be studied by an experimental approach.
14. While experiments mean repeated observations under conditions in which only one or a few controlled variables are allowed to vary, and where the magnitude of random disturbances can be estimated, it is necessary in non-experimental situations to use such observations of variable-constellations as can be obtained. The interpretation of available statistical data therefore becomes difficult, uncertain or systematically biased; sometimes a statistical analysis cannot be undertaken at all, because no quantifications are possible.
15. For these reasons, the development of demographic simulation models offers important and very useful means of analysing demo-graphic-socio-economic interrelations and of making realistic population forecasts closely connected with socio-economic projections and planning.
16. It seems probable that the idea of simulating the elementary demographic events, births and deaths, in a theoretical model has occurred to a number of scientists during the last decade. In order to formulate this idea it would be necessary to be well acquainted with the technique of randomization as a means for achieving randomness in the occurrence of events. Even so, a small hand-made series would be of interest more as a curiosity than as a scientific instrument for ambitious research. Only the use of modern large-sized electronic computers has made it possible to develop simulation processes with a sufficient differentiation and at the same time with a large enough volume to correspond to scientific needs.
17. What is meant by demographic models will be indicated here by a brief review of two micro-models.
18. As a first example may be mentioned the study Micro-analysis of socio-economic systems by G. Orcutt, M. Greenberger, J. Korbel and A. Rivlin (New York, 1961).
19. The purpose of this work was to obtain the demographic skeleton for a general model of the United States economy. A miniature
population corresponding to the composition of the country's population at the last census was subjected to risks of various demographic events by means of pre-established distributions and the use of random numbers. The procedure was checked by repeated forecasting and comparisons with observed data from the labour force surveys.
20. The methods used in constructing this model should be judged according to its purpose. With other objects for the model, different methods could have been chosen. In some respects it might have been possible to simplify the technique. In other respects, however, a more advanced approach would be necessary. A great deal depends on the possibilities of quantification of the various input elements. The authors were hampered by the difficulties of obtaining appropriate data of the population chosen for the study.
21. The second example of micro-models to be considered here is a fertility simulation model developed at the University of Göteborg, A fertility simulation model by H . Hyrenius and I. Adolfsson (Göteborg 1964).
22. The report presents the first steps in developing a micro-model of fertility. Characteristic of the approach is that physiological phenomena have been included to such an extent that the model can describe fertility not only on an unplanned level ("natural fertility") but also at different transitional stages and under well-planned conditions.
23. The model includes measures of fecundability, proportion of abortions, distributions of length of pregnancies and of post-partum infecundity periods at different outcomes of pregnancy, sterility risks of different kinds and during different phases of the reproductive age period etc. The development of the model so far includes the possibility of variation of the different input variables by age, duration of marriage, and parity. Subsequent work will be devoted to a further refining of the fertility model and to inclusion of mortality and nuptiality. Important aspects are the variation of fecundability and the effect of heterogeneity of a group of marriages with regard to fecundability and sterility.
24. The purpose of this model is twofold. The main object is to develop an instrument for research into changes and variations in various sub-factors of fertility. In this connexion the model may serve for carrying out specific studies. The effect of different methods of birth control can be analysed in a variety of ways. Forecasts can be made which reveal the structure of the families.
25. The second purpose is the derivation of a suitable sub-model of fertility as part of a "general-purpose demographic model".
26. The construction of a general demographic model may be included here as a third illustration of simulation models.
27. It should be mentioned that this more ambitious work requires various kinds of supporting studies. Although the goal would be a general model applicable to almost every combination of population conditions, it is necessary to utilize numerical data for developing and testing the consistency of the model. This calls for extensive time series of population data presented on a cohort basis. The historical population data which have been recorded in

Sweden since the middle of the eighteenth century will be of decisive importance. Work has been started at the Demographic Institute in Göteborg on two sub-studies in the attempt to develop a general demographic model.
28. In addition to the examples of work on simulation models quoted above, it should be mentioned that studies in this field have been made, and others are going on, in a number of places. At the United States Bureau of the Census, research has been done on separate demographic factors with a view to developing a model for the population changes in the United States. Simulation work is also being done by Professor Mindel C. Sheps, University of Pittsburgh, in connection with her recent research on fertility using other methods.

# Stochastic models utilized in demography 

D. D. Joshi

## I. Stochastic processes

1. A stochastic process is a family of random variables $\{X(t)\}$. The manner in which the variables influence each other is described by specifying the joint probability distribution of every finite set $\left\{X\left(t_{1}\right), \ldots, X\left(t_{n}\right)\right\}$ of variables of the family. These distributions determine completely the probabilistic behaviour of the family.
2. Being evolutionary in nature, demographic phenomena are best studied mathematically as stochastic processes. We interpret $t$ as time (which may be counted in generations), and $X(t)$ as the state of the system at time $t$. It is then natural to assume that the variable $X(t)$ depends only on the past history (that is, only on $X(r),(r<t)$ and not on the future. A further simplification is to assume that the process is Markovian, that is, the knowledge of the state at time $\tau$ is sufficient to determine the probability distribution at any subsequent time $t>\tau$; the past history prior to $\tau$ ceases to have any effect.
3. We use the term stochastic model in the restricted sense of a stochastic process model.

## II. Classification of models

4. Stochastic models may be broadly classified into four categories as follows:
(a) Discrete variable, discrete time models, for example, $X(t)$ may denote the number of individuals in the $t$ th generation;
(b) Discrete variable, continuous time models, for example, $X(t)$ may denote the number of children born to a woman to age $t$;
(c) Continuous variable, discrete time models, for example, $X(t)$ may denote the interval between the birth of the $(t-1)^{\text {th }}$ and the $t^{\text {th }}$ child;
(d) Continuous variable, continuous time models, for example, $X(t)$ may denote the relative frequency of a particular gene at time $t$.

## III. Construction of models

5. To construct a stochastic model to represent a demographic phenomenon we must,
apart from specifying the parameter $t$ and the variables $X(t)$, lay down the assumptions governing the evolution of the process. These assumptions usually describe the manner in which the variables influence each other, and enable one, at least theoretically, to arrive at the complete description of the probabilistic behaviour of the process in the sense mentioned earlier. For example, if the process is Markovian and time discrete, it is enough to specify the initial probability distribution of $X\left(t_{o}\right)$ and the conditional probabilities $P\{X(t+1) / X(t)\}$ for all $t \geqslant t_{0}$. The history of the process subsequent to $t_{0}$ can then be built step by step.
6. A complete solution generally is not available, except in very simple cases, but one can usually obtain, in place of a complete probabilistic description, certain characteristics of the process, for example, the various moments of the joint distribution of $\left\{X\left(t_{1}\right), \ldots, X\left(t_{n}\right)\right\}$.
7. We now proceed to a review of certain selected demographic models. Because the emphasis is on methods, the models have been grouped under the four categories mentioned above irrespective of the domain of application. In each model an attempt is made to describe in detail the manner in which the assumptions regarding the evolution of the natural process are translated into probabilistic language. Subsequent mathematical details are touched upon only briefly.

## IV. Stochastic models in demography

(a) Discrete variable, discrete time models
(i) A model to study fecundity
8. Consider a woman's life history from the time of marriage. Every month she is exposed to a risk of conception. Each conception is followed by a temporary sterility period which may vary from one conception to another. We represent this by the process $\{X(n), n=$ $1,2, \ldots\}$. Each $X(n)$ is either 0 (no conception in the $n^{\text {th }}$ month) or 1 (conception in the $n^{\text {th }}$ month). If any $X(n)$ is 1 , the subsequent variables $X(n+1), \ldots, X(n+g)$ are zero, $g$ itself being a random variable. We suppose further that the probability of a conception
taking place in the $n^{\text {th }}$ month, provided the and woman is not temporarily sterile, is $p(n)$.
9. We introduce:

$$
\begin{gathered}
\operatorname{P(n)=\operatorname {Pr}\{ X(n)=1\} } \\
Q(n, n)=\operatorname{Pr}\{X(n)=1 / X(m)=1, X(m+1) \\
=0, \ldots, X(n-1)=0\}
\end{gathered}
$$

We then obtain
$P(n)=q(1) q(2) \ldots q(n-1) p(n)+\sum_{m=1}^{n-1} P(m) Q(m, n)$
with

$$
P(1)=p(1) \text { and } q(n)=1-p(n) .
$$

10. The probability that the $k^{\text {th }}$ conception takes place in the $n^{\text {th }}$ month ( $n \geqslant k$ ) is

$$
\begin{gathered}
P(k, n)=\sum_{u=k-1}^{n-1} P(k-1, n) Q(u, n), \quad k \geqslant 2 ; \\
P(1, n)=q(1) q(2) \ldots q(n-1) P(n) .
\end{gathered}
$$

And, if $I(j)$ denotes the interval between the $(j-1)^{\text {th }}$ and the $j^{\text {th }}$ conception, we have

$$
\begin{gathered}
\operatorname{Pr}\{I(1)=r\}=P(1, r) \\
\operatorname{Pr}\{I(j)=r\}=\sum_{u=j-1}^{\infty} P(j-1, u) Q(u, u+r)
\end{gathered}
$$

11. In particular, if we have $p(n)=p$, $q(n)=q$, and a constant sterility period of $h-1$ months following each conception, then

$$
\begin{aligned}
Q(m, n) & =0 & \text { for } & & n<m+h \\
& =p q^{n-m-n} & \text { for } & & n \geq m+h .
\end{aligned}
$$

We then get

$$
P(n)=q P(n-1)+p P(n-h),
$$

and

$$
\left.\lim _{n \rightarrow \infty} P(n)=p /[1+(h-1) p] \quad \text { (if } \quad q>0\right)
$$

12. L. Henry ${ }^{1}$ calls this quantity "fécondité centrale". The distribution of the total number of conceptions in the first $T$ months of marriage has been obtained by S. N. Singh. ${ }^{2}$
13. The case with a variable sterility period has been studied by L. Henry., ${ }^{3} \mathrm{He}$ introduces $K(m, g)$, the probability that conception in the $m^{\text {th }}$ month causes temporary sterility till the month $m+g$ at least. We then have,

$$
P(n)=p(n)\left[1-\sum_{m=1}^{n-1} P(m) K(m, n-m)\right]
$$

[^156]\[

$$
\begin{gathered}
P(k, n)=p(n)_{u=0}^{n-1} \\
{[P(k-1, u)-P(k, u)-P(k-1, u) K(u, n-u)] .}
\end{gathered}
$$
\]

(ii) A migration model
14. Consider a population divided into $m$ groups, its state at any time $n$ being described by the vector

$$
X(n)=\left\{X(n), \ldots, X_{m}(n)\right\}
$$

$X_{i}(n)$ is the number of individuals in the $i^{\text {th }}$ group. Each individual of the $i^{\text {th }}$ group has a probability $p(i, j)$ of migrating to the $j^{\text {th }}$ group in one unit of time. (These may be called "migration probabilities".)
15. Let $X_{6 j}(n+1)$ be the number of indivi duals moving from the $i^{\text {th }}$ group at time $n$ to the $j^{\text {th }}$ group at time $n+1$; then

$$
X_{i}(n+1)=\sum_{i=1}^{m} X_{i j}(n+1) .
$$

$X_{i j}(n+1)$ have, for each fixed $i$, a multinomial distribution with parameters $X_{i}(n)$ and $p(i, j), j=1,2, \ldots m$. The distribution of $X(n+1)$ can now be obtained if $X(n)$ is known. In particular,

$$
E\left[X_{j}(n+1)\right]=\sum_{i=1}^{m} p(i, j) E\left[X_{i}(n)\right]
$$

16. Such a model can be used to study interregional migration, ${ }^{5}$ and social or occupational mobility. ${ }^{6}$ G. Malécot ${ }^{7,8,9}$ has developed similar models for genetical studies.
17. P. A. P. Moran ${ }^{10}$ and G. A. Watterson ${ }^{11}$ have developed discrete variable, discrete time models for studying genetical evolution under mutation, selection and non-random mating.
(b) Discrete variable, continuous time models
(i) A model of population growth
18. $X(t)$ is the number of individuals in the population at time $t$. The probability that in the
${ }^{5}$ R. Tominson, Journal of the American Statistical Association, vol. LVI (1961), pp. 675-686.
${ }^{6}$ ). Matras, Population Studies, vol. XV (1961), pp. 187-197.

7 G. Malécot, in Le calcul des probabilités et ses applications (Paris, Centre national de la recherche scientifique, 1949), pp. 121-126.
${ }^{8}$ G. Malécot, Entretiens de Monaco en Sciences Humaines (1962), pp. 205-212.
${ }^{\bullet}$ G. Malécot, "Sciences-Mathématiques", Annuaire de l'Université de Lvon, série III, Fascicule 17 (1954), pp. 19-35.
${ }^{10}$ P. A. P. Moran, Procedures Royal Society, Series B, vol. CXLIX (1958), pp. 102-112.
${ }^{11}$ G. A. Watterson, Annual of Human Genetics, vol. XXIII (1959), pp, 221-232.
interval $(t, t+d t)$ an individual will give birth to another is

$$
\lambda(t) d t+0(d t),
$$

that he will die is

$$
\mu(t) d t+0(d t),
$$

and that an immigrant will come in is

$$
\eta(t) d t+0(d t)
$$

In the small interval ( $t, t+d t$ ) the only possible changes are a unit increase or decrease in population size, the conditional probabilities being

$$
\operatorname{Pr}(n \rightarrow n+1)=(n \lambda+\eta) d t+0(d t)
$$

(birth or immigration)

$$
\begin{gather*}
\operatorname{Pr}(n \rightarrow n-1)=n \mu d t+0(d t) \quad(\text { death })  \tag{death}\\
\operatorname{Pr}(n \rightarrow n)=(1-(n \lambda+n \mu+\eta) d t)+0(d t) \\
(\text { no birth, death or immigration })
\end{gather*}
$$

19. Let $P(n, t)=\operatorname{Pr}\{X(t)=n\}$ and let $\phi(t, z)=\sum_{n=0}^{\infty} P(n, t) z^{n}$. We then get

$$
\begin{aligned}
P(n, t+d t) & =P(n, t)(1-n \lambda+n \mu+\eta d t) \\
+P(n-1, t) & \{(n-1) \lambda+\eta\} d t+P(n+1, t) \\
& (n+1) \mu d t+0(d t) .
\end{aligned}
$$

$$
\frac{\delta P(n, t)}{\delta t}=\{(n-1) \lambda+\eta\} P(n-1, t)
$$

$$
-\{n \lambda+n \mu+\pi\} P(n, t)+(n+1) \mu P(n+1, t)
$$

$$
\frac{\delta \phi}{\delta t}=(z \lambda-\mu)(z-1) \frac{\delta \phi}{\delta z}+\eta(z-1) \phi(t, z)
$$

20. For the solution of these equations see 12, 13, 14. If $\lambda, \mu$ are constant and $\eta=0$ the population grows according to the Malthusian law

$$
\dot{E}[X(t)]=N \exp \{(\lambda-\mu) t\} \cdot N=X(0),
$$

and the probability of extinction is 1 (if $\lambda \leqslant \mu$ ) and $[\mu / \lambda]^{N}$ (if $\lambda>\mu$ ).
21. Let $s(u, t)$ be the probability that an individual born at time $u$ is alive at time $t$. Then

$$
\begin{gathered}
s(u, t+d t)=s(u, t)[1-\mu(t) d t+\mathrm{o}(d t)] \\
s(u, t)=\exp \left[-\int_{\mu}^{t} \mu(t) d t\right]
\end{gathered}
$$

[^157]and the distribution of the life time $T=t-u$ has density
$$
\mu(u+T) \exp \left[-\int_{\mu}^{T+u} \mu(t) d t\right] .
$$
22. Similarly one easily obtains that the probability that an individual born at time $u$ has $r$ children during $(u, t+u)$ is
$$
\frac{1}{r!}[L(u, t)]^{r} \exp [-L(u, t)], L(u, t)=\int_{u}^{t+u} \lambda(v) d v,
$$
and the probability that an individual born at time $u$ will have $r$ children during his lifetime is
\[

$$
\begin{gathered}
\int_{0}^{\infty} \frac{1}{r!}[L(u, t)]^{r} \mu(t+u) \exp [-\{L(u, t)+M(u, t)\}] d t \\
M(u, t)=\int_{u}^{t+u} \mu(v) d v
\end{gathered}
$$
\]

23. Taking $u=0$, the above results apply to the case where $\lambda$ and $\mu$ depend on the age of the individual. ${ }^{15,16}$ Another application of this model is due to W. Brass. ${ }^{17}$ He takes $\lambda$ to be constant for an individual but varying from person to person. If $\lambda$ has the gamma distribution

$$
d F(\lambda)=\frac{a^{k}}{\Gamma(k)} e^{-a \lambda} \lambda^{k-1} d \lambda
$$

the probability of $r$ births in $T$ years of marriage is

$$
\begin{gathered}
\int \frac{1}{r!}(\lambda T) r e-\lambda r d F(\lambda)= \\
\left(\frac{a}{a+T}\right)^{k} \frac{\Gamma(k+r)}{r!\Gamma(k)}\left(\frac{T}{a+T}\right)^{r}
\end{gathered}
$$

This technique of introducing non-homogeneity is frequently used. ${ }^{18,19,20,21}$
24. Similar models have been proposed to study growth of a bisexual population, ${ }^{22,23}$
${ }^{15} \mathrm{R}$. Consael and A. Lamens, op. cit., pp. 83-112.
${ }^{16}$ D. D. Joshi, Publication de linstitut de statistique de lUniversité de Paris, vol. III (1954), pp. 153-177.

17 W. Brass, Bulletin of the International Statistical Institute, vol. XXXVI (1958), pp. 165-178.
${ }^{18}$ L. Henry, Population, No. 3 (1957), pp, 413-444.
19 L. Henry, Population, No. 1 (1961), pp. 27-48 and No. 2 (1961), pp. 261-282.
${ }^{20}$ E. B. Perrin and M. C. Sheps, Biometrics, vol. XX (1964), pp. 28-45.
$21 \mathrm{~S} . \mathrm{N}$. Singh, Journal of the American Statistical Association, vol. LVIII (1963). pp. 721-727.
${ }_{22}$ D. D.' Joshi, Publication de linstitut de statistique de l'Université de Paris, vol. III (1954), pp. 153177.

23 A. Lamens, Académie Rovale, Belgique, Bull. Cl. Sci., vol. XLIII (1957), pp. 711-719.
aging, ${ }^{24}$ deaths from different causes, ${ }^{25}$ population growth in clusters, ${ }^{26,27}$ and genetical evolution. ${ }^{28}$
(ii) A model to study human reproduction
25. The reproductive history of a woman since marriage is described by the time spent in any of the five states:
$S_{0}$-non-pregnant, fecundable
$S_{1}$-pregnant
$S_{2}, S_{3}, S_{4}$-post-partum sterile following abortion, still birth, live birth respectively.
At marriage state is $S_{0}$ and the subsequent changes of state are as follows:

26. The time spent in $S_{0}$ is a random variable with density $g_{0}(t)$, mean $\mu_{0}$, variance $\sigma_{o}^{2}$. From $S_{1}$ the woman goes to $S_{2}, S_{3}$ or $S_{4}$ with probabilities $\theta_{2}, \theta_{3}, \theta_{4}$; the time spent in $S_{1}$ (conditional on transition to $S_{i}$ ) has density $g_{i}$, mean $v_{i}$, variance $\xi_{i}^{2}(\mathrm{i}=2,3,4)$. Time spent in $S_{i}$ (before transition to $S_{0}$ ) has density $f_{i}$, mean $\mu_{3}$, variance $\sigma_{i}^{2}$. The process is nonMarkovian as changes from state to state depend on the time spent in each state.
27. In such a model ${ }^{29}$ the following aspects of the reproductive process can be studied:
(a) Distribution of the intervals between successive pregnancy terminations of the various types;
(b) Distribution of the number of miscarriages, still births, or live births per individual in a given period of time;
(c) Probability of occurrence of a live birth, that is, the fertility rate.
28. Let $t(i, j)$, (with mean $\mu_{i f}$, variance $\sigma_{i j}^{2}$ ), be the time taken to pass from $S_{i}$ to $S_{j}$, and $T(i, j)$ the time spent in $S_{i}$ given that the next state is $S_{j} .(T(0,1)=t(0,1), T(i, 0)=t(i, 0)$
${ }^{24}$ W. F. Taylor, Proceedings Fourth Berkeley Symposium of Mathematical Statistics and Problems, vol. IV (1961), pp. 347-368.
${ }^{25}$ C. L. Chiang, Proceedings Fourth Berkeley Symposium of Mathematical Statistics and Problems, vol. IV (1961), pp. 169-180.
${ }^{26}$ R. Consael, Bulletin de la classe des sciences, Académie Royale de Belgique (5), vol. XLV (1959), pp. 845-858.

27 J. Neyman and E. L. Scott, Cold Spring Harbor Symposium on Quantitative Biology, vol. XXII (1957), pp. 109-120.
${ }^{28}$ C. J. Mode, Biometrics, vol. XVIII (1962), pp. 543-567.
29 E. B. Perrin and M. C. Sheps, Biometrics, vol. XX (1964), pp. 28-45.
for $i=2,3,4)$. Then $t(0,0)=t(0,1)+T(1, i)$ $+T(i, 0)$ with probability $\theta_{6}, i=2,3,4$,

$$
\begin{gathered}
\mu_{00}=\mu_{0}+\sum_{i=2}^{4} \theta_{i} \eta_{i}, \quad \eta_{i}=\eta_{i}+\mu_{i} \\
\sigma_{00}^{2}=\sigma_{0}^{2}+\sum_{i=2}^{4} \theta_{i} \lambda_{i}^{2}+\sum_{i<j=2}^{4} \theta_{i} \theta_{j}\left(\eta_{i}-\eta_{j}\right)^{2}, \\
\lambda_{i}^{2}=\xi_{i}^{2}+\sigma_{i}^{2} .
\end{gathered}
$$

One also obtains

$$
\mu_{44}=\frac{1}{\theta_{4}}\left(\mu_{0}+{\left.\underset{i=2}{4} \theta_{i} \eta_{i}\right), ~\left(\frac{1}{2}\right)}^{4}\right.
$$

The variance $\sigma_{44}^{2}$ and means and variances of $t(i, j)$ can also be obtained.
29. However, the behaviour of $N(i, t)$, the number of times a woman enters the state $S_{i}$ in time $t$, is difficult to characterize. But the asymptotic means and variances of $N(i, t)$ can be obtained by using the theory of renewal processes. In particular, one finds that the asymptotic fertility rate is $1 / \mu_{44}{ }^{30,31}$
(iii) Finite population size model of genetical evolution
30. State at time $t$ is described by four variables
$\left.\begin{array}{l}X(t)-\text { number of } a a \text {-males } \\ Y(t)-\text { number of } A A \text {-males }\end{array}\right\} X(t)+Y(t) \leqslant M$
$\left.\begin{array}{l}W(t)-\text { number of } a a \text {-females } \\ Z(t)-\text { number of } A A \text {-females }\end{array}\right\} W(t)+Z(t) \leqslant F$
$M$ and $F$ are constants. This is a model with overlapping generations. Deaths take place at random times, the probability that in $(t, t+d t)$ an ( $a a$ ), ( $A a$ ) or ( $A A$ ) individual will die being $\lambda_{1} d t+o(d t), \lambda_{2} d t+o(d t), \lambda_{3} d t+o(d t)$ respectively. A dying individual is replaced by another of the same sex formed by the union of two gametes, one selected from the male and one from the female gametic output of the population existing before death.
31. Suppose at time $t$ the state is $(k, l, r, s)$, then the conditional probabilities of deaths of individuals of different types, if a death has taken place in $(t, t+d t)$, are $k \lambda_{1} / \Delta(a a-$ male), $(M-k-l) \lambda_{2} / \Lambda$ (Aa-male), $l \lambda_{3} / \Lambda$ ( $A A$ - male $), \quad r \lambda / \Lambda(a a$-female $), \quad(F-r-s) \lambda_{2} / \Lambda$ (Aa-female) and $s \lambda_{3} / \Lambda$ (AA-female), where

$$
A=\lambda_{1}(k+r)+\lambda_{2}(F+M-k-1-r-s)+\lambda_{3}(1+s) .
$$

32. Let $x(a \rightarrow A)$ and $y(A \rightarrow a)$ be the mutation probabilities. Then, the proportions

[^158]of $a$ and $A$ in the male and female gametic outputs are
$p_{m}(a)=\frac{1}{M}\left[k(1-x)+1 y+\frac{1}{2}(M-k-1)(1-x+y)\right]$, with similar expressions for $p_{m}(4), p_{f}(a)$ and $p_{t}(A)$.
33. Assuming non-random mating, the probabilities (same for males and females) that the replacement of the dying individual is of type (aa), (Aa) or (AA) are ${ }^{32}$
$p(a a)=(1-c) p_{m}(a) p_{f}(a)+\frac{1}{2} c\left[p_{m}(a)+p_{f}(a)\right]$
$p(A a)=(1-c)\left[p_{m}(A) p_{f}(a)+p_{m}(a) p_{f}(A)\right.$
$p(A A)=(1-c) p_{m}(A) p_{f}(A)+\frac{1}{2} c\left[p_{m}(A)+p_{f}(A)\right]$.
$(0 \leqslant c \leqslant 1)$. For random mating we have $c=0$. For another, generalization to account for non-random mating. ${ }^{33}$
34. From the state $(k, 1, r, s)$ at time $t$ there are thirteen possible transitions. The transition probabilities can be written down easily; for example,
\[

$$
\begin{aligned}
\operatorname{Pr}[(k, 1, r, s) \rightarrow(k-1,1, r, s)] & =\operatorname{Pr}[a a-\text {-male dies, replaced by } A a \text {-male }] \\
& =p(A a) k \lambda_{1} / \Lambda \\
\operatorname{Pr}[(k, 1, r, s) \rightarrow(k, 1, r-1, s+1) & =\operatorname{Pr}[a a-\text {-female dies, replaced by } A A] \\
& =p(A A) r \lambda_{1} / \Lambda
\end{aligned}
$$
\]

35. This model has been used to study the rate of approach to homozygosity. ${ }^{34,35}$
(c) Continuous variable, discrete time models
(i) A model of genetical evolution
36. Consider a population with constant size $N$ per generation. The state is given by $X(n)$, the proportion of a particular gene in the $n^{\text {th }}$ generation. For large $N$ we may assume $X(n)$ to be a continuous variable ( $o \leqslant X(n) \leqslant 1)$ with density $f(x, n) \cdot\left(\int_{0}^{1} f\left(x_{1} n\right) d x=1\right)$.
37. We assume that the process is Markovian the conditional distribution of $X(n+l)$, given $X(n)=x$, having density $f(y, x)\left(\int_{0}^{1} f(y\right.$, $x) d y=l$ ). We then get ${ }^{36}$

$$
f(y, n+1)=\int_{0}^{1} f(y, x) f(x, n) d x .
$$

Putting $F(s, n)=\int_{0} e^{s x} f(x, n) d x$ we get

$$
\begin{aligned}
F(s, n+1) & =\int_{0}^{1} e^{s y f}(y, n+1) d y \\
& =\int_{0}^{1} e^{s y}\left[\int_{0}^{1} f(y, x) f(x, n) d x\right] d y \\
& =\int_{0}^{1}\left[\int_{0}^{1} e^{s(y-x)} f(y, x) d y\right] e^{s x} f(x, n) d x
\end{aligned}
$$

For fixed $x, \int_{0}^{1} e^{s(y-a)} f(y, x) d y$ may be developed in a series to give the conditional moments of $X(n+l)$. Suppose
$\left.\int_{0}^{1} e^{s(y-x)}\right) f(y, x) d y=1+s b(x)+\left\{s^{2} / 2!\right\} a(x)+\ldots \ldots ;$

[^159]we then get, ${ }^{37}$ assuming that powers of $s$ higher than the second can be neglected,
\[

$$
\begin{aligned}
F(s, n+1)= & \left.\int_{0}^{1}\left[1+s b(x)+\left\{s^{2} / 2\right]\right\} a(x)\right] e^{s x f}(x, n) d x \\
= & F(s, n)+s \int_{0}^{1} \varepsilon^{x x}\left[b(x) f(x, n)-\frac{1}{2}\right. \\
& \left.\frac{\delta}{\delta x}\{a(x) f(x, n)\}\right] d x
\end{aligned}
$$
\]

This leads to

$$
\frac{1}{2} \frac{\delta}{\delta x}[a(x) f(x)]-b(x) f(x)=0
$$

for the asymptotic stationary distribution, $f(x)$ denoting the limiting density function. Similar results are obtained ${ }^{38}$ if one assumes that $f(y, x)$ is normal with mean $x+b(x)$ and variance $a(x)$. For the calculation of $a(x)$ and $b(x)$ under mutation, selection, etc., see the next section.
(d) Continuous variable, continuous time models
(i) Continuous variable, continuous parameter Markovian processes
38. Let $f(t, x ; u, y)$ denote the conditional probability density of the random variable $X(u)$ given that $X(t)=x, u>t$. Let

$$
\begin{aligned}
b(t, x) & =\lim _{d t \rightarrow 0} \frac{1}{d t} \int_{|y-k|<\delta}(y-x) f(t, x ; t+d t, y) d y \\
& =\lim _{d t \rightarrow 0} \frac{1}{d t} \int_{|y-k|<\delta}(y-x) f(t-d t, x ; t, y) d y
\end{aligned}
$$

and

$$
\begin{aligned}
a(t, x) & =\lim _{d t \rightarrow 0} \frac{1}{d t} \int_{|y-\kappa|<\delta}(y-x)^{2} f(t, x ; t+d t, y) d y \\
& =\lim _{d t \rightarrow 0} \frac{1}{d t} \int_{|y-\kappa|<\delta}(y-x)^{2} f(t-d t, x ; t, y) d y
\end{aligned}
$$

[^160]We may think of $b(t, x)$ and $a(t, x)$ as the mean change and the mean square change in the variable per unit time. Under certain regularity conditions it can be shown ${ }^{39}$ that $f$ satisfies the following equation (called Kolmogotoff's forward equation)

$$
\begin{aligned}
\frac{\delta f}{\delta k}= & \frac{1}{2} \frac{\delta^{2}}{\delta y^{2}}[a(u, y) f(t, x ; u, y)]- \\
& \frac{\delta}{\delta y}[b(u, y) f(t, x ; u, y)] .
\end{aligned}
$$

39. In the stationary (or time homogeneous case) we write

$$
\begin{gathered}
f(t, x ; t+u, y)=f(x ; u, y), a(t, x)=a(x) \text { and } \\
b(t, x)=b(x),
\end{gathered}
$$

and the forward equation becomes
$\frac{\partial f}{\delta \mu}=\frac{1}{2} \frac{\partial^{2}}{\delta y^{2}}[a(y) f(x ; u, y)]-\frac{\delta}{\delta y}[b(y) f(x ; u, y)]$.
This equation may be solved for every fixed $x$, to give $f$ as a function of $u$ and $y$, provided $a(y)$ and $b(y)$ are known. These in turn depend on the assumptions regarding the relation between $X(t)$ and $X(t+d t)$.
(ii) Application to the study of genetical evolution
40. We consider a population of fixed size $N, N$ being sufficiently large for the gene-frequency to be approximated by a continuous variable. $X(t)$ denotes the proportion of the gene $A$ at time $t(0 \leqslant X(t) \leqslant 1)$. Time $t$ is measured in generations and a continuous approximation of this discrete time is assumed possible.
41. The transition from one generation to the next is supposed to take place in the following manner:
42. We start with $N$ individuals of the $n^{\text {th }}$ generation of which $X_{n}, 2 Y_{n}, Z_{n}$ are $A A, A a$ and $a a$ respectively. These individuals con-

$$
\begin{aligned}
& P(A A)=x_{1}\left(x_{1}+\lambda y_{1}\right)=P \\
& P(A a)=2 x_{1} y_{1}(1-\lambda)=2 Q \\
& P(a a)=y_{1}(y+\lambda x)=R
\end{aligned}
$$

44. Suppose actual numbers of zygotes at birth are $X_{n+1}, 2 Y_{n+1}, Z_{n+1}$ (sum $=N_{1}$ ). Due to zygotic selection the number of zygotes actually reaching the reproductive stage are $\alpha X_{n+1}, 2 \beta Y_{n+1}, \gamma Z_{n+1}$, where $\alpha, \beta, \gamma$ are the relative viabilities of the zygotes. To keep the

[^161]tribute to the gametic pool giving rise to the next generation, the proportion of $A$ in the pool being
$$
x=\left[X_{n}+Y_{n}\right] / N
$$

Due to mutation, immigration and gametic selection the proportion of $A$ in the pool effectively contributing to the birth of the next generation is different from $x$, say $x_{1}$. If $\mathfrak{u}(A \rightarrow a)$ and $v(a \rightarrow A)$ are the mutation rates, then

$$
x_{1}=x(1-w)+(1-x) v .
$$

If $m$ is the immigration rate, the reproducing population consists of "immigrants" (fraction $m$ ) and "autochtones" (fraction 1-m), so that

$$
x_{1}=x(1-m)+m c,
$$

$c$ being the proportion of $A$ among the immigrants. Due to gametic selection, we get

$$
\frac{x_{1}}{1-x_{1}}=(1+s) \frac{x}{1-x}
$$

where $A$ or $a$ has selective advantage over its allele according as $s>0$ or $s \leqslant 0$. If $s$ is small we have approximately

$$
x_{1}=x+s x(1-x)
$$

When all the three factors are present we assume that the effects are additive and get

$$
\begin{aligned}
x_{1}= & x+\Delta x=x+\{v(1-x)-u x\}+ \\
& \{m(c-x)\}+\{s x(1-x)\}
\end{aligned}
$$

43. The birth of individuals of the $(n+1)^{\text {th }}$ generation is assumed to result from random mating. Taking into account the inbreeding effect due to limited population size, the assumption of random mating amounts to selecting $N_{1}$ individuals of the $(n+1)^{\text {th }}$ generation with the following probabilities (multinomial distribution)

$$
\begin{aligned}
& x_{1}+y_{1}=1 \\
& \lambda=\text { inbreeding coefficient }
\end{aligned}
$$

population size constant we choose $N$, such that

$$
\begin{gathered}
E\left(\alpha X_{n+1}+2 \beta Y_{n+1}+\gamma Z_{n+1}\right)= \\
a E\left(X_{n+1}\right)+2 \beta E\left(Y_{n+1}\right)+\gamma E\left(Z_{n+1}\right)=N
\end{gathered}
$$

that is

$$
(\alpha P+2 \beta Q+\gamma R) N_{1}=N .
$$

45. The gametic output of these individuals will now have $A$ genes in the proportion

$$
z=\left[a X_{n+1}+\beta Y_{n+1}\right] / N
$$

$z$ is thus a random variable related to the initial value $x$ through the random variables $X_{n+1}$, $Y_{n+1}, Z_{n+1}$. We have

$$
\begin{aligned}
E(z) & =(1 / N)\left[a E\left(X_{n+1}\right)+\beta E\left(Y_{n+1}\right)\right] \\
& =\left(N_{1} / N\right)[\alpha P+\beta Q] \\
& =(\alpha P+\beta Q) /(\alpha P+2 \beta Q+\gamma R),
\end{aligned}
$$

$$
\begin{aligned}
\operatorname{Var}(z)= & \left(1 / N^{2}\right)\left[a^{2} \operatorname{Var}\left(X_{n+1}\right)+\beta^{2} \operatorname{Var}\left(Y_{n+1}\right)\right. \\
& \left.+2 a \beta \operatorname{Cov}\left(X_{n+1}, Y_{n+1}\right)\right] \\
= & (1 / 2 N)\left[2 a^{2} 2(1-P)+\beta^{2} Q(1-2 Q)\right. \\
& -4 \alpha \beta P Q] /[a P+2 \beta Q+\gamma R]
\end{aligned}
$$

We can now obtain $b(x)$ and $a(x)$. In fact

$$
\begin{gathered}
b(x)=E(z)-x \\
a(x)=E\left[(z-x)^{2}\right]=\operatorname{Var}(z)+[E(z)-x]^{2}
\end{gathered}
$$

46. In special cases we may take $\alpha, \beta, \gamma$ as follows: $\alpha=\beta=\gamma$ (zygotic selection absent) ; $\alpha: \beta: \gamma=1+s: 1: 1-s$ (uniform genetic selection), $\alpha: \beta: \gamma=1: 1: 1$-s (selection with dominance) ; $\alpha: \beta: \gamma=1-s: 1: 1-s$ (heterozygote advantageous).
47. The exact solution of the forward can now be attempted and has been obtained in some
special cases by Kimura. ${ }^{40,41,42}$ The steady state solution ( $\partial \mathrm{f} / \partial u=0$ ) is given by

$$
f(x)=[K / a(x)] \exp \left[2 \int\{b(x) / a(x)\} d x\right]
$$

Special forms of this solution in the different cases are listed by S. Wright. ${ }^{43}$
48. For those interested in details of these demographic models, we refer to the sources listed in the foot-notes throughout this paper. In addition to these sources, detailed bibliographies will be found in the sources listed in footnotes ${ }^{13,} 14,20,37$ and ${ }^{39}$. Other writings that treat the subject are those of D. Basu ${ }^{44}$, V. M. Dandekar ${ }^{45}$ and W. F. Taylor. ${ }^{48}$

[^162]
# The use of population models 

## Sully Ledermann

1. Although the term "model" is of recent date, the use of models dates back to the earliest attempts to describe and explain natural phenomena. The geocentric astronomical system of Ptolemy and the heliocentric system of Copernicus are examples of celebrated models.
2. Models are usually understood as formalizations of actual reality. We shall consider here only the mathematical formalizations. ${ }^{1}$
3. The elaboration of models presupposes a certain minimum of previous scientific theory. They are not identifiable with the theory, which is a broader construction, but, as Malinvaud notes, "they apply to the most crucial part of the theory".
4. Because of this, they provide the most sensitive tests of its validity. They thus contribute, in a precise manner, to the criticism and improvement of basic hypotheses, which are at the core of scientific progress.
5. We may also note that the mere construction of a model, even if it is to be devoid of numerical application, may play a powerful role in the elaboration of a theory.
6. Models present certain characteristics by which they may be classified. Here we shall examine several simple characteristics, with the help of examples.

## Example I

7. Since it is a mathematical formalization, the model begins with a numerical equation.

$$
P_{2}=P_{1}+N-D+I-E
$$

8. This equation gives the population of a territory on date No. 2 when the population on date No. 1, the number of births $(N)$, the number of deaths $(D)$, the number of immig-

[^163]rants ( $I$ ) and the number of emigrants ( $E$ ), are known.
9. If the data $P_{1}, N, D, I$ and $E$ are known, there is no point in carrying out a population census on date No. 2. The model, which is a substitute for actual reality, provides the answer ( $P_{\mathbf{2}}$ ).

## Rewarks

10. Adopting economic terminology, we may note in this example the exogenous variables $P_{1}, N, D, I$ and $E$, whose numerical value derives from outside the model, and an endogenous variable $P_{2}$, whose value is a mathematical function of the exogenous variables proposed by the model. Here there is a causal relationship involved in the passage from the exogenous variables to the endogenous variable, but such a relationship does not always exist.
(a) Each variable may be endogenous in its turn, without necessitating any change in the model. For example: $D=P_{1}-P_{2}+N+$ $I-E$;
(b) This model is a determinist one. The exogenous variables being numerically fixed, the endogenous variable is rigorously determined;
(c) Model $P_{2}=f\left(P_{1}, N, D, I, E\right)$ is constructed on the basis of structural analysis of the passage from $P_{1}$ to $P_{2}$. What reacts on or influences what, and how?
(d) The relationship between $P_{2}$ and $P_{1}$ is complete; here, the model is not a simplified representation of reality. This is an exceptional case which is encountered only at the level of numerical equations.

## Example II

11. Let $n$ be the length of a marriage measured by the number $n$ of the wife's ovalation cycles since the beginning of the marriage. ${ }^{2}$ Let

[^164]$p$ be the probability of conception during a cycle, assumed to be the same for all women and constant in time. The number of women not yet having conceived for marriages of duration equal to $1,2, \ldots n$ cycles is ( $N=$ number of married women):
$$
f=N(1-p)^{n}
$$
12. Where $N=1,000, p=0.30$ and $n=12$ cycles, we shall obtain, by way of example, a figure of $f=14$ women per 1,000 who have not yet conceived up to the twelfth cycle.

## Remarks

(a) Like the preceding one, this model is derived from a prior structural analysis: here the passage from $N$ and $p$ to the final number $f$;
(b) This is a simplified representation of reality, for probability $p$ is assumed to be (i) the same for the $N$ women; (ii) constant in time;
(c) The model is a determinist one: $p$ and $N$ being fixed numerically, the final number $f$ is strictly determined;
(d) The value of $f$ is strictly valid only if the two assumptions (i) and (ii) are satisfied;
(e) We can, of course, try to improve the model by introducing sub-groups of women characterized by different probabilities. We may then, in the sub-groups, try to vary the probabilities in time. We shall thus, for the calculation of the final and global rate $f$, have a combination of "microdemographic" models, the mathematical formalization of which will be the more difficult to handle the greater the number of microdemographic models used.
13. Experience shows that this approach rarely leads to a simple "macrodemographic" model, i.e., a model of simple relationships between masses of units.

## Example III

14. Examination of 154 mortality tables shows that there is a mean linear relationship between the logarithm of the probability of death within the age interval 0 to 5 years and the logarithm of the probability of death in another age interval 10 to 15 years, for example: ${ }^{3}$

$$
\begin{aligned}
\log _{5} \hat{q}_{10}(M F)=- & -0.9058+0.90356 \log _{5} q_{0}(M F) \\
& +0.125 e
\end{aligned}
$$

When ${ }_{5} \hat{q}_{10}(M F)=60$ per 1,000 , for example, we have $\log 60=1.77815$ and $\log { }^{5} \hat{q}_{10}=$ $0.7009+0.125 e$ where $e$ is a reduced Gaussian variable with a mean of zero and a variance

[^165]of unity. Ninety-five per cent of the values of $e$ are included in the range plus or minus 2. The value of $s q_{10}$ is therefore in the range 2.8 to 8.9. The estimated value corresponds to $e=0$, i.e., ${ }_{5} q_{10}=5.02$.

## Remarks

15. The model does not originate in a structural analysis of the passage of the probability of death from age interval $0-5$ to age interval $10-15$. It was simply noted empirically that this mean linear relationship existed for the 154 mortality tables, i.e. for a variation of ${ }_{5} q_{0}$ rising appreciably from 20 to 450 per 1,000.
16. Upon reflection, we can diagnose two preponderant influences:
(1) The age difference between the individuals in the two groups considered, which is a factor common to the various populations and which, in this case, must be reflected in values for ${ }_{5} q_{10}$ generally lower than the values for ${ }_{5} q_{0}$;
(2) The local context, which simultaneously increases (or decreases) the probability of survival of the two groups of individuals-a factor common to the two groups and variable from one population to another. This is clearly the origin of the linear regression noted in the logarithms of ${ }_{5} q_{0}$ and ${ }_{5} q_{10}$.
17. But this is an a posteriori qualitative explanation. (Why, for example, is the relationship linear for the logarithms? We do not yet know.) The estimates for ${ }_{5} q_{10}$ given outside the range $s q_{10}=20$ at 450 per 1,000 should therefore be viewed with increasing caution the further we deviate from this range, because the model has no theoretical demographic basis:
(a) The model provides an estimate of $5 q_{10}$ approximately formalized in the random term $e$. The model is called random, or stochastic, or probabilist, or again statistical. The terminology is not fixed;
(b) It permits the use of a partial causality or a simple partial co-variance, while still allowing for many unknown factors or for an influence that is too complicated to formulate;
(c) The simulation of the behaviour of $e$ is provided by means of a theoretical distribution, in this case Gaussian. This distribution reflects the substantially symmetrical form of the deviations from the linear trend; the theoretical probability density also gives an acceptable picture of the respective densities of the deviations; the theoretical probability of deviations outside the range plus or minus $3 \sigma$ is so small that we can ignore the range of the "normal" theoretical variable, $-\infty$ to $+\infty$, which is inconceivable for the concrete variable;
(d) The exogenous variable is ${ }_{5} q_{10}$, and the endogenous variable $5 q_{0}$. This must be made clear, for the estimator is not symmetrical. Let us exchange the roles of the variables: the best estimate of $\log s q_{0}$ (former exogenous variable) on the basis of $\log _{5} q_{10}$ (former endogenous variable) is not given by:

$$
\begin{aligned}
\log _{5} q_{0} & =\frac{0.9058+\log _{5} q_{10}-0.125 e}{0.90356} \\
& =1.002+1.1067_{5} q_{10}-0.138 e
\end{aligned}
$$

but by:

$$
\log _{5} q_{0}=1.2154+0.8934 \log _{5} q_{10}+0.124 e,
$$

i.e., by an estimator other than the inverse of the preceding one. The numerical value of its coefficients depends on the specification of the variables;
(e) The value assumed by $5 q_{1}$ is not the cause of the value observed for ${ }_{5} q_{10}$ (or inversely). What we have is merely co-variation due to common factors. The law of the conditional probability of the endogenous variable may be expressed in various ways. Instead of adopting a linear regression relative to the logarithms, we could, for example, have used in $s q_{0}$ a second-degree or third-degree polynomial which would have given mean values of ${ }_{s} q_{10}$ (and not of the logarithm). There is thus a shift here from the concept of the model to that of the estimator, which is required to possess certain qualities (convergence, absence of distortion, etc.). According to the numerical data, the requirements may be contradictory, and it may be necessary to choose between several possible estimators, giving varying degrees of satisfaction;
(f) The numerical coefficients of the model were determined by the method of least squares, which minimizes the mean quadratic error of the estimate and hence the "loss" suffered by the user because of the inevitably erroneous result provided by the estimator. The value $s q_{10}=5.02$ where ${ }_{s} q_{0}=60$ corresponds to this minimization (in the logarithmic universe but not in the rates themselves: priority was given here to another quality of the estimator).

## Example IV

18. The process of reproduction may be represented by a succession of random phenomena. At each moment of her life, a woman is in one of the following states $S$, such as: $S_{0}=$ initial sterile period before puberty $S_{x}=$ period of fertility before sexual union $S_{2}=$ period of fecundability etc.
19. The passage from one state to another is characterized by a variation in the probability of fertilization and also by the random appearance of fertilizations. The length of time for which a woman remains in one of the above states is also considered as a random variable, characterized by a distribution of frequencies. This is a demographic model using the theory of the stochastic processes. ${ }^{4}$
20. These processes were described by Mr. Joshi in the paper he delivered at this meeting, and we shall not go into their special characteristics.
21. Let us note merely that this type of model achieves the transition from microdemography to macrodemography through the intermediary of a transition and aggregation operator which ensures the free play of individuals (this is still conventional, for there are simplifications at the level of the micro-models) and the synthesis of these individual freedoms so as to ultimately produce mactodemographic results.

## Conclusion

22. The preceding examples have illustrated some of the simplest characteristics of mathematical models used in demography. To sum up:
(1) A model is generally a simplified representation of reality;
(2) The variables may be classified as exogenous and endogenous. The exogenous variables are those whose value is taken from outside the model. The endogenous variables are those whose value is derived, so to speak, from the interior of the model: it results from the mathematical function of the exogenous variables posited by the model;
(3) There are broad categories of models: (a) determinist; and (b) random, or probabilist or stochastic. In the determinist models, the value of the endogenous variables is strictly determined when the exogenous variables have been given their value. In random models, the value of the endogenous variables is only determined within certain limits given by a probabilist sub-model (theoretical laws of the distribution of frequencies, etc.). In random models, there is often a tendency to move from the idea of a model towards the "estimator" concept, of which certain characteristics may be required (absence of distortion, convergence, etc.). This estimator is linked to the variable to be estimated. That is one of the reasons why the form of random models is not usually

[^166]independent of the specification of the variables as exogenous and endogenous. They are not symmetrical so far as the variables are concerned;
(4) Two extreme classes of models may be considered, with an intermediate class combining the characteristics of the extremes: (a) the models may be determined on the basis of a prior structural analysis of a greater or lesser degree of elaboration, i.e., on the basis of a certain number of causal relationships between the exogenous and endogenous variables; (b) they may be determined without any structural analysis, on the basis of the empirical observation of simple co-variations; (c) the intermediate class combines the two above approaches. Models which are not based on prior structural analysis are common and extremely useful. But since they lack any theoretical basis in the field in which they are applied, the forecasts they provide should naturally be treated with caution when extra-
polated outside the area of available empirical observations;
(5) Two other classes may also be considered: (a) microdemographic models, i.e., those relating to small demographic units: individuals, small communities, etc ; (b) macrodemographic models. These are designed to establish only relationships between large masses of units. These two categories of models are not usually of the same nature, and the aggregation of a large number of microdemographic models does not usually produce any more than it does in economics, simple and easily usable macrodemographic models. Nevertheless, a decisive step forward has been taken in this field with stochastic processes (simulation, etc.), which make possible such a transition from micro- to macrodemography. The practical use of these processes is bound up with the calculation possibilities offered by electronic machines.

## The increased scope of demographic investigations through the use of sampling surveys

Forrest E. Linder

1. There are many scientific ways by which the boundaries of demographic knowledge are cxtended. These include the official census and civil registration systems, casual study of available groups, intensive investigations of an epidemiological type, detailed anthropological researches, and a wide and heterogeneous variety of activities which often are grouped indiscriminately under the heading of "sampling surveys".
2. The utility of the whole group of sample surveys as a means of extending the scope of demographic studies could be discussed in a general way, but the discussion can be more precise if it is limited to the consideration of sample surveys which are based on sound probability theory, which are drawn from a sample of individual persons or households, and which utilize interview techniques to collect information.
3. Consideration of possible contributions from sample surveys of this type must be in relation to the potential of traditional sources of basic demographic data. The traditional sources, namely, the decennial or quinquennial censuses and the continuous civil registration system for decades have provided, and undoubtedly will continue to provide, the basic facts for understanding structure and changes in national populations. It is often implied that traditional sources would be fully adequate if developed to a high level of efficiency and that sampling surveys are only a substitute and interim method primarily for use in the developing countries.
4. No one can dispute the value and economy of sample survey methods in countries where the traditional demographic sources are not effectively operating. Indeed, in some areas the sample survey method may be the only available source of data, but the emphasis on the use of sample surveys in developing countries tends to hide the point that even in the most developed countries, the census and civil registration systems are necessarily inadequate sources and that sample surveys in such areas
have a major place and an increasing role as a method for collecting demographic data.
5. To discuss in detail the basic limitations of even highly perfected census and registration methods is not necessary. The complete census method is extremely costly and for this reason, new census data usually are available only once a decade. Even with modern methods, the time required for processing and printing results is long. Another factor in the limitations is that for technical and policy reasons, the list of items for which data are compiled is not extensive. The civil registration system, as a source of demographic data, is restricted in ways similar to the census method. The volume of records involved in a complete registration system imposes processing problems and delays in dissemination of tabulated data. The legal character of the registration process, and the use of birth and death registration documents for many public purposes make them inappropriate instruments for the collection of many demographic, social and economic facts.
6. An examination of the various international and regional recommendations for items to be included in censuses and vital statistics systems show these items fall far short of satisfying the catholic interests of modern demography. It is true that most of these recommendations tend to define basic programmes designed for countries with minimum statistical resources, but examination of the range of topics covered by the censuses and registration systems of the most advanced countries leads one to the conclusion that the data are also insufficient for the developed countries.
7. General limitations of even highly developed census and vital registration systems have led to a rapid increase in the use of sample surveys in countries that are advanced in their statistical methods. These surveys usually are not directed solely at the collection of demographic or fertility data, but collect a wide range of social, economic, labour, or health data to which purely demographic factors are related or for which population data form a
base. Sample survey programmes of this type have been carried on with notable success in such countries as Canada, the Federal Republic of Germany, Japan, the United Kingdom, the United States and other nations with effective census and registration programmes.
8. Studies in which a defined or undefined part of a population has been covered by adequate data collection procedures are, of course, not new. However, recent continuing progress in survey theory and method is developing a much sharper and better tool than previously has been available. These theoretical and methodological advances have been in five major areas:
(a) Improved sampling theory and design. The modern survey design is greatly sophisticated and much more powerful than earlier simple random designs. A survey today may quite possibly include such features as deep stratification, multi-stage structure clustering, and controlled selection schemes;
(b) Computer-related complex estimation. Estimation methods of improved efficiency and additional complexity have accompanied the development of more elaborate designs. These methods emphasize the use of all relevant information, and often employ extensive computational routines which were always theoretically possible and which became economically feasible when adapted to the capacity of electronic computers;
(c) Improvement and evaluation of the response. There is less acceptance of an interview response at face value. Much attention is given now to the art and science of improved questionnaire design. Survey designing and estimation processes are arranged so that they facilitate the calculation not only of sampling errors, but also of the components of measurement error, and permit improved evaluation of the quality of the results of the survey;
(d) Field control. Development of more rigorous methods of field organization and control has narrowed the potentially dangerous gap between the plan for a survey, and its execution;
(e) Technological developments in data processing. The advent of the electronic computer has been well-publicized, but other processing aids collectively may have as much impact on survey data as the computer. In addition to the conventional punch card equipment, these aids include a wide range of optical, mechanical, electrical, and electronic devices which improve the recording and transcription of information, reduce processing errors, and contribute greatly to the quality of final output.
9. Theoretical and operational advances continue to increase the intrinsic advantages of the sample survey method. It is true that some of these advances also have increased the value and soundness of conventional census methods, but the use of sampling has had the effect of directing additional attention to the whole problem of the sources of measurement error. Because sample surveys usually deal with samples much smaller than the universe under observation, it is possible to maintain improved control of the complete range of data collecting and processing operations. The reduced volume of material to be collected permits a speed and flexibility of great advantage. The legalistic character of a registration system means that its content and pattern of operation is "lockedin" and that it is subject to only rare revisions or minor ones. The cumbersome complete census procedure is too heavy to repeat except at quinquennial or decennial intervals. The total time-span of operation, on the other hand, can extend over a period of a year or less and some continuing survey operations produce data on new topics on a quarterly or monthly basis. The decreased volume of data and the shortened time period result in reduced costs. This economy, in turn, permits an increased frequency of data collection and a more liberal range of subject coverage.
10. These intrinsic advantages arising out of the reduced cost and more limited extension of the sample survey mean that each interview can be more intensive and cover a much wider range of interrelated topics than can the census or registration system. The way is opened to a fruitful analysis in great detail of interrelated factors that goes far beyond what previously has been possible. Utilization of intensive interviews means that the survey can be directed more sharply to the exploration of a topic in depth and permits demography to move into a more scientific phase of development that is beyond the mere descriptive stage. For many studies of fertility and other demographic factors, probability surveys produce, in addition to the numerator information, the basic denominator data without which meaningful rates and ratios cannot be computed.
11. How these advantages may be exploited to increase the scope of demographic investigations can be appreciated by an examination of the range of topics that are considered appropriate for study with survey-collected data. The modern study of demography, concerned not only with the static structure of population, but also with the forces working to influence population distributions, is necessarily con-
cerned with a range of topics much broader than the basic demographic variables themselves. Interest obviously extends to natality and the factors, attitudes and practices affecting fertility. Mortality and the pattern of death in relation to age is the basis of a fundamental tool for demographic analysis and research. The geographic distribution of people and the changing plan of population from one area of a country to another, or from rural to urban sectors, has a bearing on the elements of natality and mortality. Beyond these, demography is concerned not only with the quantity of population but also with its quality and characteristics. It is concerned with qualitative factors not only because of their determining effect on quantity, but also because population quality is a proper area for demographic study.
12. Demographic interests extend to broad fields of health and nutrition, educational and cultural characteristics, and economic behaviour of people. The programme of the World Population Conference, 1965, includes, among other things, plenary meetings or discussion group meetings on fertility, mortality, internal migration, labour supply and employment, educational development, agricultural development and food supply, urban development and housing, demographic aspects of savings, investments and industrialization, and demographic aspects of economic growth. Where, it may be asked, are the sources of data for this almost universal coverage of demographic interest? It is true, of course, that in addition to the conventional vital registration system and the population censuses, there is the agricultural census, the housing census and an enormous armamentarium of traditional reporting systems producing data on education, employment, trade and other social and economic factors.
13. For demographic analysis it is often important to study the interrelation of these factors. What is frequently essential is not a system giving macro-data expressed in total aggregates, but rather micro-data in which each variate can be determined for the individual and developed in a way that presents distributions and relationships built from separate observations for each separate member of the population. Another promising technique being utilized in demographic analysis is computer simulation of human populations. Simulation methods, to be effective, require a substantial input of real-world parameters. The sample survey is perhaps the most efficient instrument for obtaining the variety and detail of needed data. It is in these applications that the adaptability and flexibility of the survey method has
its greatest potential-a potential which is now being recognized increasingly and effectively realized in the highly developed countries, as well as in countries in the early stages of economic development.
14. The full detail of important topics for demographic analysis which are potentially susceptible to investigation by the sampling survey method would cover practically the whole range of statistical knowledge. This potential coverage of subject matter combined with a survey method that is flexible, rapid, manageable and relatively inexpensive opens a broad and inviting field for the demographer; however, there are pitfalls of a serious character which must be taken into account. The sampling survey is not an "open sesame" to demographic knowledge.
15. Sampling theory itself relates only to the connexion between a subgroup of responses and the theoretically complete group of responses. The theory provides the basis for correct selection of the subgroup, for estimating the parameters of the complete group and for estimating the errors expected by virtue of the fact that only the subgroup, rather than the total group, has been examined. None of these points has bearing on the validity of the complete group of responses as truly reflecting the facts under investigation. Both sampling surveys and collection of data from the complete population under study are subject to response errors of a priori unknown magnitude.
16. The design of sampling surveys and recommendations for operating procedures create a necessity for a careful determination of concepts, definitions, and relations of design to operating steps. In addition, a sound survey requires a firm control over operating procedures to keep them in reasonable conformity with the theoretical design. All these requirements promote and facilitate the evaluation of total measurement and response error, but: there is nothing in this process that guarantees validity of response.
17. The process of data collection by interviews is subject to numerous defects arising from simple memory loss, conscious suppression of known facts, biases of distortion or omission resulting from psychological mechanisms, systematic shifts in recalled time references, possible lack of clarity and ambiguity in concepts and questions, interviewer-created biases, lack of rapport and many other factors perhaps still unidentified.
18. With numerous investigators in social science rapidly expanding the collection of information by using surveys, it may be said
that we are approaching a major crisis in social and demographic research, since methodological research into problems of response is not receiving the continued and intensive attention that it deserves. It may be said safely that whenever the validity of interview survey data is challenged rigorously by objective tests, the validity of such data fails to come up to expectations. The science of survey interview is in its infancy and phenomenal increases in technical sophistication are required before the interview survey becomes an instrument of known dependability. This is no claim that the potential of the survey method is hopeless now that these same defects do not apply to other methods of collecting data. Defects in present survey methods will yield to serious and sustained methodological research. Areas in which
the present methods will yield satisfactorily accurate results can be delineated. For areas in which present methods are inadequate, it may be possible to measure the magnitude of response bias so that data are usable for some purposes, if not for studies requiring the rigorously perfect data.
19. New developments in methodology have offered the demographer a process of greatly increasing the scope of demographic investigations through the use of sampling surveys; however, without proper attention to problems of survey design and response validity, these new tools can lead to scientific disaster. With proper attention to these factors, a new and fruitful era of demographic research presents itself.

# The use of electronic machines in demographic models 

Luu-Mau-Thanh

## Intronuction

1. Relatively little use has yet been made of electronic machines at the demographic research level, for such reasons as lack of information among research workers and, in some cases, financial problems.
2. It may be recalled that a model is a mathematical function of exogenous variates from which values of endogenous variates can be worked out. ${ }^{1}$ Electronic machines can be used for this mathematical function purpose and can also handle numerical data. Because of their enormous capacity for storing numerical data, they are an ideal tool for large statistical centres (for analysing census and survey data, etc.). This paper, being concerned rather with demographic research models, will deal primarily with the mathematical forms used.
3. Three main headings may be considered; they may be called, purely for convenience:
(a) Classical mathematics;
(b) Matrix computation;
(c) Statistical and probability computations and models.

## I. Classical mathematics

4. Most demographic models now constructed are based on classical mathematics; a distinction may be drawn between the following:
(a) Computations relating to integrals and differentials;
(b) Resolutions of systems of equations.
5. Generally speaking, integrals or differentials cannot be conveniently handled at the level of numerical applications. The difficulties may be theoretical (lack of integrability, lack of explicit form, transcendental functions, etc.) or practical (length of the computations).

[^167]6. Lotka's basic equation relating to the intrinsic rate of increase $r$ of a stable population provides an example of this:
\[

$$
\begin{equation*}
\int_{(D)} e^{-r a p(a)} \cdot m(a) d a=1 \tag{1}
\end{equation*}
$$

\]

( $p(a)$ and $m(a)$ being the probabilities of survival and of fertility respectively at a given age).
7. Solutions can be obtained only by successive approximations, and the length of the computations depends on the speed of convergence, which may be very low, even when such acceleration procedures as Newton's method or the trapezes method are used.
8. A similar problem arises in the computation of series and runs involving a large number of parameters.
9. The following may be cited as examples of the use of computers in this connexion.
10. Demeny (1961), who calculates the true root and the complex roots of equation (1), by various methods of approach (Taylor's development, Coale's method), using an IBM 650. The time taken for each iteration and for each step of the computations is given by the author. Keyfitz (1964), who uses Newton's approximation and successive iterations on the basis of an arbitrary value of $r$, using an IBM 7094.
11. In a study on fertility, Henry (1961) expresses the number of conceptions according to the order $k$, in the case of non-restriction of births, by means of the following equation (discontinuous):

$$
\begin{equation*}
C_{k}=p \sum_{x_{0}}^{x-1}\left(C_{k-1}-C_{k}-C_{k-1} K\right) \tag{2}
\end{equation*}
$$

$x_{0}$ being the age of marriage, $p$ being the probability of conception.
12. These computations are made "manually" for a period of eighty quarters ( $t$ is discontinuous and is expressed in quarters) and for each order $k$ varying from 1 to 15 , taking $p=0.488$ as the average fecundability. Although this computation is easy in com-
parison with the computation of a sum of integrals in the continuous case, it is still very laborious and requires several weeks of computation with an office machine. It can easily be programmed, and computation takes only a few minutes. In the continuous case, computation would take longer.
13. A similar study, but on a stochastical process basis, was made by E. B. Perrin and M. C. Sheps (1964). The average number of conceptions during a given period and its variance are roughly estimated by means of linear time relations. In a particular case where the parameters are given in advance (only live births and foetal deaths are recorded, and the sterile period following each pregnancy is constant), the exact values of the number of conceptions and its variance are computed with an electronic machine for a period of approximately 100 months, beginning with the first month of marriage (the authors did not mention what machine and method were used). These points trace a damped oscillation curve around the asymptotic right limit.
14. Systems of equations, whether linear or not, are seldom encountered in demographic research. They will probably appear more often with electronic machines. In Henry's study on fertility (1961), the "central fertilities" of thirty-two months are the solutions of a system of thirty-two equations. In the absence of an electronic machine, these results were computed by the author by "testing, but not resolving" the system. The resolution of such systems is the type of computation for which an electronic machine can at present be used.

## II. Matrix computation

15. The formulation of certain models can be greatly facilitated by the use of matrix computation, and most matrix operations are programmed on electronic machines. A programme can therefore be written directly from matrix relations, but it should be pointed out that the most economic computation programme is not always obtained in this way.
16. We may cite the studies by Leslie (1945), Lopez (1961) and Keyfitz (1964) relating to stable populations. The age structure $P_{n}$ during the year $n$ is expressed in terms of the initial age structure $P_{0}$ by the very simple matrix relation

$$
P_{n}=A^{n} P_{0}
$$

where $A$ is a transition matrix, the elements of which are probabilities of survival and of fertility.
17. Computation of the crude rate of increase, in particular, is simply a matter of determining the characteristic foots of the limit matrix $A^{n}$, when $n$ increases indefinitely.
18. Keyfitz, in an application to the French population of 1961-1966, used an IBM 7094 to compute all the characteristic roots of a transition matrix $(9 \times 9)$. Age groups were needed. This is an example where more precise computations would probably have been possible if matrix relations had not been used at the programming level.
19. We may also cite the studies by Madras (1961) on differential fertility; Musham (1962) on immigration; and Ledermann (1959 and 1964) on mortality.

## III. Statistical and probability computaTIONS AND MODELS

20. Statistical and probability computations and models are used in many demographic models.
21. Models such as those provided by the theory of factor analysis and canonical analysis : factor analysis sets out to explain the correlations noted between the variates of an aggregate paired by a combination of latent variates. Canonical analysis attempts to summarize in the most economic manner the relations between two systems of variates in covariation.
22. Reference may be made to the studies by S. Ledermann (1959 and 1964), Luu (1963) on mortality, and Westoff (1959) on fertility.
23. Adjustment. Methods of adjustment have found many applications in studies of the human sciences.
24. What is involved is to adjust a curve (two dimensions), a surface (three dimensions), or a hypersurface (several dimensions) to an aggregate of points observed in that space.
25. One variate may be expressed in terms of the others in the following form:
$Y=f(X)+e \quad$ ( $e$ being a random deviation).
26. The minimization of $e$, by the least squares method, for instance, provides a system of equations to be resolved in order to determine the parameters of $f(X)$.
27. If $f(X)$ is linear, the time needed for the whole computation is equal to the time needed to compute the linear system plus the time needed to compute the table of covariances of the variates. For small dimensions, when the values do not exceed 100 vectors $X Y$, for instance, and a number of exogenous variates
$X$ less than 10 , it is still conceivable that the computations can be made. ${ }^{2}$ However, the multiple regression is at present available in all electronic machine programmes.
28. If $f(X)$ is not linear, the computations, except in a few simple cases, may be very lengthy, and it becomes necessary to use electronic machines, since the solution generally requires arduous iteration procedures.
29. Examples of adjustments by electronic machine in demographic models are still relatively few. We may cite the preparation of standard mortality tables by Ledermann (1965), the computations of which would have been inconceivable without an electronic machine.
30. The use of electronic machines for stochastical processes does not, as a rule, raise any particular problems. Examples of such models will be found in Mr. Joshi's paper, and examples of application with an electronic machine in Keyfitz (1964) and in Hyrenius and Adolfsson (1964).

## IV. Construction of a programme

31. Let us summarize the essentials for the construction of a programme.

## 1. Method of computation

32. The first step is to seek a method of numerical computation to resolve the problem involved. The best method is, of course, one which requires less time of the electronic machine. At least some knowledge of numerical analysis is therefore recommended.

## 2. Programming

33. The programmer must next write the programme, either directly or through a coder, with the appropriate machine language (Algol, Fortran, etc.). Here, a perfect knowledge of the language of the machine and of its capacity (especially the number of memories) is necessary.
34. The use of sub-programmes which have already been prepared considerably reduces this part of the work and the cost of the operation. It is useful, therefore, to consult a programme library.

## 3. Testing the programme

35. Once the programme has been constructed, it must be tested. This is both a difficult and a frustrating step.
36. The programme is seldom correct at the first attempt. Errors are practically inevitable,

[^168]and they vary in number according to the length of the programme and the skill of the programmer.
37. They are of two kinds-errors in writing and errors in method of computation. A single writing error causes the machine to stop. With some languages, errors are more easily detectable. The time lost in obtaining a correct programme can vary from a few minutes the time needed to redo the tape or the punched cards-to weeks. A programme is usually checked by testing it with very simple data, the results of which are known in advance. Errors due to the method of computation are more serious, since they are not indicated by the machine.
38. It is hazardous, therefore, to launch immediately into the construction of a programme, without trying to simplify the computations, to reduce them as much as possible, to break them down into simple computations, or even to reduce them to computations for existing programmes, the content of which is almost exactly known (another problem).

## Conclusion

39. Let us leave aside theoretical research without numerical applications. A research worker seldom creates a mathematical model without considering the computations that will be needed for numerical applications. The correlation between existing models and the capacity for numerical computation is obvious.
40. As electronic machines are being improved and becoming more widely used, most mathematicians and statisticians do not hesitate to contemplete practical applications of increasingly complicated mathematical or probability theories.
41. This being so, it must be noted that, while there are few problems which cannot be resolved by electronic machine, there are many problems for which it is uneconomic to use electronic machines.
42. In order to estimate whether such use would be economic where the programme does not already exist, account must be taken of the following:
(a) The time needed to prepare the correct programme-days or weeks, as the case may be;
(b) The waiting time, either because the computer is not at liberty or because the programmers are busy.
43. It is desirable, therefore, from the outset, that a research worker should have some idea of electronic machines, of programming
and of the implications of approaching a solution by means of electronic machine.
44. Lastly, it must be borne in mind that computers do not resolve problems. They merely perform the computations called for by the research workers. Solutions remain the prerogative of the research worker. All that electronic machines can do-and this opens the door to a vast area-is to enable problems to be tackled for which it was not possible to envisage a solution in the past, thus making it possible to use larger and more complex models than the former ones and, consequently, to come nearer to the truth which is so difficult to arrive at.

## Summary list of existing programmes ${ }^{3}$

45. Matrix computation: transposition of matrices; diagonalization; addition; subtraction; multiplication; inversion (with resolution of a linear system) ; computation of characteristic roots and proper vectors (symmetrical matrices, unsymmetrical matrices) ; computation of determinants.
46. General mathematics: Bessel function; Legendre functions; complete and incomplete beta and gamma functions. Series: Fourier's series (addition of two series, evaluation, multiplication); breakdown into series, chronological series and graduation. Integrals and differentials; differential equations, equations with partial derivates, computation of integrals (trapeze method), Laplace's transformed curve. Simultaneous equations (linear and non-linear). Classical values (natural logarithms, Napierian logarithms, square root, power, trigonometric values, etc.).
47. Statistics and probability: characteristic values (mean, variance, comparison of means and variances, coefficient of correlations, multiple correlations, comparison of coefficients of correlation). Tests and graduations: test of non-parametric distribution, test of $X^{2}$, test of mean vectors, comparison of mean vectors, test on matrices of covariances (comparison of a matrix with a given matrix). Linear regression (simple, multiple, selective)-non-linear regression (simple, multiple, selective). Graduation with the laws of probability: binomial law (computation and graduation), polynomial law (computation and graduation), hyper-

[^169]geometric law, Poisson's law, Laplace-Gauss law, bivariate normal law.
48. Multivariate analysis: factor analysis (centroid, principal components, Varimax, etc.), canonical analysis, covariance analysis, incomplete blocks (comparison), Latin squares.

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## Some concepts of sample surveys in demographic investigations

## P. C. Mahalanobis

1. Non-sampling errors in sample surveys. Sample surveys can supply, with speed and economical cost, demographic information with sufficient accuracy for most practical purposes. Properly designed and properly conducted, a sample survey has the possibility of making a valid estimate of the margin of errors of sampling. The total margin of error, however, includes not only the theoretical errors of sampling, but also "non-sampling errors" which arise from the personal bias of different investigators, or which arise from differences in collecting the data or in processing it. Such non-sampling errors are often large and may be even larger than the theoretical errors of sampling. The object of this paper is to draw attention to some recent techniques for the study of "non-sampling errors" in sample surveys.
2. The design of inter-penetrating network of sub-samples (IPNS). This method can be used to study the differences arising from two or more sources of errors, such as two or more investigators or parties of investigators, questionnaire forms, etc. The logic of the IPNS design is simple. The sample (that is the total number of sample-units to be investigated) is selected in the form of two or more independent sub-samples with replacement. Each sub-sample has full coverage of the whole population under survey. The information is collected or processed for each sub-sample so that one sub-sample is assigned to each source of non-sampling error. To study the nonsampling bias done by two investigators or two parties of investigators, information for one sub-sample would be collected by one party of investigators and the information for the other sub-sample would be collected by the other party of investigators. Differences in the results based on the two sub-samples or components of the IPNS may then be ascribed to (nonsampling) differences between the two parties of investigators. An appropriate analysis of variance would supply relevant information for the study of non-sampling errors. ${ }^{1}$

[^170]3. Four demographic characters in India. These characters, based on the National Sample Survey, round 9; made in India, May to November, 1955 are: (a) sex-ratio (number of males per hundred females); (b) proportion of population in labour force; (c) proportion of population of age fifty and above; and (d) proportion of population literates.
4. Sample design and procedure. The design was a two-stage one, stratified with IPNS. Rural India was divided into a number of strata, each stratum consisting of districts or district groups. Within each stratum, sample villages were selected with probability proportional to population and with replacement. In each selected sample village, ten households were selected with random start. Urban areas were divided into blocks as first-stage units; sample blocks were selected systematically with four independent random starts and in each selected sample block, sixteen households were selected systematically with random start. The survey was conducted by two parties of investigators in each state, each party working in two periods of three months each, giving four different estimates for each demographic character for each state.
5. Analysis of variance, by states. For each of nineteen different states, an analysis of variance was done with the following partition into three degrees of freedom (d.f.): one d.f. between time, one d.f. between party; and one d.f. as error (party $\times$ time) with a total of three d.f. In this way, nineteen $F$-ratios for each of party/error and of time/error were obtained for each demographic characteristic for the nineteen states of India.
6. Table 1 gives an analysis of the variance of proportion of literate persons for each of the nineteen states of India.

[^171]Table 1. Analysis of variance of proportion of literate persons,

| State <br> (1) | Mean square |  |  | F-ratio ${ }^{\text {b }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Party* <br> (2) | Tine * <br> (3) | Error ${ }^{\text {a }}$ <br> (4) | Party <br> (5) | Time (6) |
| 1. Uttar Pradesh | 1.73 | 10.99 | 2.39 | $1.38(r)$ | 4.60 |
| 2. Bihar | 8.67 | 1.65 | 0.38 | 22.82 | 4.34 |
| 3. Orissa | 29.59 | 6.55 | 2.50 | 11.84 | 2.62 |
| 4. West Bengal | 1.48 | 1.65 | 0.20 | 7.40 | 8.25 |
| 5. Assam | 89.02 | 0.04 | 0.94 | 94.70 | 23.50(r) |
| 6. Andhra | 8.61 | 0.32 | 4.78 | 1.80 | 14.94(r) |
| 7. Madras | 0.08 | 12.04 | 7.24 | 90.50(r) | 1.66 |
| 8. Mysore | 12.08 | 0.11 | 6.62 | 1.82 | $60.18(r)$ |
| 9. Travancore and Cochin. | 22.04 | 34.28 | 30.75 | $1.40(r)$ | 1.11 |
| 10. Bombay | 17.64 | 2.34 | 7.02 | 2.51 | 3.00 (r) |
| 11. Saurashtra | 46.31 | 83.63 | 3.48 | 13.31 | 24.03 |
| 12. Madhya Pradesh. | 0.90 | 2.25 | 7.03 | $7.81(r)$ | $3.12(r)$ |
| 13. Madhya Bharat | 1.09 | 0.01 | 13.59 | 12.47 (r) | 1,359.00(r) |
| 14. Hyderabad | 0.22 | 2.53 | 0.28 | 1.27 (r) | 9.04 |
| 15. Vindhya Pradesh. | 7.02 | 4.75 | 0.14 | 50.14 | 33.93 |
| 16. Rajasthan, Ajmer..... | 0.11 | 0.07 | 1.37 | 12.45 (r) | 19.57(r) |
| 17. Punjab, Delhi. | 22.56 | 0.42 | 2.54 | 8.88 | $6.05(r)$ |
| 18. Pedialla East Punjab |  |  |  |  |  |
| State Union | 3.76 | 63.68 | 25.91 | $6.89(r)$ | 2.46 |
| 19. Jammu and Kashmir | 6.13 | 0.32 | 7.04 | $1.15(r)$ | 22.00(r) |

[^172]7. Notice that none of the nineteen $F$-ratios is statistically significant. This indicates that there was no significant difference between results based on the information collected by the two parties or between those based on information collected in two different time periods. The survey in respect to proportion of literates showed no significant non-sampling errors due to either party or to time factors. Out of nineteen $F$-ratios, nine values, those
marked ( $r$ ) within brackets, were cases of $F \leqslant 1$ (less than or equal to one) and ten were cases of $F>1$ (greater than one).
8. Three similar tables of $F$-ratios for each of the three other characteristics are not shown here. The combined frequency distribution of observed values of the $F$-ratio for all four demographic characteristics are shown in columns two and five in table 2.

Table 2. Frequency distribution of observed $\boldsymbol{F}$-ratios

| Demographic characterstics <br> (1) | $F=$ party mean square |  |  | $\frac{F=\text { time mean square }}{\text { Error mean square }}$ |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Error mean square |  |  |  |  |  |
|  | $\begin{aligned} & \bar{F} 1 \\ & (2) \end{aligned}$ | FI | Chi-square <br> (4) | $\begin{array}{r} \mathrm{F} 1 \\ (5) \end{array}$ | $\begin{aligned} & \mathrm{F} 1 \mathrm{C} \\ & (6) \end{aligned}$ | Chi-square <br> (7) |
| 1. Sex-ratio (19) proportion of population | 8 | 11(9.5) | 0.4737 | 9 | 10 | 0.0526 |
| 2. In labour force (19) | 9 | 10(9.5) | 0.0526 | 6 | 13 | 2.5789 |
| 3. Age 50 and above (19). | 14 | $5(9.5)$ | 4.2632 | 11 | 8 | 0.4737 |
| 4. Literate (19) ........ | 9 | 10(9.5) | 0.0526 | 9 | 10 | 0.0526 |
| 5. 4 characteristics (76).... | 40 | $36(38)$ | 0.2105 | 35 | 41 | 0.4737 |
| 6. 4 characteristics each for party and time (152). |  |  |  | 75 | 77(76) | ) 0.0263 |

9. Half the $F$-ratios are expected to be less than or equal to one (that is, cases of $F \leqslant 1$ ) and half greater than one (that is, cases of $F>1$ ). The expected numbers of $F$-ratios are shown within brackets in column three; the expected numbers would be the same for column six. The corresponding values of chi-square, to test the agreement between observed and expected numbers of $F$-ratios are given in columns four and seven for party and time respectively.
10. Party differences clearly were not significant which shows that the survey was conducted under satisfactory statistical control. Time differences also were not significant
showing that these demographic characteristics were not affected by the difference in the time of collection of information.
11. Combined analysis of variance. It is possible to make this analysis between state, party and time with either three interactions (party $\times$ time, state $\times$ party, and state $\times$ time) or with a single interaction (party $X$ time). With three interactions, the error would be based on eighteen degrees of freedom, and with one interaction on fifty-four degrees of freedom. Results for such an analysis of variance are given in table 3 for proportion of literates.

Table 3. Analysis of variance of proportion of literates between state, party and time

|  | Source (1) |  | Degrees freedom (2) | Sum of squares (3) | Mean square (4) | $\begin{gathered} \text { F-ratio } \\ \text { (5) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| With three interactions |  |  |  |  |  |  |
| 1.1 | State |  | 18 | 7,984.00 | 443.56 | $64.86^{\circ}$ |
| 2.1 | Party |  | 1 | 0.35 | 0.35 | $19.60(r)^{\text {a }}$ |
| 3.1 | Time |  | 1 | 13.06 | 13.06 | 1.90 |
| 4.1 | Party $\times$ time. |  | 1 | 0.77 | 0.77 | 8.91 (r) ${ }^{\text {a }}$ |
| 5.1 | State $\times$ party |  | 18 | 278.69 | 15.48 | $2.26{ }^{\text {e }}$ |
| 6.1 | State $\times$ time. |  | 18 | 214.58 | 11.92 | 1.74 |
| 7.1 | Error (1) |  | 18 | 123.43 | 6.86 | - |
| 8 |  | Total | 75 | 8,614.88 | - | - |
| With one interaction |  |  |  |  |  |  |
| 1.2 | State |  | 18 | 7,984.00 | 443.56 | 38.84 |
| 2.2 | Party |  | 1 | 0.35 | 0.35 | $32.63(r)^{\text {a }}$ |
| 3.2 | Time |  | 1 | 13.06 | 13.06 | 1.14 |
| 4.2 | Party $\times$ time |  | 1 | 0.77 | 0.77 | 14.84(r) ${ }^{\text {a }}$ |
| 7.2 | Error (2).. |  | 54 | 616.70 | 11.42 |  |
| $(5.1+6.1+7.1)$ |  |  |  |  |  |  |
| 8 |  | Total | 75 | 8,614.88 |  |  |

a $(r)$ indicates error/party, or error/party $\times$ time.
${ }^{\mathrm{b}}$ Significant at 1 per cent level.
${ }^{c}$ Significant at 5 per cent level.
12. Differences between states definitely are significant, whether the analysis is made with three interactions or with one single interaction. Different states clearly have different proportions of literates. On the other hand, differences between results collected by different parties or at different periods of time are not significant. Neither are the interactions significant.
13. Fractile graphical analysis. With the IPNS-design it is possible to use a simple graphical analysis for detailed investigations of demographic characteristics, for example, the
change in the proportion of adults with increasing level of living. In a household survey of expenditure it is usual to record the age, sex composition, size of the household, and total consumer expenditure during a suitable reference period (in thirty days in the case of the National Sample Survey of India, round 8: July 1954-March 1955). For each household, the per capita expenditure can be found by dividing the total expenditure by the number of persons in the household. This per capita expenditure may be used as an approximate indicator of the level of living. Data for per-
centage of adults in households in table 4 are given separately for rural and urban areas of

India, based on the National Sample Survey, round 8.

Table 4. National Sample Survey of India: round 8:
July 1954-March 1955
(Percentage of adults) ${ }^{\text {a }}$

| Decile per cent (t) | Subsemple 1 (2) | Com- <br> bined <br> (3) | Sub. sample 2 (4) | $S_{w} b$. sample 1 (5) | Combined (6) | Sub. sample 2 (7) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Rural |  |  | Urban |  |  |
| 0-10. | 51.1 | 49.4 | 48.6 | 58.4 | 55.0 | 53.3 |
| 10-20. | 51.4 | 54.3 | 55.6 | 52.8 | 56.8 | 59.0 |
| 20-30. | 58.6 | 56.0 | 53.8 | 60.9 | 62.5 | 56.3 |
| 30-40. | 55.6 | 57.1 | 58.9 | 66.3 | 57.4 | 54.3 |
| 40-50. | 59.0 | 58.0 | 56.5 | 63.5 | 64.8 | 59.0 |
| 50-60. | 60.9 | 61.3 | 61.5 | 69.8 | 59.3 | 63.3 |
| 60-70. | 59.0 | 61.0 | 63.1 | 58.4 | 66.8 | 64.0 |
| 70-80. | 62.4 | 60.9 | 59.0 | 68.6 | 64.5 | 65.5 |
| 80-90. | 61.3 | 61.1 | 63.1 | 65.7 | 68.7 | 72.4 |
| 90-100. | 67.3 | 67.9 | 66.8 | 74.6 | 75.2 | 75.0 |
| 0-100... | 58.6 | 58.7 | 58.7 | 64.0 | 63.0 | 62.2 |
| Number of sample households | 931 | 1,869 | 938 | 224 | 447 | 223 |

a Ranking of households by per capita total consumption expenditure.
14. In the IPNS-design such information will be available for at least two sub-samples and for the combined sample. The sample households in each sub-sample and in the combined sample are ranked in ascending order of per capita expenditure. The number of sample households is multiplied by the appropriate probability factor to give the estimated population, and the total (estimated) number of households is divided into a number of equal divisions, for example, ten decile groups. The proportion of adults in each decile is then calculated and plotted on the $y$-axis corresponding to successive decile groups shown at equal distance apart on the $x$-axis; successive points are finally joined by straight lines to give graph 1 for the first sub-sample. Graph 2 may be plotted in the same way for the second subsample, and the combined graph for the combined sample. The area included between graph 1 and graph 2 supplies a geometrical or graphical error-area associated with the combined graph. Two sets of graphs, each consisting of graph 1 for sub-sample 1, graph 2 for sub-sample 2, and graph 1 and 2 for the combined sample, for urban and rural areas are shown in the accompanying chart.
15. The percentage of adults is higher in urban areas in comparison with rural areas and increases with increasing level of living in both rural and urban areas. The error-area is given by the area enclosed within graph 1 and graph 2 in each case. The error-area is larger for the


National Sample Survey: Round 8: July 1954March 1955. Ranking by per capita expenditure of households. Percentage of adults in households
urban area, partly at least, on account of the smaller size of the sample. The error-areas
overlap to a large extent to about 70 per cent of the population (ranked according to increasing level of living) showing that on the basis of the available evidence differences in the percentage of adults in rural and urban areas are not statistically significant in this range. No overlap exists in the error-area for the percentage of adults in the top 20 per cent
of population (ranked in accordance with the level of living) indicating that for the richer households the percentage of adults is siguificantly higher in urban areas. A proportionately larger number of adults in the household probably implies a proportionately large number of earners and a larger per capita income.

# Demographic analysis and computer programmes 

## Howard B. Newcombe and James M. Kennedy

1. The most common use of computers for population study relates to the extraction in tabular form and the statistical analysis of demographic information recorded in census enumeration forms and in the civil registrations of the vital events of birth, death, and marriage. Preparation of programmes for these two operations depends upon the demographer's understanding of the capabilities of the machine and the form in which the instructions must be put and the programmer's understanding the rules by which the same task would be accomplished if it were carried out by hand on a smaller scale.
2. The extent to which demographer and programmer are required to comprehend the other's methods and procedures, indeed, may be limited to simple tabulations when elementary analyses are the sole requirements, but uncomplicated procedures serve to extract only a limited part of the information contained in demographic records. Mutual understanding and an appropriate division of labour become greatly important as the complexities of the computer operations increase. A number of examples will be cited to illustrate the point.
3. The purpose of this paper is to acquaint the demographer with the manner in which computers function and the form in which instructions must be supplied, a few of the ways computers may deal in fairly simple fashion with problems of data extraction and statistical analysis, and the special demands that may be placed upon users of data. These demands involve forming and testing new rules which a computer may be programmed to follow.

## I. Manner in which computers function

4. An electronic computer essentially consists of a central processor capable of arithmetical and simple decision making operations and various storage devices (such as magnetic core memory and tape units) to hold information while it is not being processed. The central processor includes some temporary storage locations (called registers) that hold limited amounts of information during manipulation; it also has provision for reading information into and out of the system.
5. The instructions for any task, regardless of its complexity, ultimately must be reduced to very simple commands to be executed by the computer. For example, adding a pair of numbers may require as many as six commands, two to read the numbers into storage locations, two to perform the addition, one to store the result, and one to print the result.
6. The preparation of a programme written in so-called machine language is a tedious task for a human programmer, because it calls for meticulous attention to trivial details. In recent years, it has become common practice for programmers to write in a language suited to the problem they are attempting to solve, and to leave the detailed encoding of the instructions to the computer itself. The programmes that carry out this translation are known as compilers.
7. A number of problem-oriented languages for writing programmes are available, known by names such as ALGOL, FORTRAN, or COBOL. The use of these languages is so wide-spread that a new generation of programmers have grown up who are not initiated into the mysteries of machine language, and who have little concern for the detailed steps in executing a single sentence of compiler language. It is possible to supply the computer with a "source deck" of cards, containing a description of the job written in the compiler language, and to demand from the computer either immediate execution of the translated programme or the translated machine language programme punched on cards for later use.
8. For the most part, it is unlikely that demographers will undertake their own programming. What the programmer will need is explicit information concerning the required manipulations; for some of the complicated operations, the demographer will need guidance from the programmers on the simplest way of achieving an objective.

## II. Programming for extraction of demographic statistics

9. A further step in simplification is the "generalized" tabulation programmes, which can put directly into the hands of the
demographer the means for extracting actual data in almost any form. Once a programme has been written, it can be used repeatedly to extract virtually any tabulation or cross-tabulation from the various information contained in a punch card or magnetic tape file. The only instructions required (apart from the programme proper) are simple statements indicating the data to be tabulated, such as occupations, religions, ages or age classes, and the tabular form in which the information is to be distributed. These instructions are easily written by the user who has had no programming experience, and are easily revised. They usually are presented to the machine in the form of a dozen or more control cards, which are added to the deck containing the main programme.
10. The advantage of the programme just described is that the demographer needs no help from a busy programming group each time he wants a new kind of tabulation. With modern computers, the times required for such tabulations are exceedingly modest in relation to the sizes of the files. In our own work, processing rates of 5,000 records per minute for operations yielding ten to twenty two-way tables have been achieved with the Control Data G 20 computer, which has a memory access time of $6 \mu$ seconds and addition times of 6 to $20 \mu$ seconds. For relatively small files, relating to 13,000 records of still-born, handicapped, and dead children, a total of five minutes is required to produce as many as forty two-way tables showing the numbers of cases by cause of disease, birth order, legitimacy of the child, and age class of the mother, cross-tabulated in various ways. Most of the time is used in printing the tables after the processing has been completed.
11. Such tabulations relate only to the numbers taken from individual records of various kinds. Unless special methods are employed to interrelate pairs or groups of records, it is not possible to extract information on the bearing that one recorded event may have on the occurrence of another recorded event. The special problems of programming to extract this information will be discussed later on.

## III. Programming for analysis of demoGRAPHIC STATISTICS

12. Conventional methods for statistical analysis are, for the most part, sufficiently defined by the mathematical expressions that describe them to raise no special problems for the programmer. For example, multivariate analyses that would be exceedingly laborious
if carried out solely with the aid of a desk calculator are commonly programmed for execution on the more modern computers.
13. Such multiple regression procedures possess advantages and disadvantages. On one hand, when employed with data broken down simultaneously by potentially important variables, in the form of a matrix, they permit virtually exhaustive analyses of the relation of one sort of variation to all other sorts of recorded variations. On the other hand, these procedures may be insensitive or even misleading when the associations are other than linear. As an illustration of such non-linearities, one might mention the relationships between the risks of certain congenital anomalies and maternal age or parity, which may be $J$-shaped or $U$-shaped, or which may exhibit an abrupt rise at some point in the curve.
14. Some simpler statistical tests that are readily programmed may be used to avoid this difficulty. For example, splitting the data into two groups with respect to one of the variables permits comparison of the incidence of a condition in the one versus the other, and application of a chi square test of the significance of anty difference found. As an example, the procedure may be used to show that the incidence of certain congenital anomalies is higher for one maternal age group than for another. While it seems to waste information, this approach has an efficiency of not less than $2 / \mathrm{r}$, or 64 per cent.
15. B. Woolf has developed a readily programmable extension of this procedure, which permits the combining of data from an indefinite number of population sub-groups in such a way that comparisons made within subgroups are not biased in the pooling process. ${ }^{1}$ We have found this method useful for demonstrating the effects of maternal age on the risks of various diseases independent of contributions from possible birth order differences, and vice versa. For the sake of convenience, the statistical tabulation programme we have used has been written so that the output can be taken on cards that are fed directly back to the computer to yield the required chi square analysis.
16. If the statistical requirements are clearly stated, there is no great difficulty in providing such programmes for tabulations and for analyses in forms that will make their repeated use convenient in a variety of situations.
[^173]
## IV. Programming for longtitudinal analyses througif individual follow-up

17. Particular mention should be made of the possibilities formed by the computers' ability to carry out longitudinal analyses that involve following very large numbers of individuals and families by name, and using the accumulated files of routine records which they generate. Although the approach is potentially capable of releasing, in statistical form, information that could not be extracted from the files in any other way, the necessary "linkages" or matchings of successive records relating to the same persons until recently have been regarded as beyond the capabilities of machines, because of the numerous discrepancies encountered in the names and other identifying particulars. Now, however, procedures have been described which make nearly maximum use of items of identification that are individually unreliable, but collectively of substantial discriminating power. ${ }^{2,3,4}$ Their development, however, depends upon an unusual degree of collaboration between the programmer and the statistician or demographer.
18. Methods to minimize the effects of discrepancies in spelling names and to assess numerically the assurance that a pair of records relates to the same individual or family must be devised and tested by hand, using the actual files, before these files can be programmed. The refined procedures have little in common with crude rules of thumb that can be used with modest success for ad hoc studies. Since the logic of such operations is still in its infancy, even the best procedures currently available can be improved.
19. In our own experience, merging and linking records of birth and marriage into family groupings has been carried out on the G 20 computer at a rate of about 2,300 incoming records per minute. Further integration of these family files with accumulated records of still births, child handicaps, and child deaths has permitted extraction of reproductive and health histories of families on a limited statistical scale.

[^174]20. A glimpse at the possible complexities and potentialities of the approach, and at the demands it may place on the programmer and the user, may be gained if one considers the problem of multi-generation studies of whole population groups, which would interest the demographer and the population geneticist. Within each family pocket in the file would be a hierarchy of records, relating to the primary event of marriage, the secondary events of live birth and still birth from the marriage, and the tertiary events of ill health and death among the live born offspring.
21. Such family pockets, arrayed linearly along the file, would need to be cross-referenced to the family pockets of first degree relatives. For most Canadian provinces, the marriage records contain all necessary cross-referencing information, because each identifies three married couples, the bridegroom and bride, the bridegroom's parents, and the bride's parents. Thus, the full marriage information may be filed in triplicate, serving as a primary record in the pocket of the family unit of which the marriage is the first event and as tertiary records in two pockets of the family units into which the bridegroom and bride were born. In each location, the record serves as a reference to the other two family pockets. When the cross-referencing information is placed, it makes possible storage in retrievable form of pedigree information of unlimited complexity relating to whole populations. Such files might be visualized as being arrayed in order of the two family names of husband-wife pairs, perhaps in phonetically coded form, and as being continuously updated.
22. The advent of such systems is not as remote as it may seem. There are now both administrative and statistical uses for the information which could be derived from files of this complexity; the capabilities of the new machines are adequate for establishment and maintenance of such files; and the speeds of sorting, merging, and linking are now suffcient to reduce the processing costs to modest proportions in comparison with the costs of card punching. The chief limiting factor is the detailed thought and collaboration required of the programmer and the user of the statistics. Rapid increases in machine speeds and information storage densities undoubtedly will reduce further the processing costs, and should serve to make increasingly worth-while the necessary investment of design and programming effort.

# Sample surveys in the checking of population censuses 

G. Vangrevelinghe

[Translated from French]

## I. Introduction

1. There is no need to stress here the growing importance of general population censuses. First and foremost, they are an irreplaceable source of data on population, employment, housing and migration, which they supply in very great geographic detail. In this connexion, the importance of censuses in the preparation of regional and national development programmes cannot be minimized.
2. In addition to their own importance, it should be noted that census data are to an increasing extent providing the basis for many economic, sociological and other works and studies, which are becoming more and more scientific in character.
3. For all these reasons, it is particularly important to have some idea beforehand of the accuracy of the returns being used. Moreover, an appraisal of the accuracy of a census throws light on the nature and frequency of the errors made and makes it possible to seek the causes. The results of such analyses will obviously be very valuable when new censuses are to be prepared.
4. Lastly, census quality studies indicate how the statistical results obtained should be corrected if necessary to reflect the facts more accurately.

## II. Possible checks

5. There are many possible checks of a census and they can be made at different stages. The most original, and the most difficult, are checks of the quality and completeness of the information collected, i.e., of errors made at the collection stage; or the purpose of the checks may be to detect and analyse the numerous errors which may occur during the data processing (coding of documents, card punching, tabulation, actual processing). The latter kind of check has no special technical originality and we shall therefore confine ourselves here to a study of errors occurring at the collection stage.

## 6. The possible checks are of two kinds:

(a) Qualitative checks: these are studies of the quality and accuracy of the information collected on buildings, dwelling units and respondents. This study may be made by means of a conventional sample survey, in which the sample can advantageously be taken from the sampling frame of the census itself. Any demographic survey sufficiently close in time to the census may provide an opportunity for checking some of the census data;
(b) Quantitative checks: their object is the detection of omissions and duplications (and, on certain occasions, improper entries) of buildings, dwelling units and persons; in other words, they are checks on the completeness of the census. The quantitative control of the data collected in a census presents great problems:
(i) It may be hoped that errors in coverage will be few - of the order of a few per cent at most. Unless adequate precautions are taken, the evaluation of such a small percentage may be affected by a considerable random variation;
(ii) Errors occur mainly in difficult cases which are especially hard to detect: isolated buildings, dwelling units that are difficult to identify, vacant dwelling units or secondary residences, transients. In most ordinary surveys, the difficult cases are in fact somewhat neglected because they can cause only minor errors; here they must be treated with special care, because they are the very subject of the survey. Unfortunately, however carefully the control survey is made, the likelihood of the same error being made as in the census and consequently not being detected is far from negligible;
(iii) On the other hand, some faults in the quantitative checks may in some cases wrongly appear as errors in the census.

## III. Various possible checking methods

7. Several different methods may therefore have to be used in order to grapple with the problem.
8. The possible methods consist of internal census checks (matching of census documents) and external checks (matching with the results of field surveys, with the data in existing administrative files, such as the electoral roll, the taxation roll and the social security file, and with other statistical sources, e.g., vital records).
9. Duplications can be studied directly in the census documents. However, when only one sample is used for the study, a special method of sampling must be used, for in the case of a sample taken at random from all the documents the probability of the two forms representing a duplication both being included in the sample is equal to the square of the sampling fraction; it is therefore very slight. In practice, the solution is to take not a random sample in the strict sense of the term but a whole "section" of the population. For example, in the case of the 1962 census in France a check was made by comparing all forms for persons born on 1, 2, 3 or 4 May. An estimate of the frequency of duplication and an analysis of them by this method cannot, however, be made before the coding of the documents has been completed. In this process of estimating duplications, two types of error may occur: either a form has by mistake not been included in the "section" taken as a sample or else an error in the identification characteristics makes a pair of cards which in fact represent a duplication appear to be normal.
10. This leads to an underestimate of the number of duplications but a rapid calculation shows that this source of bias is a minor one. For example, there are two chances in a hundred that a form belonging to the "section" will be overlooked. The result will be a 4 per cent underestimate of the number of duplications, which is still perfectly acceptable.
11. Similarly, for the study of omissions, what might seem an attractive method would be to take an entire whole section from a file existing elsewhere (presumed to have been brought up to date beforehand), e.g., an electoral roll, and to look for the forms of the individuals on the roll among the census documents.
12. A major disadvantage of this method is that any error in the file or in the making of the documents would wrongly appear as an
omission, since it would be impossible to pair up the corresponding cards. Such a check would reveal the frequency of matching errors as much as the true omission rate and, because of the procedural difficulties of making such a study, the estimation of the omission rate in this way is impracticable. Consequently, for the detection of omissions, it is difficult to use the census itself as a sampling frame; we have just seen that the use of other files as sampling frames is also a source of many difficulties. There is a more satisfactory method, which is to repeat the census complete-ly-not throughout the entire territory, of course, but in a number of sample geographic areas: this is the area sampling method. Since the two enumerations are very close in time and space, it is much easier to compare the returns and detect a real omission. As will be seen below, however, many precautions must be taken to eliminate numerous sources of imprecision.

## IV. Checking by area sampling

13. Since the general principle of checking by area sampling is well established, it remains only to study the methods.
14. One plan may be to estimate only the variability of the returns of a population census. To the extent that accidental errors have occurred in the enumeration, the census returns are affected by a random error whose variance may be estimated by repeating the census operation in identical conditions.
15. Since it is difficult to repeat two independent measurements in identical conditions after a short interval and particularly since in a census systematic errors, which may well be expected to recur in a second operation and therefore to pass unnoticed, are much more frequent than accidental errors, this method is unsuitable in most cases.
16. It would thus seem that the second possible procedure the detection of errors in coverage - has to be followed. This implies that the observations made during the sample check can be considered to be almost perfect. This means:
(a) That the enumerators must have a much higher standard and much better training than the canvassers;
(b) That their working conditions in the field must be better; and
(c) That the working of the questionnaire and the actual technique of the survey must
be such as to prevent the same errors being made in the control survey as in the census.
17. From this point of view, the experiment conducted in France in 1962 clearly shows that, in this type of survey, the subtleties of a sample plan are much less important than a purely practical concern to avoid repetition of the errors made in the census. This concern should be felt at all stages of the preparation of the survey: if the sampling is to be effective, the areas chosen must be numerous and must therefore be small and approximately equal in size. The erroneous inclusion or exclusion of whole dwelling units should, however, be avoided in the control survey-in other words, the difficulties of identifying the areas in the field must be minimized. For this reason not only must the cartographic documentation be as accurate as possible, but must be chosen areas whose boundaries can be easily identified on the spot and which are sufficiently large and varied in size.
18. Many errors at the collection stageomissions, moreover, as well as duplica-tions-are the result of errors made in the often ticklish process of applying general rules to difficult individual cases. The concepts applied in the preparation of the census documents are often determined by the legal character of this operation; hence, in France, in particular, the desire to pin-point the precise geographic domicile of each individual. In a control survey, whose only purpose is to ascertain whether each individual has been counted once, omitted or counted twice, there is no need to be bound by these concepts and a more direct and more complete questionnaire can be devised. The most reliable method seems to be to evolve, for each area, rules for the inclusion of individuals in the field of inquiry which are very broad and, naturally, different from those adopted for the census.
19. For example, in France in 1962 the entumerators were instructed to enumerate all persons in any way connected with a dwelling unit in the area allotted to them (root sampling), to find out all the addresses at which those persons could have been counted and to note each person's principal socio-demographic characteristics. In processing the data, it will be sufficient in a second stage to determine whether or not each person has been counted at each of the addresses given for him and then, when the returns are totalled, to weight him inversely as the number of different areas where it would have been possible to include him in the field of control. The special cases of persons with secondary residences, persons residing in collective dwellings (residential institutions, hospitals, etc.) or persons who have moved in the interval between the census and the control survey-cases which, it should be recalled, are often the cause of census errors and therefore deserve special attention-make it necessary to evolve special rules for inclusion in the field of inquiry (also called "selection rules"), which must again be different from those used for enumerating the populations concerned in the census. It is not necessary here to describe the methods to be used.
20. As this paper has indicated throughout, the study of the completeness of enumeration, while it raises no real problems of a theoretical nature, is in its many aspects a particularly delicate task because of the actual difficulty of detecting census errors. Perhaps the best proof of this is the fact that the surveys made in the past by a number of countries have not yielded all the desired results. Nevertheless, the essential requirement for the success of a survey to check the completeness of an enumerationthat its results should approximate as closely as possible to the truth-is imperative and difficult to fulfil.

## A cursory consideration of electronic computers and their use in demography

Paul Vincent

[Translated from French]

1. Electronic computers are designed to be able to handle automatically a large variety of problems. For this purpose, they are equipped with a number of devices having the following functions: the input of the information required for solving the problem ("programme" and "data"); the storage of this information and of the intermediate and final results of the calculation; the processing itself (the exectution of the "arithmetic" and "logical" operations specified in the programme); the output of the "results"; and finally, the control of the other devices.
2. Physically, an electronic computer consists of a system of interconnected "units" among which the various devices are distributed. These units are often so numerous that the term of "electronic system" is preferred to "electronic computer".
3. The main part of a computer, which gives it its basic characteristics, is known as the central unit. This comprises the control and processing devices and the central memory which is the essential, if not the only, storage device of the system. The central unit covers what is known as the "internal area" of the computer. In this area, the data are transmitted and stored in a special form, which varies ac-
cording to the material but which is always based on the use of the system of binary notation for the "internal representation" of numbers and characters. In the "pure binary" system, the numbers are expressed entirely in binary terms, which facilitates calculation. In other systems, the numbers retain their usual decimal structure while their decimal figures are coded individually in binary terms; this facilitates input and output conversions.
4. As the figure shows, the central memory, also known as the "internal memory", communicates directly both with the control and arithmetic devices and with the input and output devices. The latter are distributed in "peripheral" units, which vary greatly in number. A single "input-output" unit, comprising one input device and one output device, may in some cases suffice to ensure the essential communications between the internal memory and the "external area" but large systems usually include not only input, output or input-output units of several types, but also many units comprising at the same time an input device, an output device and a storage device acting as an auxiliary memory. These memories, known as "external memories", communicate with the internal memory through the input and output devices associated with them.


Schematic diagram of an electronic computer
5. The internal memory is divided into locations, each capable of storing a group of characters constituting what is known as a "ma-chine-word" or simply a "word". Each memory location is given an address, i.e., an identification number. By means of this address, the control devices are able to establish communications with a given memory location, either to "write in" a word there or to "read out" the word in it. Unlike writing in, which substitutes a new word for the one previously recorded in the same location, reading does not change the content of the location; a word written in at a certain address therefore remains available at that address so long as no new word is written in there.
6. To solve a problem with an electronic computer, we first insert, through an input device, the programme of all the operations to be carried out by the computer. Each of these operations is the subject of a programme instruction. This instruction is expressed in the computer's machine language, in the form of a word made up of several coded numbers. During the "programme insertion" the instructions are simply stored in the memory in their order of input, without being analysed. Since the insertion of the problem data is effected by input operations laid down in the programme, the insertion of the programme necessarily precedes the input of the data.
7. When the insertion of the programme is completed, the control devices read the first instruction of the programme from the address where they stored it. They interpret the coded elements of the instruction and initiate the execution of the prescribed operation. Then they read the next instruction of the programme and analyse it in its turn. The renewal of the same process thus results in the "sequential" execution of all the programme instructions, except when the programme includes instructions designed to bring about a "transfer" or "jump" to an instruction other than the following one.
8. Transfers are known as "conditional" if they are subject to the fulfilment of a condition, or as "unconditional", if not. Conditional transfer operations play an important part in electronic computation, since they make it possible to simulate human reasoning by making the machine take "decisions" in the light of rational criteria. These criteria are usually comparisons, which lead to analysis of the sign of a difference-a "logical" operation carried out by the computer's arithmetic devices.
9. By means of transfers, chains of operations can be built up; these may indeed be
highly complex, because instructions can be treated like numbers and consequently modified by arithmetical operations. It will thus be seen that the utilization of a programme stored in the memory to control the process of solving a problem gives electronic computers incomparable flexibility.
10. Unfortunately, this advantage is not without corresponding disadvantages. The machine must be told everything that it has to do; for example: "receive a piece of information and store at such and such an address"... "read the number stored at such and such an address and add it to the contents of such and such a device"... "store the contents of such and such a device at such and such an address"... "print the information stored at such and such an address"... and all these orders must be given to the machine in its own language. Obviously, this is work which can only be done by a specialist in "programming' for the subject in question.
11. It is also time-consuming and laborious work, for the automatic processing of even a relatively simple problem always involves a large number of operations. And the fact is that it is almost impossible to write several dozens of instructions in machine language without making a mistake. Hence the need for "debugging" the programme is often a long and expensive process, for to detect errors, trial runs have to be made, and numerous instructions may have to be rewritten to correct the errors found.
12. Many methods have been devised to simplify programming. One of these is the use of sub-routines, i.e., sets of standard instructions for the solution of specific problems likely to be frequently encountered: the evaluation of square roots for example. Generally, the designers themselves build up "libraries" of sub-routines which they keep available for users. The latter are thus freed from the task of writing any part of the programme corresponding to a sub-routine already "in the library": they merely have to insert, at the correct place in the "main programme", appropriate instructions for performing the sub-routine in question, which, of course, has to be stored in the memory as a supplement to the main programme.
13. Sometimes a common sub-routine which is permanently stored in the memory of the computer may be brought into play by an instruction in every way similar to those which initiate built-in operations, i.e., operations carried out by special circuits designed into the computer. So far as the user is concerned,
there is nothing to distinguish operations "simulated" in this way by sub-routines from built-in operations, except that they are performed much more quickly.
14. In spite of the simplification achieved by methods of this kind, programming would have remained the province of specialized "programmers" if designers had not hit on the idea of making the machine "translate" into its own language programmes drawn up in very different languages. These new languages could then be designed as genuine electronic language, adapted to electronic computation in general, not restricted to the specific technology of a specific subject, and at the same time simple, synthetic and very close to ordinary language.
15. The use of such languages involves some slight additional complication of procedure, since it necessitates breaking down the solution of a problem into the following phases:
(a) The preparation of a source programme in electronic language;
(b) The conversion of this source programme into an object programme, formulated in machine language;
(c) The execution of the object programme. However, the second phase is carried out automatically by means of a special programme, called the translator, written once and for all in machine language by the designer.
16. Furthermore, the instructions which make up the source programme are actually "macro-instructions", each implying the execution by the computer of a whole series of operations. A few dozens of instructions in electronic language may thus represent several hundreds of instructions in machine language.
17. This considerably facilitates the task of programming, particularly as some dozens of instructions can easily be formulated in electronic languages without a single mistake. Furthermore, the simplicity of electronic languages makes them easy to use by anyone wishing to programme his problems for himself.
18. These advantages are particularly valuable in the field of scientific research, where scientists are constantly having to deal with new problems which for the most part have only to be solved once and which are generally much too technical for their solution to be expressed in a form comprehensible to professional programmers. That is why most electronic languages are "scientific" language based directly on mathematical language. However, there also exist some "commercial" languages designed to facilitate the pro-
gramming of problems connected with the "administration" of enterprises.
19. The main applications of electronic computation may, in fact, be divided into two categories: administrative applications and scientific applications. The differences between these categories are so great that designers have felt it desirable to diversify the available equipment to adapt it better to either administrative or scientific problems.
20. Let us consider in this connexion administrative applications such as payrolls, accounting, stock control, invoicing, etc. They have certain characteristics in common: the operations are repeated regularly; they cover a considerable volume of information and involve a large number of items, which can be arranged according to identification numbers; they entail many sorting and cross-referencing operations but few calculations-which, moreover, are very simple; and they produce numerous documents, often requiring alphabetical indications.
21. Administrative computers therefore need powerful input and output devices and largecapacity auxiliary memories (external memories). On the other hand, they need a central memory of only small capacity, and arithmetic devices comprising only a few built-in operations. Furthermore, they benefit by using an internal representation of characters based on alpha-numerical positions, grouped in words of variable lengths.
22. In scientific applications, the work is rarely repetitive; it is therefore essential to be able to use an electronic language for programming. Moreover, the data and results are usually few in number, and essentially numerical. Finally, the volume of calculations is always considerable.
23. Scientific computers can thus operate with relatively small input and output devices; but they must be equipped with a large-capacity central memory and arithmetic devices comprising numerous operations, preferably builtin, or at least simulated. In addition, they benefit by using the pure binary system for the internal representation of numbers, and words of fixed length.
24. The diversity of electronic equipment is still further increased by differences of "power". We may note in this connexion that while speed, both in access time and in calculation, is costly, it is generally economic, in the sense that a machine which can solve the same problem ten times faster than another machine is not ten times more expensive. That is why we have witnessed the emergence of more and
more powerful computers, which have the additional advantage of being able to solve problems beyond the range of more modest types.
25. However, the use of large scientific computers ceases to be economic as soon as they are left at all idle. Only very large research firms can hope to keep such machines busy; thus, other interested organizations can use them with advantage only on a jobbing basis. Furthermore, each operation is carried out so rapidly that the machine would become uneconomic if the slightest idle time was tolerated between consecutive operations; all operations are therefore inserted into entirely automatic sequences. The user is therefore faced with troublesome delays when the solution of a problem calls for numerous tests.
26. On the other hand, certain types of small scientific computers are very well adapted to work of this type; these are computers with memories large enough for the translator to be retained in storage during the execution of the object programme. The process of calculation can then be modified in the light of the results already obtained, exactly as if the work was being done manually. This facility is obviously highly valued by research workers.
27. The above considerations will enable us to define the contribution which electronic computation is able to make to demography. We shall distinguish three categories of applications:
(a) Survey analysis;
(b) Numerical calculations;
(c) Simulation.
28. Survey analysis is similar in nature to the administrative applications of electronic computation, because it has to deal with a large number of statistical units, calls for classification and enumeration rather than calculation, and produces a fairly large volume of reports. For this type of work, electronic computers have undoubted advantages over punched-card machines, as the experience of statistical departments has shown. The help of a professional programmer is usually necessary, but the definition of the problems gives rise to no difficulty.
29. Numerical calculations naturally form part of the current scientific applications. Thus, each scientific machine has a library of routines which the designer is constantly expanding on the basis of the experience of users. If, however, it should happen that a demographer is faced with an entirely new problem, he will probably be well advised to apply to a specialist in numerical calculation by electronic computer. For this is a special discipline involving fairly
difficult questions, such as the choice of suitable methods in the light of the degree of accuracy required and the internal technology of the machine used.
30. Simulation is probably the field in which electronic computation will be of the greatest service to demography. For demographic projections are a form of simulation, as are models, which are playing an increasing part in research. Any distinction between these two categories of applications may indeed seem somewhat artificial, so closely are they related. From our point of view, however, there are certain differences between what is usually called a projection and what is usually regarded as a model which are worthy of mention. The calculations involved in projections are generally fairly simple and provide fairly voluminous results, whereas models usually call for much more complex calculations to produce results of a high degree of concision. We may thus anticipate that the equipment best suited for the calculation of models will not always be as well adapted to projection calculations.
31. Moreover, needs as varied as those of demography cannot be satisfied without the use of equipment of several different types. This is quite possible by employing computers on a jobbing basis; but it must be stressed that the use of a number of different machines necessitates as many different learning processes, and this is hardly conducive to the perfect mastery of any one machine.
32. To avoid this disadvantage, the use of a dual-purpose computer may be considered; for besides the specialized machines which have been mentioned there exist machines designed to carry out both administrative and scientific programmes. Actually, this solution is not very attractive where jobbing work is concerned, for machines of this type, because of their hybrid character, are always of limited range. Thus the demographer, still assuming that he will be using computers on a jobbing basis, will need to employ at least two machines: an administrative computer of small or medium power for survey analysis and a large scientific computer for other work.
33. Where, on the other hand, a demographic research department is to be equipped with an electronic machine, considerations of cost and load will necessarily restrict the field of choice to low-powered equipment. This cannot be regarded a priori as an obstacle, for no one who is not obsessed with size in computers can fail to agree that small scientific computers equipped with capacious memories
offer a range of calculation facilities which are entirely adequate to satisfy the needs of demographers in this field.
34. The difficulty will be rather to see that these machines are supplied with enough scientific work to avoid their being used for survey analysis, to which they in general are ill-suited. On the other hand, dual-purpose computers may be unable to satisfy fully the scientific needs of research workers. Whatever
the equipment envisaged, therefore, the possibility will have to be left open of supplementing it by the use of computers on a jobbing basis.
35. These conclusions are valid today, but they may no longer hold good tomorrow, so rapid is the pace of computer development. But whatever form this development may take, one point already seems clear: the electronic computer will have an important part to play in demography as in all other spheres of research.

## SUMMARIES OF PAPERS

# The electronic computer as an instrument for demographic analysis 

James W. Brackett

To date most applications of electronic computers to demography have been designed to exploit the computer's ability to perform "rapid arithmetic". The author maintains that his experience with programs for the preparation of population estimates and projections and for the construction of population pyramids for printing on the high speed printer indicates computers can be used to perform demographic analysis. The paper suggests an analytical program might check demographic data for "reasonableness" and internal consistency, and correct or reject faulty segments. The program then would prepare estimates for gaps in the data and finally proceed to the analytical phase where the relevant implications of the data are determined. Output from the program could be tailored to the prospective audience. It might serve as the basis for a written report, or it might be used in lieu of a report.

The paper advances a plan for the development of an analytical program. This plan calls for a series of clearly defined stages, the goals of each stage to be established in accordance with the accomplishments of the previous stage and the needs of the sponsoring organization. This stage-development approach appears to offer adequate opportunity for experimentation, safeguards against the pursuit of uneconomical or ill-conceived schemes, and an expandable framework capable of adapting to almost any new situation.

Computation of growth rate for a stable population from the age pyramid and the survival curve

J. M. Callies

Assuming a stable population with negligible external migration, the equation of the age pyramid (female side, for example) is

$$
y=N s(x) e^{-t x}
$$

where $s(x)$ is the survival function.

This equation involves two parameters:
$N$ : the base of the age pyramid at the time of the census
$t$ : the rate of growth.
The basis of the curve fitting method is to minimize the surface bounded by the observed pyramid and the fitted pyramid.

This implies minimizing the integral

$$
\int\left|y-N s(x) e^{-t x}\right| d x
$$

In practice, since the age pyramid is given in terms of age-groups, it is required to minimize the sum

$$
\underset{i}{S} \mid y_{i}-N s\left(x_{i}\right) e^{-t x_{i} \mid}
$$

Fitting proceeds by successive adjustment of the pyramid for females, based on a growth rate assumed close to the true rate.

This method, when applicable, allows a test of the consistency with other data, namely: survival curve; births in last twelve months; rate of growth. In the case of pyramids distorted by inaccurate age determination, in countries where registration of births is virtually non-existent, the procedure leads to a pyramid of a more natural shape and enables reasonably plausible population projections to be made.

This method has been used in the "Duck's Head" region of North Cameroon and gave good agreement with other sources.

## On the difference between the vital statis. tics and the census survival rate methods of estimating net migration among subclasses of the nation's population

## C. Horace Hamilton

Experience with data for the United States in recent decades indicates that estimates of net migration based on the vital statistics (VS) method tend to be higher than those based on the census survival rate (CSR) method. Investigations of the mathematical relationships between the two methods lead to finding that improvements in census enumeration will result in VS estimates that are higher than CSR estimates. Experimentation with various assumed values for the population, the proportion
enumerated and the "true" survival rate lead to the conclusion that the CSR method is generally superior to the VS method for estimating net migration.

## Example of the application of the analysis of variance in the study of fertility

Sultan S. Hashmr

In this paper an attempt has been made to measure the variability of marital gross reproduction rates (MGRR's) of various sub-groups within Karachi metropolis using applications of analysis of variance. The data used were obtained through a sample of about $33 / 4$ per cent (on the average) of the total population of the metropolis. The variables used in the twovariables classifications for analysis of variances are migrant status, family classification, personal monthly income of husband, and size of place of origin of migrants.

Analysis of the influences of family classification and migrant status has shown that family classification is the major source of variation in MGRR's and the differential effect of classification on MGRR's is significant at 1.5 per cent level. In addition, holding migrant status constant, a pattern of increasing fertility from the traditional joint and extended family settings to the modern nuclear family settings is observed. Migrant status seems to have mild differential effect on MGRR's and is significant at 22 per cent level.

Analysis of the influence of personal monthly income of husband and migrant status on MGRR has shown that both the independent variables have insignificant or mild differential effect on MGRR's. The effect of personal income of husband is not significant even at the 25 per cent level, whereas the effect of migrant status is mildly significant at the level of 25 per cent.

Analysis of the influence of family classification and size of place of origin of migrants on MGRR's has shown a strong differential effect of family classification (significant at 1 per cent level) and a mild effect of size of place of origin (significant at 16 per cent level). Migrants of rural origin do not have highest MGRR's but migrants from cities of 100,000 population or more have lowest MGRR's. On the other hand, nuclear families show a pattern of decreasing MGRR's with increase in the size of place of origin. This analysis leads us to infer the following transitional pattern: when a family system changes from a traditional familistic type to a modern individualistic type,
fertility increases but, as an individualistic family becomes more urbanized, fertility tends to decline.

## A revision of model life tables

## R. S. Kurup

Notestein and others in "The future population of Europe and the Soviet Union" made the first systematic study of mortality data and presented models which would enable the projection of observed regularities. The United Nations demographers later prepared model life tables by considering all the mortality tables available. The reliability of the United Nations model life tables was critically appraised by Gabriel and Ronen. R. S. Kurup in his doctoral dissertation to the University of Chicago presented revised model life tables in 1964.

In the revision of the model life tables, the various countries have been stratified according to socio-economic and health conditions and the mortality trends have been analysed. In the analysis only the recent data have been considered. Model life tables have been constructed from whatever technically correct life tables that are available by linking two consecutive mortality rates with the previous rate and constructing the life table on the basis of the relations obtained. This has been done separately for males and females and for various strata. This revision has been able to eliminate defects of the United Nations system of model life tables.

## Regional computer projection by demographic types of partial populations with incomplete data

## Rainer Mackensen

Recent developments in demographic research suggest improvements in theoretical background and methodology of projections. This paper reports on a series of experiments designed to test some improvements concerning the development of populations, socio-economic structure of partial populations, techniques of regional projections, use of electronic computers, and applications in regional planning.

The development of populations depends on their demographic structure which, in turn, varies with socio-economic characteristics. To find partial populations of typical structural characteristics in a population, both conventional and sophisticated procedures are tried. A larger number of population units are
grouped into partial populations by minimum: variance criteria on single demographic variables and on principal component values from factor analysis. These again are matched with components of socio-economic characteristics to ensure structural homogeneity within partial populations. Both types of partial populations are projected over a period of forty years, and the results compared with a conventional projection of the total (national or regional) population. Deviations in results should show the effect of the more elaborate procedure.

For regional (total and partial) populations statistical sources are less specified than for national populations: therefore, a sequence of estimations and standardizations must be used to meet typical characteristics of partial populations. The techniques applied might be interesting in other situations where data are incomplete.

Preparation of input data, life tables, smoothing and standardization, projections of partial and total populations afford extensive calculations without complicated mathematical techniques. Electronic computers have been used to facilitate analysis and projections. For steps requiring higher mathematical training (such as factor and canonical analysis) standard routine programmes are available. Special programmes and sub-routines developed may be used for further studies. A pool for demographic computer routines should be discussed.

After demographic projections, ecological considerations are necessary regarding regional populations to project in- and out-migrations, and prospective distribution of projected population within the region. Some illustrative examples of results and techniques are explained in the paper.

## A mathematical model relating to the chronological evolution of a human population

## Gif. Minoc and Gh. Theiler

It is impossible to make a study of the chronological evolution of a human population without taking into account the distribution by category of age, determined at the outset, as also other characteristics which enable us to break down the population into sufficiently homogenous categories and to apply the procedure of calculation of probabilities and of mathematical statistics.

The mathematical nodel that the authors envisage presupposes an initial population comprising $w+1$ categories: $C_{0,}, C_{1,}, \ldots C_{y} \ldots$ $C_{w}$; category $C_{\psi}$ numbers $s(y)$ living persons.

It is also presupposed that it is only possible to leave the population by death, that the events corresponding to the different categories are independent one of the other and that $\mu(x, t)$ $\Delta t+0(\Delta t)$ represents the probability that a person aged ten years at moment $t$ will die during the period ( $t, t+\triangle t$ ), whereas the possibility that two or more persons of the same category will die during the same period would be $0(\Delta t)$. The population considered can be increased only by birth; in that respect recourse is had to the function $\Phi(t)$, which for every $t>0$ shows the number-corresponding to moment $t$-of children of an age calculated 0 , in other words an age comprising between 0 and $1 / 2$ time units, exclusively speaking.

On this basis the authors make estimates of the chronological evolution of the human population considered.

They also demonstrate that it would be possible also to consider cases in which certain persons would temporarily leave the population under consideration; that has been done in the case of an observation carried out on the chronological evolution of a population made up of active persons and pensioners. A mathematical model corresponding to this situation is presented.

## Contributions to the preparation of a set of methods for the composite study on population

## St. M. Milco and V. V. Caramelea

The carrying out of "pluridisciplinary" or "interdisciplinary" research for the purpose of a composite study on phenomena is an advanced method of investigation which is being increasingly used by the various sciences and is, moreover, characteristic of certain schools and certain scientific systems.

In Romania this method is of long standing; it has been successfully used in the practical research undertaken on certain human populations, both by sociologists and by anthropologists. At present it is in general use in yet other disciplines, which apply it to the study of the respective phenomena.

Hence those who use it for the study of population have the benefit of the experience gained by both sociologists and anthropologists, which is based in particular on the results achieved by the anthropological school of Bucharest. That school had a number of human, natural and social disciplines, including demography, collaborating in its studies. The experience thus gained shows clearly the
advantage of collaboration between disciplines in the study of certain problems of population, co-ordinated in this case by demography.

The population of a large or small social unit-village, town, country-can be well determined, from the point of view of both its natural movement and its migratory movement, if demography associates certain neighbouring sciences in its studies.

In particular, a whole series of secondary pointers which are used to reflect in detail the normal or exceptional development of the population, the demographic "explosions" or "cataclysms", the high rate of intra-uterine mortality, etc., can be much better understood if recourse is had, for example, to anthropological or biological human sciences-chiefly genetics-and to social, economic, ethnographic sciences, etc.

Demography can also benefit considerably from collaboration in composite anthropological research.

The cognitive value of the results obtained by this composite set of methods is considerably greater than that gained from the use of the methods of one single discipline for the study of a given phenomenon.

## A few properties of the expectation of life $\stackrel{o}{e}_{\boldsymbol{x}}$

## S. Mitra

Life table ordinarily is constructed from $q_{x}$ values. While this is a logical step, it has been found that $q_{x}$ values cannot always be obtained. Model life tables prepared by the United Nations provide normative values of life table functions for a given mortality level which corresponds to a particular life expectancy at birth. This paper has shown that $\dot{e}_{x}$ (and also $q_{x}$ ) can be closely approximated by a mathematical function, the parameters of which can be estimated for given values of $\dot{e}_{0}$.

## Studying determinants of natality. Quantitative estimation through a simulation model

## Mindel C. Sheps and Jeanne Clare Ridley

This paper is a description of work in progress: an attempt to use a simulation model on an electronic computer as an approach to analytic problems of natality studies, particularly for investigating the quantitative effects on
reproductive performance of changes in mortality, in marriage patterns, in use of contraceptives and their effectiveness, in size of family desired, in fecundity or in rates of pregnancy wastage. The report deals with the particular problems to which the model is directed, its purposes, its nature and its expected uses and limitations.

The model described in the paper probabilistically simulates detailed reproductive histories of a hypothetical cohort of women. Each woman is treated individually, and her reproductive history is developed sequentially. The model provides for a woman's dying, becoming sterile, marrying, becoming a family planner, becoming pregnant-with varying outcomes of pregnancy -as well as for the dissolution of marriage due to widowhood or divorce. The probabilities of these events vary with age, status and, in some cases, with parity.

The expected contributions of this model lie in its usefulness as an analytic tool for disentangling the effects on natality of various social demographic, and biological factors; as a vehicle for developing criteria for the choice of appropriate natality indices as well as a method for investigating sampling variability of such indices. Thus, the model will have both substantive and methodological implications. The need for suitable input data creates diffculties. Since the model falls short of realism in many respects, direct application of the results to human population data may be limited. Even unrealistic results, though, should have implications for studies of human populations and may suggest new hypotheses to be tested in future studies.

## The renewable set - A means of population analysis

## Z. T. Sougarey

The replacement of the population is regarded as a system of renewable sets. Each set is made up of a current set (or sub-sets) and of two flows-an inflow and an outflow.

The classification of the sub-sets is based on three categories of characteristics: invariant characteristics (sex), characteristics which vary discontinuously (civil status, profession), and characteristics which vary continuously (age). A portion of the flows of the second and third categories consists of the movement of units from one sub-set to another (marriages, divorces, migrations).

Each renewable set is completely described by the laws governing the densities of its flows
(births, deaths, migrations ...) and the size of the set at an initial point in time. These are the elements of the law of population.

One measure of the renewal rate of the set (the average duration) is represented by a generalized formula; this would be of practical value if one knew the analytical form of the functions expressing the law of population and the law (integral or differential) of the outflow.

From another point of view, the inflow and outflow are regarded as being made up of events-births, marriages, divorces, deathswhich constitute the demographic history of each individual, the unit of the set. A certain probability, which in the general case would be a conditional probability, is assigned to each event. The probability of the final event (e.g.g birth) is expressed in terms of conditional probabilities. Thus, to obtain the probability of a birth at age $X$ of the mother, one must know the whole chain of conditional probabilities: that of the mother's survival to age $X$; of her marrying, in the event that she survives to that age; of her not being divorced, not becoming a widow, not being sterile, conceiving, and giving birth. To estimate these probabilities it would be necessary to calculate the relative frequencies, i.e., to undertake a longitudinal analysis, by cohorts. This is usually replaced by a cross-sectional analysis.

## Biases in the major estimates of net intercensal migration

## Leroy O. Stone

Formula for the total biases in the four principal estimates of net intercensal migration are indicated. The total bias is shown to be the sum of (1) structural bias and (2) the mathematical expectation of measurement error. Elements (1) and (2) previously have been treated separately. Systematic and comprehensive analyses of the relative accuracy of the four estimates under varying conditions may be conducted by evaluating the terms in the formulas.

Tentative conclusions about the relative accuracy of the estimates, as measured by bias, are suggested. The relative accuracy of the vital statistics and the survival ratio estimates depends on the covariance between the measurement errors in the survival ratios and those in the population totals, as well as on the structural bias in the survival ratio estimate. The vital statistics estimate is free of structural bias. When the measurement of net migration is intended to reflect internal migration only, there seems to be little difference between the total bias in the adjusted birth-residence estimate and that in the survival ratio estimate. These two estimates have the same structural bias in this case, subject to the condition that they use the same survival ratios.

# PROMOTION OF DEMOGRAPHIC RESEARCH AND TRAINING IN DEVELOPING COUNTRIES 

## PAPERS

## Demographic training and research in Tropical African universities which employ English as the medium of instruction

J. C. Caldwell

## The region and its problems

1. Slightly over 150 million people live in Tropical Africa. They form almost three fifths of the population of the continent and occupy about the same fraction of its area. It is a region of very considerable ethnic, cultural, historical and even topographical homogeneity. Problems of rapid population growth and of the analysis of that growth are already facing many of the new Governments of the area. Such problems will not be transient. Although precise vital rates are not known, the United Nations Demographic Yearbook gives the general outline of the situation. There, it is suggested that, with a crude birth rate of around forty-seven per thousand, Tropical Africa's potential for population growth is the greatest of the world's major regions. As yet, high mortality has acted as a brake on population increase. Nevertheless, a crude death rate of perhaps twenty-six per thousand has allowed an average annual growth rate of 2.1 per cent since 1950 .
2. In recent years, nearly all the countries of the region have achieved independence and most have plans for further economic and social development. Before the Second World War, the pool of experts available to Tropical African administrations was to be found almost entirely within the colonial administrations themselves. The position has changed quite rapidly. Many of the foreign civil servants have returned home and have not yet been replaced by sufficient numbers of local appointees with the required specialized technical training. At the same time, educational facilities in these countries have increased enormously, and nowhere has this been more markedly so
than at the level of tertiary education. Nearly all the universities of the region have been the product of the last decade. Thus, there has been a very considerable concentration of local specialized talent in the universities. This is not to be deplored. But it does mean that the universities will have to participate in governmental planning and in the research upon which governmental planning should be based to a far greater extent than is necessary in the economically more advanced countries.
3. The organizers of demographic training programmes and research projects, especially those based upon universities, will have to determine the answers to a range of quite difficult questions. These questions concern the balance of research and training, the mode of participation in governmental projects, the type of research undertaken, the training of research workers, the further training of students subsequent to graduation, the position of the discipline within the university and the financing of activities within the field.

## The current position in the region

4. In early 1964, the author made a survey of demographic training and research in those universities of Tropical Africa which employ English as the medium of instruction. There are now fourteen such universities, as well as one research institute, which is similar in nature to a research university. The survey attempted to cover all fifteen institutions and failed to elicit any response from only one of them. All the universities, except one, are in territories which either have been or still are under the administration of the United Kingdom. They cater to territories with a total pop-
ulation of over 90 million, or about three fifths of that of Tropical Africa. As two of the universities had not yet begun teaching at the time of the survey, the findings are limited to twelve institutions.
5. In practically all these universities, views were expressed in favour of a very considerable extension of demographic research and training. Quite frequently, economists, anthropologists, agriculturalists or those engaged in medical research stated that their work really required adequate prior demographic research. This is now more possible than ever before, for within the last few years all these countries have taken censuses, the results of which have begun to appear in considerable volume.
6. However, in only four universities was a full demography course, which formed a unit of the degree of structure, either already in existence or about to begin. In the Universities of Ghana and Khartoum, the course has been in operation for some time, in Fourah Bay College, it began in the 1963-1964 academic year, while in Makere University College, it will commence in the 1964-1965 year. In two universities, the course is being given within sociology departments, in one, in a department of economic and social studies, and in the other, in a department of geography.
7. All universities in the region give some training within the general field of population study. Apart from the specialized demography courses, most work is done in geography departments. In six universities, these departments do a very considerable amount of such work but most of the effort is concentrated on study of the distribution of population and of certain characteristics of population. Five economics departments undertake somewhat shorter periods of training on population problems, especially those connected with economic development. A lesser amount of population study is carried out in five other departments of various universities, namely, those of anthropology, agriculture, medicine, statistics and African studies.
8. More population research of depth and broad scope would appear to have arisen from sociology and anthropology departments than elsewhere. But geography departments follow fairly closely behind, as do economics departments at a greater distance. Some research has also been done in each of the other departments mentioned above. A great deal of this research has centred on population distribution, and to date, very little of it has been analytical. Some studies of fertility, especially in small com-
munities, had been undertaken, but larger-scale inquiries have begun only recently.
9. Of the twenty-three major research projects or programmes investigated, ten had been financed by the universities themselves, five by governmental or municipal funds, four by foundations, two by United Nations agencies and two by the Government of the United Kingdom. The large-scale projects, however, were those financed from outside sources.
10. Thus far, the professional staffing of these projects and the publications which have arisen from them have been undertaken almost entirely by persons of overseas origin.
The Porulation Council demographic training and research programme at the University of Ghana
11. There are some lessons to be learnt from the experience of this pioneering multipurpose project, which commenced at the beginning of 1960 . By that date, preparations for taking the 1960 population census of Ghana were in an advanced stage. It was realized that the results could be analysed adequately only if a core of students and public servants were trained in demographic techniques; and furthermore, that research and other demographic studies, which might throw additional light on the nature of Ghanaian society and provide a firmer basis for economic planning, could be pursued more effectively if foreign demographers spent periods in the country.
12. The Population Council post was attached to the Sociology Department. During the first four and one-half years of its existence, it was held by four demographers from four different continents. Funds were provided by the Council for salaries, ancillary transport costs, equipment and research. As the teaching load grew, the University agreed to make it possible for the holder of the post to continue to enjoy a considerable amount of time for research, by appointing from its own funds a junior lecturer in the subject. This appointee may well be one of the original graduates of the course. Thus, it will begin to become selfsustaining. Funds have now been provided to extend the programme to six years, the cost for the full period averaging about $\$ 20,000$ per annum.
13. By the end of the first four and one-half years, the Population Council demographers had taught a large number of sociology honours students, of whom over forty had taken their final examinations in the subject. A considerable fraction of this number subsequently went overseas to undertake graduate work in de-
mography. Lectures had also been given to public servants, and co-operation for mutual benefit had developed with the Census Office and the Central Bureau of Statistics. At least one holder of the post took part in a United Nations international technical training scheme. By the 1962/63 academic year, graduate work was also being undertaken in Ghana.
14. During the first years of the programme, no results of the 1960 population census were available for analysis. During this period a variety of surveys were undertaken on the social and demographic structure of selected communities, rural-urban migration, international migration, changing family structure and attitudes on the restriction of family size, conjugal histories, the efficacy of birth and death registration, age mis-statement during census enumeration and the testing of various hypotheses arising from demographic transition theory. Henceforth, census analysis will undoubtedly be more important, although some of the findings of the surveys will probably be used to supplement these analyses.

Problems of demographic training and research in Tropical Africa
15. The primary aim in setting up a teaching course in demography is usually to produce a group of specialists who can understand and interpret the new population data becoming available for their country. In practice, it may also become apparent that the demography course is the only course available to many future public servants which provides training in the handling of quantitative social data.
16. The greatest teaching problem is that inevitable defects in the schooling system, together with the non-quantitative nature of the culture, make it necessary to spend a great deal of time on basic mathematics and on the meaning of quantitative data, if the subsequent demographic training is to be meaningful. To this end, laboratory classes dealing with as much local data as can be acquired are very helpful. An attempt must be made to accumulate all types of population records from the country itself and to acquire census, sample survey and registration reports from as many African countries as possible. This can be surprisingly time-consuming and expensive.
17. In view of the small size of some of the new African universities, it is still important that the more capable graduates be sent overseas for graduate work. However, even at this stage, the establishment of local graduate programmes leading to a Master of Arts degree
may well be advisable, both for those students who fail to gain entrance overseas and, occasionally, as a method of consolidating basic training before proceeding to other graduate programmes.
18. The research side of such a programme would necessarily be more important than is often the case in economically more developed countries, because so much must be done quickly and because the university-based unit often is the only organization available to undertake much of the necessary work. The work currently most needed in Africa is of the type which lies at the core of demographic studies, namely, the assessment and correction of population data collected by the Government, the estimation of mortality and fertility levels and their trends, the interrelation between population growth and economic development, and the projection of future population growth.
19. Where this work requires the use of assistants, either for survey work in the field and the subsequent processing of data or for the analysis of official statistics, these assistants must be trained. Thus, to carry out any major demographic research programme, the head of a multipurpose demographic unit would usually find that he must establish a specific training programme for the project, quite distinct from the demographic courses being given. In countries with limited higher education, he would usually be well-advised to recruit university students. Normally, the core of such a group would be formed by the demography students, whose more formal training would benefit greatly from the interrelation of teaching and research. On the other hand, if the survey were to be an extensive one, the linguistic and tribal variations within African countries would usually necessitate the recruitment as well of other university students who could meet specialized requirements in terms of background.
20. Co-operation with Governments can be rewarding and can yield both financial help and official approval for access to records and assistance in the field. Usually, both African interviewers and respondents are ready to cooperate in an effort to establish the facts, to a degree surprising to those from other continents. On the other hand, the respondents often cannot remember that which culturally was not regarded as important, and this is especially true with regard to numerical data.
21. In an area where the assessment of the quality of data is still of more importance than any amount of manipulation of that data and where the assessment must often be based on local experience and knowledge, there is much
to be said for inducing visiting experts to stay for at least two years, unless they have had previous African experience.
22. When processing data, shortages of trained assistants or facilities may arise. Sometimes an arrangement should be sought with an external organization to undertake some of the processing of the material.
23. Finally, teaching materials in demography and population analyses on which to base government planning are currently so meagre in Africa that encouragement should be given both to researchers to write up their material with a minimum of delay and to those who might assist, financially or otherwise, with the publication.

## Conclusions and recommendatrons

24. The following points are listed in an effort to summarize what may make for better demographic research and training in Tropical Africa. They represent a personal viewpoint and are meant neither to be exhaustive nor to define the minimum requirements for the setting up of university-based demographic units:
(a) Although quite a few population studies have been carried out in Tropical Africa, very little of the work has been demographic in the stricter sense. Such work is now urgently needed in the Commonwealth countries, for, in most of them, census findings are becoming available and more accurate developmental planning is dependent on analysis by professional demographers;
(b) Because of inadequate or non-existent registration systems, field surveys will continue to be necessary. Only in this way can measurement be made of levels and trends of mortality, fertility and migration across land borders. This is also true of any attempt to measure the probable reaction to family planning programmes or the effectiveness of any programmes already instituted;
(c) In many Tropical African countries, the university communities will, for some years to come, form a very large proportion of the total pool of highly trained talent within the country. If developmental plans and projects are to be properly formulated and based on an accurate understanding of social and economic conditions, the university staffs must play a more significant national role than is often the case in more developed countries;
(d) In terms of technical aid in the field of demography, multipurpose demographic training and research units attached to universities
have much to recommend them. They can undertake university undergraduate and graduate teaching, public service training, the proffering of technical advice and research, either independently or as part of governmental projects;
(e) There is much to be said for these units being initially set up by specialized overseas bodies having the required experience in the field of demography. In some cases, such bodies might be the population research centres of universities and, in others, non-university organizations. In the formative stage, such bodies could give invaluable help with finance, the finding of staff (for in such a specialized field, African universities do not enjoy the necessary contacts), the provision of books and equipment, and the collection and provision of demographic material for teaching and research from other African countries. Foreign currency exchange control can make such acquisition difficult from some countries within the continent;
(f) The African university should be given some kind of reasonably long-term financial guarantee, such as a definite three-year period extendable to six years if co-operation has been willingly given. In return, it might be expected to take over the unit at the end of the period. In addition, it might support supplementary teaching and clerical staff in the earlier period, as well as providing office space and housing. Perhaps after six years, some of the original trainees of the programme would be able to staff the unit as an integral part of the university;
(g) The provision of reasonably experienced demographers is a major problem. African universities, advertising posts in the usual way without outside assistance, do not seem to be able to attract them. Possibly the single most important function of the external sponsor of a demographic unit is to be able to give the type of assurance about the post which might induce demographers of suitable calibre to apply. Probably, however, the only really satisfactory solution to the staffing problem would arise from the willingness of universities in developed countries to lend staff members for periods of twelve, eighteen or twenty-four months without in any way penalizing them professionally for their periods of absence. This might well be regarded as meeting a certain moral obligation to provide technical aid. A further inducement might be the payment of salaries and superannuation in some convertible currency, with the right to lodge savings and pay insurance in a country of choice;
(h) The exact form of attachment between the university and the demographic unit is important. If it must be an integral part of any particular department, its place is probably with sociology, because of the relation between the social structure of a community and its demographic characteristics. However, this may preclude the giving of adequate instruction within such departments as economics and geography, or full research co-operation with these departments. The best arrangement is probably the creation of a special demographic unit, which could service several departments with lecture courses and co-operate with them in research projects. The unit staff should be members of the university staff or should at least have the same rights and privileges in the sense that a visiting professor would. The status of the head of the unit should be high enough to allow him to participate in university decision making;
(i) The demographic unit, or the demographic unit plus its external consultants, should be autonomous with regard to the planning and financing of the research programmes;
(j) Some kind of liaison should be set up with United Nations regional demographic
centres. Arrangements could possibly be made for the head of the unit to act as an observer at United Nations regional demographic conferences;
(k) The unit should be expressedly regional in concept and should be encouraged to take an interest in demographic phenomena which extend across national boundaries;
(l) Some kind of permanent relation should exist with an external research organization, to allow such processing of research material as cannot be carried out in the country because of insufficiency of research assistants or facilities;
( $m$ ) The cost of such a unit should not be underestimated. It is unlikely to fall far short of $\$ 20,000$ per annum. With two or more members of the staff supplied from outside, it could cost considerably more;
(n) At some stage, it would probably be possible to make a full analysis of the establishment of the Population Council demographic post at the University of Ghana, which has, of necessity, been pioneering and experimental in its nature. Such an analysis might be useful as a guide. The post meets many, but not all of the list of suggested requirements given above.

# Status and problems of demographic research and teaching in Iran 

Jean-Claude Chasteland and A. M. Djamchid Behnam

[Translated from French]

## Introduction

1. Like other countries in the region, Iran began to take an interest in population questions only quite recently. However, demography has perhaps developed even more slowly there than in other neighbouring countries which are urgently confronted with the vital problem of balancing population and means of subsistence. Iran, which has a population of about 22 million spread over a territory three times as large as that of France, with considerable petroleum resources, has so far encountered no insurmountable difficulties in meeting the basic needs of its population. However, since the need for primary schooling and full employment for all is officially recognized, a rate of natural increase of about 3 per cent a year inevitably gives rise to difficult adjustments, so that demography is at last coming into its own.

## I. Origin of demography in modern Iran

2. One of the first manifestations of interest in population questions was of an administrative nature. In 1926, a register of vital statistics was established in order to ascertain the potential number of men of military age. In 1939, 1940 and 1941, censuses were taken in about thirty towns.
3. It was not until 1956 that the first exhaustive population census was taken. Like all first censuses, it has its shortcomings but the experience thus acquired has been extremely valuable.
4. This traditional aspect of governmental interest in demography was gradually modified as the State began to intervene more and more frequently in economic and social matters. The institution of the Planning Organization in 1948 provided the decisive impetus. The need for demographic analysis and statistics created by the preparation of medium-term plans brought increased awareness of the problems of rapid population growth.
5. In addition to the Central Statistical Service, created in 1950, various Ministries
(primarily the Ministries of Health, Education and Labour) have established statistical departments, which have made a notable contribution to the preparation of demographic statistics, both exhaustive and partial.
6. Outside these government bodies, a few demographic surveys were made in the 1950's, on the initiative of individuals and with the help of foreign foundations; among the most important, mention may be made of the survey of certain demographic characteristics in 173 villages in the Teheran region and of the survey in the Demavend district. Despite their merits, these surveys had the initial disadvantage of providing limited coverage and being made in villages very near Teheran.
7. In 1958, the University of Teheran came into the picture when it established first a chair of demography in the Faculty of Literature and then a Social Studies and Research Institute which, from the beginning, had a section for the study of demographic and economic problems.
8. The support given by the United Nations in the form of fellowships for study abroad and by the establishment of the Chembur Centre in India, where each year Iranians go to obtain demographic training, has helped to create a nucleus of technicians working on population problems at the university or in the various Ministries concerned.

## II. Existing organization of instruction

9. At the University of Teheran, instruction is given both at the Faculty of Literature, as part of the course for a degree in social sciences, and at the Social Studies and Research Institute. The degree course, lasting four years, includes four hours of theoretical demography and two hours of applied demography each week. The universities elsewhere in the country do not yet provide instruction in demography.
10. The Social Studies and Research Institute, which is responsible to the Faculty of

Literature, is open to graduate students of all disciplines wishing to specialize in the social sciences. From the outset, both theoretical and practical training have been stressed. This is particularly striking since the Institute is a research body and most of the teachers direct research work there, assisted by the students. The course of studies lasts two years. A oneyear course in demography is given during the second year, with one and a half hours of instruction a week.
11. Outside the university, various departments or Ministries have started interval training courses which may include demography. This has been done, for example, by the Ministry of Health and the Department of Vital Statistics.

## III. Status of demographic research

12. Outside the university, a good deal of work has been done in fields related to demography. The statistical departments in the Ministries of Labour, Health and Education, the Planning Organization and the Central Statistical Service collect statistics, usually by means of sample surveys, and from time to time analyse the data thus collected.
13. In the field of demography proper, it is the Central Statistical Service which has made the largest contribution. In addition to the 1956 population census, it also carried out sample surveys (each covering about 70,000 households) in 1959 and 1963, not to speak of the agricultural census of 1960 , of which the part concerning the agricultural population is also of interest to demographers.
14. It is at the university, however, that demographic research is being done systematically and in conjunction with other work. General supervision is exercised by the demo-graphic-economic surveys section of the Social Studies and Research Institute. Let us examine in turn the direction of the work, the initiating authorities and the means of execution.
15. The work actually has four main directions:
16. The analysis of existing documents should be by far the section's most important activity but it will be seen below why this is not possible. The starting-point of the work was the analysis of the 1956 population census.
17. Conventional studies on the validity of the data were made first: structure by age and by sex. Then came more elaborate interpretation work on fertility, nuptiality, mortality and migration. Studies were also made of the structure of the urban population, the working pop-
ulation, the school-age population and the population of Teheran. Lastly, a series of projections of the Iranian poptlation is being prepared.
18. Subsequently, research was undertaken on the sample surveys made by the Central Statistical Service, including the 1963 demographic survey and the 1960 sample census of agriculture. These studies revealed the main shortcomings of the surveys and they will help to improve the work of this kind to be undertaken shortly. So far such work has been done at the Social Studies and Research Institute, either because of the professional competence of the research workers or because they have freedom in the choice of work.
19. Sample surveys have a threefold purpose: to fill the gaps existing in the most important statistical fields, to test new survey techniques in Iran and, lastly, to train personnel for this type of work. Because of the importance of these three aims, the section has to do more than merely perform its traditional function of analysing data already collected. For example, last year the Social Studies and Research Institute made a sample survey of fertility in six rural districts, interviewing a total of some 7,000 households. This survey actually is in two parts: a conventional demographic survey using a pre-coded questionnaire and a more limited psychological survey based on a subsample, to allow the attitudes and behaviour connected with fertility to be analysed in depth. A tape recording has been made of all the interviews conducted for this survey.
20. A similar survey ( 3,000 households) is being prepared for Teheran. It is to be carried out in May-June 1965.
21. The demographic section is often required to give technical advice to the various departments concerned with population problems. This role, though more unobtrusive, is important and takes up much of the research workers' time.
22. Lastly, the section is trying to collect the demographic documents which were previously scattered or were impossible to find. Translations have been made of foreign works. In this connexion, one of the most important projects, going beyond mere translation, is the preparation of a demographic dictionary in Persian, based on the French and English dictionaries of the United Nations. The first version of this work is to appear in autumn 1965. In addition, several research workers in the section have written demographic works directly in Persian. The four works already
published include a textbook of demographic analysis and a treatise on demography.
23. The initiating authority for the work varies; in some cases it is the Institute which takes the initiative, in others the work is done at the request of a state body, such as the Planning Organization, the National Insurance Corporation, etc.
24. The financial resources are extremely small. The Institute's regular budget provides only very limited funds for the demography and economic section. It has therefore been necessary to obtain outside assistance, which now far exceeds the assistance provided by the Institute. As in other fields in Iran, it is the Planning Organization which is the principai source of funds.
25. The demography and economics section, with a limited regular budget, has an even more limited staff. The limitations are twofold: the section has only one full-time research worker and the other sections of the Institute are in a similar position. The other staff members are all employed part time: at present they number about twelve, including research workers and technicians. The enumerators are all recruited for specific assignments, depending upon the availability of funds.

## IV. SOME problems of demographic reSEARCH

26. The pattern of demographic research is determined by actual performance possibilities and by the needs of the bodies which provide the funds. In the scale of priorities the place of pure demography is a modest one. The main trend is towards demography applied more or less closely to the solution of specific problems. This may have unfortunate consequences for freedom of work in the future; in the long run, the price of short-term effectiveness is the subordination of research.
27. It is difficult to combat this trend when the bulk of the funds come from outside and when badly paid research workers are obliged to hold two jobs. In Iran, research workersand this is true of other disciplines besides demography-do not have established positions. Only those who have a particularly strong vocation can agree to work in conditions of permanent instability.
28. The human problems of research are not limited to career or salary problems; they
also relate to training. Most research workers are trained outside Iran. When they return home, the conditions in which they are called upon to work and the outlook are quite different from those to which they were accustomed abroad. Whereas in Europe, the United States or elsewhere they were highly specialized, they find that in Iran they must be highly flexible; while fitting into a rigid administrative structure, they have to solve the most varied problems on their own and it is difficult and sometimes impossible for them to adapt to these conditions.
29. While abroad, Iranian research workers were accustomed to frequent and fruitful exchanges of views with colleagues in the same discipline or other disciplines; in Iran, such contacts are more infrequent. The situation is aggravated by the fact that there is no homogeneous body of research workers and no research tradition and that the workers have to divide their time between different departments because they do two jobs.
30. Lastly, the actual development of research and the organization of important surveys pose administrative problems hitherto unknown. As is often the case in developing countries, there is a transition from a complete lack of administrative structures to a plethora of structures ill-suited to the problems of research work.

## Conclusrons

31. The principal difficulties involved in expanding demographic research and instruction in a developing country such as Iran seem to be:
(a) The fact that the relationship between the university and the Administration is not defined;
(b) The lack of independent financing for research, which is thus dependent on the organs responsible for national development. However, is such subordination not inevitable in a country which must devote all its efforts to the execution of its plans?;
(c) The fact that research workers have no permanent tenure;
(d) The lack of a coherent policy of scientific exchanges between universities in the developed countries and those in the developing countries.

# United Nations programmes for promotion of demographic research and training 

## Charat Kumar Dilwaly and Joyce Hines

## Introduction

1. One of the major goals of the United Nations is to aid the nations of the world, especially those of the developing areas, to achieve a better future through the application of balanced economic and social development policies aimed at improving standards of living. Wider recognition is being given to the fact that research on demographic, social and economic interrelationships is a part of the basis for policy formulation, planning and action in many economic and social fields, including population policy, and is particularly important for efforts to promote the development of the developing countries.
2. United Nations work in the field of demography has been concentrated on research on population numbers, characteristics and trends, and their interrelationships with economic and social factors; and the conduct of demographic training programmes. By building up technical and analytical demographic information on both the international and the national levels, the United Nations is helping to develop the tools and materials necessary for the formulation of practical balanced economic and social policy. By means of training courses, experts' advisory services and conferences, the United Nations is helping to create a nucleus of personnel capable of carrying out research work that may be of assistance to policy-makers in their own countries. The research programme is carried forward on both the international level (mainly in the Population Branch of the United Nations, the counterpart of the Population Commission in the United Nations Secretariat; and in the United Nations regional economic commissions) and the national level. The training programmes are carried on chiefly at regional training centres and seminars.
I. United Nations demographic programmes on the intrernational level

## A. Research and publications ${ }^{1}$

3. The United Nations Secretariat has a number of special advantages for undertaking

[^175]certain kinds of demographic research and methodological studies of international scope:
(a) The international composition of its staff, with their knowledge of conditions in different parts of the world, their familiarity with demographic literature and their command of many languages. These assets make it possible to draw from and utilize research material from world-wide sources;
(b) The consultative machinery available for United Nations work, which is not limited to contacts with Governments, but also includes contacts with universities and research institutions;
(c) A free two-way flow of consultation, demographic data and published materials between Member States and the United Nations.
4. An important area of United Nations demographic research is in world-wide studies of population trends and prospects, and their interrelation with economic and social development, with special attention to developing countries. These studies provide a framework for the interpretation of findings of national studies and further serve as a primary material for future research. They also help to disseminate knowledge and to heighten awareness of the nature and magnitude of population problems on both the national and the international levels. Current work includes surveys of world-wide conditions of fertility, mortality, and rural and urban population trends. The United Nations Secretariat is also revising, with the co-operation of experts and United Nations specialized agencies, its study, The Determinants and Consequences of Population Trends, which deals with the relation of population questions to economic and social matters. This publication has been widely used as a textbook for university teaching, a bibliographical reference work and a guide for research.
5. The United Nations Secretariat also prepares methodological manuals as aids to research workers in interpreting and analysing demographic data; these manuals also serve as training materials. Another continuing activity is making population projections on an interna-
tionally comparable basis for countries, regions and the world as a whole. The Secretariat has also undertaken intensive analyses of demographic data on an international scale and has published a number of monographs on such special subjects as foetal, infant and early childhood mortality, the causes and socioeconomic consequences of the aging of population, and factors in the post-war upsurge of fertility in many industrialized countries. The geographical scope of these studies sometimes brings to light relationships not immediately apparent when data of a more restricted group of countries are considered. Parallel studies are carried out by the United Nations regional economic commissions and the regional demographic research and training centres.
6. The improvement of techniques of census taking and the improvement, extension and international compilation of demographic statistics are important adjuncts of the programme in the field of population. These subjects lie within the competence of the United Nations Statistical Office. Among the publications issued by this office is the Demographic Yearbook, a world-wide source book of statistics of area and population, vital statistics and international migration statistics, which is indispensable to the United Nations demographic research programme.

## B. Conferences and seminars

7. Another way in which the United Nations promotes research and training in demography on the international level is through a programme of conferences, seminars and working groups. These meetings focus attention on the importance of population problems, besides providing a medium for the exchange of ideas and experience among demographers engaged in teaching and research activities throughout the world.
8. Among the principal international conferences on population questions organized under United Nations auspices are: (a) the First World Population Conference (Rome, 1954), attended by 450 participants and to which more than 400 papers were presented; (b) the Asian Population Conference (New Delhi, 1963), attended by more than 200 persons from countries of Asia and the Far East; and (c) the Second World Population Conference, held in Belgrade from 30 August to 10 September 1965.
9. Between 1953 and 1963, the United Nations also organized six regional seminars in different regions of the world for the exchange
of views among experts and officials on population questions.

## II. United Natrons demographic programmes on the national level

10. Demographic research and training are of fundamental importance at the national level also for the planning and formulation of realistic economic and social development programmes. The United Nations has promoted work in this respect in the following ways.

## A. Demographic research and training centres

11. The United Nations co-sponsors, with the respective host Governments, three regional demographic centres, in Chile, India and the United Arab Republic, which serve the countries of the respective regions, i.e., Latin America, Asia and the Far East, and North Africa and the Middle East. The two former centres were established in 1957 and the third in 1963. Plans are in progress to establish more centres. The centres provide training courses and opportunities for research in demography for students from countries within the respective regions. Through fellowships financed by the United Nations, more than 200 students have received training at the three centres. Each centre has, in addition to its training programme, a programme of research on demographic questions of special relevance to the countries of the region concerned. The technical training of research workers is thereby linked with the programmes of research on countries of the region and provides a laboratory for trainees. Each of the two older centres has carried out and published a number of important studies on the demographic profile of the region it serves.

## B. Advisory services

12. The United Nations provides experts on a short-term basis to give advisory services to Governments on request. The types of services include assistance in analysing demographic data, evaluation of the quality of demographic data, preparation of population projections and life tables, etc. Other duties may include assisting Governments in setting up demographic research units, and training counterpart personnel in demographic techniques and methodology. About twenty countries have thus far requested and received such short-term assistance. Advisory services are also rendered at the national level by United Nations experts appointed on a longer-term basis to serve the countries of a particular region as the occasion
demands. This type of service has thus far been established for Asia and the Far East and for the Middle East.

## C. Fellowships for study tours and training in advanced countries

13. A limited number of fellowships has been awarded to applicants from developing countries to study demography at institutes and government offices in more developed countries.

## D. Special pilot projects

14. The United Nations has collaborated with a few Governments in carrying out special national pilot studies on various aspects of demography. The applicability and usefulness of the results of these studies extend to other countries in similar situations. Such pilot projects have been carried out in: Mysore State, India, on household sample survey methods to obtain estimates of birth and death rates and other data for analysis of interrelations of fertility, mortality and factors of economic and social changes; the Philippines, on demographic questions pertinent to the national development plan; the Sudan, on population growth and manpower ; and the State of Guanabara, Brazil, for estimating various demographic rates and measures for a specific population.

## E. Concluding remarks

15. It should be emphasized that the contribution of United Nations demographic activities is to be evaluated not only by the number of experts sent on advisory missions, fellowships awarded, national personnel trained, field studies organized and completed, studies published, conferences held, etc., but also by the extent to which these activities serve to stimulate the interest and participation of Governments, research institutes and universities, and individuals in demographic studies, research and training.

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# The teaching of demography in Indian universities 

A. George

## Introduction

1. The teaching of demography in Indian universities originated in the form of courses on population problems or on vital statistics offered to students in economics, sociology, mathematics or statistics. Perhaps the slow development of demography as a discipline in the curriculum of the Indian universities could be traced to the lack of clarity of the exact relation between demography and the above-mentioned branches of knowledge. Of course, there is nothing surprising in this; even in developed countries, it is only recently that universities were able to fix the proper place in the curriculum for demography.
2. The dearth of qualified and well-trained persons to teach and direct programmes in demography and the lack of incentives in the form of scholarships and other financial aids might be considered two other important factors in the slow progress of this branch in universities. The best men are naturally not attracted to the field. A student of good calibre cannot be attracted without proper financial assistance. Such incentives have become essential, as serious demographic studies can be undertaken only at the post-graduate level and, even there, preferably by those who already have a master's degree in some related discipline, when the student has attained maturity in outlook and background. Only then can the student appreciate and pursue research activities. This is a matter which calls for the immediate attention of the authorities concerned; otherwise, the teaching of demography in this country will suffer. Another reason for the small number of students electing to study demography may be the relatively few employment opportunities for trainees in this field.

## The development of university education IN DEMOGRAPHY IN INDIA

3. The need for properly trained personnel who could study scientifically the problems caused by the accelerated growth of population has been seen, by planners and administrators alike, as an urgent problem requiring top priority. In view of the increasing fields of
application and the great demand for demographic studies in a planned economy, it is only fit and proper that demography should be given due recognition and proper encouragement and facilities among courses of studies. Therefore, it is definitely time for the universities of India, as seats of learning and centres for disseminating knowledge, to bestow more attention on the discipline of demography by giving the subject its rightful place, both in teaching and in research.
4. At the undergraduate level, only basic ideas regarding vital statistics and elementary notions of population theories are taught as population problems. But the same type of course for students in statistics usually includes, in addition, statistical measures of fertility and mortality, together with elementary concepts of life tables. Medical and public health undergraduates also have to undergo some similar elementary courses in vital statistics.
5. At the post-graduate level, demography has been receiving slightly more attention, though no university in India has recognized its proper place in the scheme of academic studies. It has been included as a paper or as part of a paper for the post-graduate degree examinations in statistics, sociology and economics of most of the Indian universities for more than a decade. Details are given in annex II. Among Indian universities, Kerala has been a pioneer in its efforts to give due recognition to demography. The Kerala University has begun, in the Department of Statistics, a demographic research and training programme leading to the degree of Master of Arts and to that of Doctor of Philosophy. Details of these courses are given in annex I.

## Demographic studies in the University of Kerala

6. The interest shown by Professor U. S. Nair in demographic studies since the inception of the Department of Statistics in the University has aroused interest in many others, and under his guidance, research workers in the department have taken up a number of studies in the subject. This has led to the sanction by
the University Grants Commission of a demographic section as a development scheme of the University's Department of Statistics during the Second Five-Year Plan (1956-1961). A demographic section concerned with research and training in demography was initiated in 1961; the unit immediately undertook a tribal survey connected with the 1961 census.
7. Regular courses in demography, leading to a Master's degree, were begun in 1963 for the first time in an Indian university, when the Department of Statistics established a unit for the imparting of instruction and the carrying out of research programmes in demography. A field-survey research unit also forms part of this establishment. The staff of the unit consists of a reader, a lecturer, two research assistants, four technical assistants and six field investigators.
8. Considering the advanced level of the courses offered in this programme, only those holding a Master of Arts or Master of Science degree in mathematics, statistics, economics, sociology, psychology or related fields are considered eligible for admission to the courses. Students who have not had mathematics at the Bachelor of Arts or Bachelor of Science level are required to take a special course in mathematics and to pass a test conducted by the Department of Statistics before they can be admitted to the Master of Science (Previous) Examination. Active participation by the students in an ongoing research project is an integral part of the training.
9. During the first year, the students are given intensive training in the substantive field of demography, as well as in research methods, including statistical techniques (with special reference to population studies), so that they may acquire the necessary technical competence. They also get thorough training in field research methods through active participation in the design and analysis of a major project undertaken by the department. Courses in other disciplines, such as sociology, economics, human genetics, physiology and social psychology, are also offered so as to provide a broad background for the study. The major part of the student's time during the second year is devoted to the preparation of his thesis.
10. The Population Studies Center, University of Michigan, Ann Arbor, Michigan (United States of America), the Population Council (United States of America), and the United States Bureau of the Census, have helped in obtaining the books required for the research and training programme in demography, free of cost. During July-August 1964,
the department had a visiting professor of demography from the United States.

## Research activities

11. An important feature of the demographic research and training scheme of the university is its close association with a family planning communication research programme functioning within the Department of Statistics since its inception in 1962. But for the zest and untiring efforts of the late Dr. K. C. K. E. Raja, then Vice-Chancellor of the University of Kerala, the project, with the objective of popularizing family planning among selected segments of the population, would not have materialized. He was also very insistent that the project should function as a part of the Department of Statistics. The intensive educational phase of the project was over by the end of 1964, and a well-planned evaluation study of the project is in progress. It is intended and hoped that the research studies pertaining to the target population of the family planning project will be timely and useful for those concerned with the family planning action programme.
12. A vital statistics and house-listing survey in the action areas of the family planning communication research project was completed during September-October 1964. One of the major objectives of the survey was to have a fresh and complete listing of the area so as to furnish a minimum amount of required information on household composition. A second purpose was the collection of birth and death statistics occurring in the area during the twelve-month period prior to September 1964. The analysis of this data is nearing completion and it is expected that the results can be compared with the figures filed by the field assistants of the family planning communication research project. It should be mentioned that these field assistants are aided by local informants in the collection of data on vital events, more or less on a current basis, which certainly is a new experimental method of collecting current vital statistics. The matching study is expected to throw considerable light on the relative effectiveness of the new procedure for collection of vital statistics.
13. To facilitate future sampling work, to provide for effective organization of field surveys and to assist in locating sample households, the enumerators prepared maps of the areas showing sufficient details, along with their complete listing of households.
14. A major survey on family building patterns was completed during 1963-1964, and
the report of the study will be published shortly. The students working for their Master's degree actively participate in laying out the objectives, framing the questionnaire, conducting the pretests and carrying out other tasks connected with the surveys.

## Conclusion

15. An attempt has been made in this paper to trace the developments in demography as a course of study and research in Indian universities. In spite of the efforts of experts and authorities, progress has been disappointingly slow. Among the universities in India, Kerala University has taken a leading role, not only in establishing a course of studies leading to the degree of Master of Science, but also in initiating a number of research programmes in demography.
16. In view of the extensive facilities, such as properly trained personnel, well-equipped laboratories with desk calculators and advanced books and journals covering related areas, the Department of Statistics in the University would be the proper place to establish such a demographic unit, even though demography
must maintain its contacts with such related disciplines as economics and sociology.

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## ANNEX I

## Description of course in demography leading to

 degree of Master of Science, University of KeralaOnly candidates possessing a Master's degree in mathematics, statistics, sociology, economics, anthrom pology, psychology or social psychology are eligible for admission to the two-year programme in demography leading to the degree of Master of Science. Those who did not study mathematics at the level of Bachelor of Arts or Bachelor of Science will have to take a special course in mathematics and pass a test conducted by the department during the first year. Promotion to the second year will be made on the basis of an assessment of the performance during the first year, according to the following schedule:

Table 1
Schedule of first-year courses


During the second year, the candidate will devote most of his time to the preparation of his thesis. The assessment during the second year will be made according to the following scheme:
(a) Thesis, 300 ;
(b) Seminar, 100;
(c) Participation in field research, 100 ;
(d) Viva woce, 100.

The final placement of the student will be on the basis of his over-all performance during the two years.

Table 2
Demography courses given in Indian universtites


| Universtiy | Undergraduate level |  | Postagraduate level |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Degree | Syllabus | Degree | Syllabus |  |
| Mysore |  |  | M.Sc.(Stat.) | Elementary ${ }^{\text {b }}$ |  |
| Punjab |  |  | M.A.(Soc.) | Optional - social demography ${ }^{\text {a }}$ |  |
| Patna | B.A.(Econ.) | Elementary b | $\begin{aligned} & \text { M.A.(Econ.) } \\ & \text { M.Sc.(Stat.) } \end{aligned}$ | Elementary b <br> Actuarial and vital statistics $b$ |  |
| Poona | B.A./B.Sc. | Elementary ${ }^{\text {b }}$ | M.Sc.(Stat.) | Optional (not teaching) ${ }^{\text {a }}$ |  |
| Rajasthan |  |  | M.Sc.(Stat.) <br> M.A.(Econ.) <br> M.A.(Soc.) | Compulsory - elementary b <br> Optional (not teaching) <br> Optional - elementary ${ }^{\text {b }}$ | - |
| Ranchi |  |  | M.A.(Econ.) | Optional (not teaching) ${ }^{\text {b }}$ |  |
| S. V. Vidyapeeth. |  |  | M.A.(Econ.) | Optional - advanced ${ }^{\text {a }}$ |  |
| Saugar |  |  | M.A.(Econ.) | Optional - elementary |  |
| S. N. D. T. women. |  |  | M.A.(Econ.) <br> M.A.(Soc.) | Optional - elementary ${ }^{2}$ <br> Compulsory - elementary ${ }^{\text {b }}$ |  |
| Vikram .......... | B.Sc.(Stat.) | Elementary |  |  |  |

a Full paper for post-graduate degree examination.
b Part of a paper for post-graduate degree examination.
Note. Elementary courses cover the study of birth rates, death rates, life-tables, measurements of fertility, gross and net reproduction rates, population growth, population projection, etc.

# Problems of recruitment and training of personnel for demographic training and research in Pakistan 

Muhammad Khalid Hayat Khan

1. Demography has not yet been given recognition as a separate discipline in the social sciences. In most countries of the world, persons trained as economists, sociologists and statisticians have taken up research in this field because the problem in which they were interested had some direct bearing on the growth, decay, or other characteristics of the population. In this respect, Pakistan presents no exception to the general world picture. Almost all the demographers in Pakistan are drawn from the fields of economics, sociology, or statistics. With the positive attitude of the Government towards population welfare programmes, popularly known as social welfare programmes, the biologists, particularly those in the medical profession, have also been attracted to the field of demography.
2. It is pertinent to discuss briefly the history of growth of demographic training and research in Pakistan. When Pakistan came into existence in 1947, economics and geography were the only disciplines among the social sciences which touched upon certain aspects of the study of population. Students of economics studied the growth of the labour force, the problems encountered in industrialization and the growth of population and its repercussion on the development programmes of the country, while students of geography studied the spatial distribution of population and, to some extent, the problem of urbanization. The next subject that introduced the training in certain demographic techniques was statistics. The methods of calculating a few vital rates formed a part of the general course offered, while an advanced course in certain techniques, sometimes known as "vital statistics" and at other times as "demographic statistics" or "demographics", also was available. With the introduction of the subject of sociology at the post-graduate level, the field of population study was touched upon under the topic of social problems. Although the university curricula offered the option of population study, many students preferred to select other fields which promised jobs after they obtained their Master's degrees.
3. The need for trained demographers was emphasized for the first time by the National Planning Board of Pakistan. The following section appeared in the First Five-Year Plan:
"There is need for scholarly research in at least two universities, one in each Wing, into questions of growth and change in the population and labour force. This is a difficult field, requiring the services of skilled mathematicians, statisticians and social scientists, and it may be desirable to obtain in the beginning the advisory services of specialists from abroad. We commend this problem to the attention of the universities and urge early action as a part of the process of developing their research programmes". ${ }^{1}$
4. In spite of this recommendation of the Planning Board, it was not feasible for different universities in Pakistan to implement such a programme. The field of population studies cuts across a number of well-recognized disciplines and it is not possible for any one discipline to introduce courses covering various aspects of demography. The universities have felt all along that the more acute need was to remove deficiencies in the fields already existing and to strengthen the teaching programmes by suitably augmenting the staff, both quantitatively and qualitatively. This has left little leeway for the introduction of new disciplines, owing primarily to the limited resources, but owing also to inertia.
5. In 1959, the Social Sciences Research Centre was established by the University of the Punjab with the financial assistance of the Asia Foundation for the purpose of carrying on research in the demographic, economic and sociological fields. Another purpose in setting up such a centre in the university was to train suitable persons in research methodology. Incidentally, the first research project undertaken by the Centre fell into the field of demography; the third and the fourth projects also belonged to this field. This made the
[^176]Advisory Committee of the Centre realize that research in demography could be carried out more effectively only if an adequate number of persons trained in certain aspects of the subject were available. Moreover, Field-Marshal Mohammad Ayub Khan, the President of Pakistan, laid a great deal of stress in his speeches on the population problem facing the country. An extract from one of his speeches is reproduced below:
"Scientific research in hygiene and health has resulted in a much higher expectancy of life and given relief to physical misery, but this has brought in its wake a host of pressing problems we have to contend with and find an answer for. And these problems are particularly acute for the under-developed countries of the East like ours.
"I am referring to the enormous increase in their population and the ever-increasing food shortage, poverty and sociological stresses associated with it. All these have got to receive the attention they deserve from the various sectors of study in the natural and social sciences. I earnestly hope that we will be doing all this and doing this with the requisite sense of urgency". ${ }^{2}$
The Planning Commission of Pakistan laid great stress not only on the population problem and population policy, but also on population statistics and demographic analysis:
"Since population growth can threaten to wipe out the gains of development, the Plan clearly recognized the paramount need for a conscious population policy and its implementation. A population policy must take into account many implications of population growth for other aspects of planning....
"It will be necessary, during the Plan period, to take effective steps to overcome the present limitations of population data, vital statistics, and demographic analysis...."s
As the Social Sciences Research Centre had been established for an interdisciplinary approach to the study of social problems, it was considered a suitable department of the Punjab University for the initiation of a training programme in demography. Consequently, a training programme was begun in 1961 with a grant from the Population Council, New York City, United States of America. For the first two years, the Population Council also provided

[^177]a professor to assist in various aspects of the training programme.
6. The training course conducted at the Social Sciences Research Centre is an evening course extending over eleven months, and its successful completion entitles the candidate to receive the Post-graduate Diploma in Demography. Primarily, persons possessing a Master's degree in one of the social science subjects, or in statistics or mathematics, are given admission to this course, but other suitable graduates who are interested in population studies are also admitted. One quarter of the course consists of basic demographic techniques; another quarter constitutes substantive demography; elementary principles of economics, rudiments of sociology, and basic statistical techniques each form one twelfth of the course; social research methods constitute one sixteenth; and the remaining credit of three sixteenths of the course is covered by the research report.
7. During the first eight months of the course, the students attend twelve hours of lectures during each week, besides the reading assignments and practical work. Excluding the vacations, there are thirty-two weeks available for this period of training. The students then take their final examinations in technical demography, substantive demography, economics, sociology, statistics and research methods. The remaining period of about two and one-half months is spent on research, at the end of which the student submits a research report on an approved topic in the field of demography and then takes the oral examination in which he is expected to defend his report.
8. As the Social Sciences Research Centre of the University of the Punjab is the only institute in Pakistan which provides a wellrounded training programme in demography, although it has had only limited experience of training in this field extending over the last three academic years, the remainder of this paper is based on the Centre's experience.
9. The first year this course was offered, eleven persons were admitted to the programme. Of these, nine had a Master of Arts degree (seven in statistics and two in sociology); one held a Bachelor of Arts degree in mathematics with a post-graduate diploma in statistics; one was a graduate in economics. Of those with a Master's degree, two (one each in sociology and statistics) left for higher studies abroad before completing the course; another (in statistics) left the course after the first quarter because he found it difficult to devote enough time to study. The graduate in mathematics
fell ill and could not take the examination. Of the seven who completed the course, five were declared successful. Four of these had a Master's degree in statistics and the other had a Master's degree in sociology.
10. During the second year, eight students -all of whom had a Master's degree-were admitted to the programme. Of these, three were in statistics, two in sociology, one in social work, one in geography, and one in mathematics. After the first quarter, four students (two in sociology, one in social work and one in geography) left the course because they found it difficult to allocate enough time for the work involved. Of the four who completed the course and took the examination, three were successful. Two of these had a degree in statistics and one had a degree in mathematics.
11. During the third year, eight students with a Master's degree (three in statistics, three in sociology, one in economics and one in geography) were admitted. Three students (one each in economics, geography and sociology) left after the first quarter as they could not find enough time for study. Another student with a degree in statistics left after the second quarter because he obtained a position outside Lahore. Thus, four students completed the course. However, only three of them took the examination; all three were successful. Two of these had a degree in statistics and one had a degree in sociology.
12. To summarize, over the three-year period only eleven students-all of whom had a Master's degree-qualified for the Diploma in Demography. Eight of these had their degree in statistics, two in sociology and one in mathematics. Nine of them were men and two were women. Both women had a degree in sociology.
13. Generally, persons who register for training in demography have had their previous training in different fields of social science, e.g., economics, geography, social work, sociology, or statistics. More often than not, such persons have not studied mathematics beyond secondary school level and, in some cases, not even up to that level. In taking up the study of these disciplines at college and university levels, they usually selected areas of these disciplines for which the quantitative approach was not considered essential; they were satisfied with a descriptive or qualitative approach to the areas they had chosen for study. Although they come to study demography because their interest in population problems has been aroused by their previous
studies in economics, geography, social work or sociology, they suddenly find themselves confronted with a quantitative approach to the subject of study and this seems very difficult for them.
14. Another genuine complaint of the student is the scarcity of suitably graded books and research papers in the field of demography and allied fields.
15. As stated above, academic training in demography has not yet received so much attention as training in other fields of social science. In fact, professors in the social sciences would not like to recognize demography as a separate discipline. Moreover, a one-year course for this diploma is generally considered to be a fairly difficult evening course. As these diplomas are not considered as important as degrees by all the government departments, the students do not feel that their efforts for qualifying for such a diploma will be adequately rewarded. They would prefer to undertake a longer period of training to obtain a Master of Arts degree, rather than to receive a diploma after a shorter period. Even those who have qualified for the Diploma would like to take a course leading to a Master's degree, if one were offered.
16. As is apparent from the foregoing paragraphs, most of the students who took this course already possessed a Master's degree. In two cases, the students possessed two Master's degrees. As good job opportunities are rather scarce, many of them leave the course when the demands of a good job conflict with giving their whole-hearted attention to such a course. Continuing to work for the diploma and giving up the opportunity of a suitable job would be a very great sacrifice for them to make, particularly when the need for trained demographers is not being given due recognition. Therefore, it becomes imperative that incentive should be given in the form of grants of fellowships/scholarships, covering the cost of tuition, boarding, lodging and the other expenses involved in the training. In the developing countries, this may amount to the equivalent of \$US 80 per month. Moreover, unless more research jobs in the field of population become available, the persons who receive this training may not necessarily be absorbed into suitable jobs. It may be desirable for the Planning Commission, the Central Statistical Office, the Census Office and the offices of health departments to utilize the services of trained demographers in different fields.
17. Although nuclei for demographic research exist in the country, namely, at the

Institute of Development Economics, Karachi, and at the Social Sciences Research Centre, University of the Punjab, Lahore, the number of trained personnel that can be absorbed is extremely meagre. As due importance is not being given to training in demography, pseudodemographers who know little about population problems thrive and do more harm than good to the cause of demography. In a recent survey conducted by the Social Sciences Research Centre, it was brought out that social research is the most poorly paid profession among the various types of research carried out in the country. Unless attractive job opportunities for qualified demographers are made available, it may be difficult for them to adopt demographic research as a profession and the research done by pseudo-demographers is apt to continue to be of low quality.
18. Social research is a costly business in the developing countries. Demographic research is still more costly if good results are to be achieved. For interviewing women, the cultural pattern necessitates the employment of mature
women as interviewers. Trained female interviewers available for carrying out survey work are scarce. Very often women cannot stay in rural areas and transportation becomes a costly problem. After the persons trained in field work are discharged, they are not again available for such work. In this manner, a programme of research becomes still more costly, as on each occasion fresh persons receive training as interviewers and by the time they have acquired enough experience, the particular programme of interviewing is completed. In addition to the financial loss entailed in training the persons for each survey, the quality of the work is also adversely affected. The quality can be improved only if a continuous programme of demographic research is evolved to retain the services of properly trained, talented persons.
19. To sum up, the problem is not only that of attracting suitable persons to be trained in demography, but also that of adequately utilizing the services of such trained persons.

# International co-operation in the setting up of the Regional Centre for Demographic Training and Research, Cairo 

M. S. Khodary

## Basic considerations

1. Since the Second World War, interest in the field of population problems has been mounting in many countries of the world.
2. Furthermore, developing countries are currently aware of a pressing need for population studies, mainly because economic and social development plans in these countries are being hampered by population pressure, owing primatily to high fertility and declining mortality rates.
3. Although population pressure in Africa is not-generally speaking-as acute as it is in some other regions of the world, per capita income in Africa is much too low, owing mainly to the lack of investment funds and a properly trained labour force, and to the prevalence of a subsistence economy coupled with social traditions that hamper economic progress.
4. Developing countries in general, and African countries in particular, suffer from serious deficiencies in demographic statistics. Furthermore, technicians in the field of demography are rare or non-existent.
5. The usefulness of foreign experts sent by the United Nations and other agencies to African countries is limited by three principal factors, namely:
(a) The language barrier, which makes it difficult for the expert to make use of data available only in the local language and limits his ability to train local staff who do not understand his language;
(b) Lack of well-qualified counterparts, resulting from the scarcity of university graduates, in general, and statisticians or economists in particular. Such graduates usually hold responsible posts in government service and cannot be released from their jobs to be trained by the experts;
(c) Scarcity of demographic and related data. With few exceptions, African countries have not taken more than one census, if any. In most of them, vital statistics are available only for limited parts of the country and, on
the whole, available data are unreliable. Faced with such problems, the expert usually resorts to intelligent guess-work and the adoption of models which may not be adequate or convincing to policy-makers in the country concerned, especially if one takes into consideration that politicians are not expected to appreciate or fully understand the assumptions upon which the demographer relies in arriving at his estimates. It should be noted that in many African countries, economic statistics also are lacking and this, in turn, makes any studies pertaining to interrelationships between demographic variables and socio-economic variables rather difficult.

## Setting up of the Nortif African Demographic Centre

6. Improving the standard of living of the peoples of the world is one of the aims of the United Nations. To achieve that end, the United Nations has to assume certain responsibilities in respect to population problems, which can never be divorced from economic and social development plans. It also should be noted that world population growth poses a serious problem that cannot be tackled without sincere international co-operation.
7. At the time of the establishment of the Population Commission in 1946, the Economic and Social Council could not have foreseen the developments in world population growth that were to follow. The terms of reference of the Commission, as approved by the Economic and Social Council in its resolution 150 (VII), were as follows:
"The Population Commission shall arrange for studies and advise the Economic and Social Council on:
"(a) The size and structure of populations and the changes therein;
" $(b)$ The interplay of demographic factors and economic and social factors;
"(c) Policies designed to influence the size and structure of populations and changes therein;
"(d) Any other demographic questions on which either the principal or the subsidiary organs of the United Nations or the specialized agencies may seek advice".
8. In the early years, the Commission was mainly preoccupied with the development and international compilation of demographic statistics. At its fifth session, in 1950, the Commission strongly recommended technical assistance in the demographic field for developing countries. At the sixth session, regional seminars on population problems and the organization of training courses were recommended. At its ninth session, the Commission viewed with concern the deficiency of demographic services in those parts of the world where population was growing most rapidly. The establishment, in 1957, of the Chembur Centre in India for the benefit of countries of Asia and the Far East and the Centre for Latin America (CELADE in Santiago, Chile) was noted with pleasure, and extension of these activities was also recommended at the ninth session.
9. A United Nations Seminar on Population Problems in Africa was held in Cairo in 1962. The Seminar noted that although much of Africa appears to be underpopulated, nearly all African countries suffer from the heavy strain imposed on their developing economies by the excessively rapid growth of population. Discussions brought out the fact that the demographic statistics of most African countries are inadequate. Furthermore, fundamental population research was lagging behind the development of demographic statistics in Africa.
10. The establishment of subregional centres for demographic research and training was recognized by the Seminar as an adequate means of pooling technical resources in order to overcome difficulties resulting from the scarcity of trained personnel and other resources.
11. During the Seminar, it was announced that negotiations had been successfully concluded between the Government of the United Arab Republic and the United Nations for the establishment of a subregional demographic centre in Cairo.
12. The agreement was finally signed in February 1963, and the training course began in November 1963.
13. According to the agreement, the United Nations provides the services of the director of the centre and the services of one demographer, as well as fellowships for trainees from the countries of the subregion (Algeria, Libya, Morocco, the Sudan and Tunisia). In addition,
fellowships are made available for trainees from the Arab States of the Middle East. The United Nations agreed also to provide the cost of consultants' fees, technical books, journals, teaching material and equipment.
14. The Government of the United Arab Republic undertakes to provide the necessary premises, furniture, office equipment, supplies, the services of three full-time experts (in addition to part-time experts), stipends for trainees from the United Arab Republic and the funds for the training of the necessary clerical staff.

## Achievements and problems

15. The programme of training and research was formulated with assistance from the Secretariat of the United Nations Economic Commission for Africa (ECA). The training curriculum includes technical demography, substantive demography, elementary mathematics and statistics, sociology and methods of social research, economics, human genetics, physiology of reproduction and family planning. The research programme for 1963-1965 included studies on fertility, on mortality and morbidity, and on internal migration and urbanization, an assessment of the quality of basic data and studies of demographic problems of social and economic development and other studies, such as projection of population.
16. The original plan envisaged a shortterm training programme for six months and a long-term programme for twelve months. Subsequently, the basic training course was planned for twelve months. This is considered the minimum time for training university graduates in demography, technical and substantive.
17. The programme was also reviewed and amended accordingly. Practical application of demographic techniques and analysis of demographic data have been emphasized in the form of adequate laboratory exercises. During the latter half of the training year, trainees are expected to embark on a term paper under the supervision of the staff or, alternatively, to receive on-the-job training by taking part in the research activities of the Centre.
18. In its first year, the Centre was prevented by diverse problems from carrying out research work aside from the term papers of trainees. Initially, the Government of the United Arab Republic could only provide the services of two full-time experts, instead of three.
19. Among the basic problems is the scarcity of expert knowledge in the field of demography in the subregion, mainly because demo-
graphy is not adequately dealt with in local universities. The few available demographic experts in the United Arab Republic cannot be released to take part in the Centre's activities, even on a part-time basis in some cases. Financial remuneration for such experts is insufficient to procure first-class experts from abroad. At the same time, foreign experts can only be of limited use for training purposes unless training is carried out in English, which limits opportunities for training in the countries under discussion. However, foreign experts are necessary for carrying out research progranmes, at least in the near future.
20. The scarcity of suitable trainees is another basic problem in the subregion. With the exception of a few countries, qualified graduates are scarce, and they usually hold responsible jobs and cannot be released for training. The Centre is faced with the problem of training persons who do not have adequate university education. Furthermore, a few of the trainees have no experience, since they are recruited from among newly appointed government officials. It suffices to mention that the simple handling of statistical data poses a problem for some of the trainees.
21. The scarcity of textbooks in Arabic, coupled with the inability of some students to refer to books and publications in a foreign language, poses a serious problem. It should be recognized that graduating from the Centre without the ability to supplement and substantiate such training with continuous reading in the field cannot be considered adequate training for demographers who are expected to take an active part in the formulation of policies in their own countries.
22. The training of such a diverse group of persons with different levels of education (some of them have to be trained in elementary mathematics and statistics) consumes most of the time of local and foreign experts and limits the scope of training in techniques. Thus, little time is left for the experts to embark on their own research or that of the Centre.
23. The Centre has not yet been able to collect all relevant demographic data from countries of the region, although a start has been made. In this respect, ECA may play a useful role in substantiating the Centre's efforts to obtain up-to-date information and research carried out in the field of demography.

## Fields for future international co-operation

24. The scope, quality and coverage of demographic data in countries of the subregion
are not satisfactory. International co-operation could contribute a great deal towards filling in gaps and improving quality through the initiation of field surveys. The Centre should take part in such fields of activity. A programme should be drawn up by the Centre with the assistance of ECA, the United Nations Statistical Office and any other competent agencies.
25. In spite of the progress made thus far by the Population Commission in the fields of studies, manuals and conference or seminar proceedings, there is still much to be done in methodology for tackling incomplete and inaccurate demographic data, with a view to estimating true population parameters. A sizable extension in the field is indicated and would be of great help to developing countries. Emphasis should be given to simplified techniques that have direct operational uses.
26. Textbooks and special topics in demography should be made available in as many languages as possible through international cooperation. The same applies to manuals and methodological work. Demographic centres should co-operate among themselves and with other interested agencies in preparing a variety of training manuals in local languages. Practical examples, preferably utilizing local data, should be dealt with at length in such manuals. Thus, research in the field of demography would not be limited only to those who can read English and/or French.
27. Since training in demographic centres will not be fruifful unless it is substantiated by subsequent extensive reading, it may be useful, currently, to limit training to those who know English or French until reading materials are made available in local languages. Much time may be gained if trainees are selected from those who have mastered elementary mathematics, at least up to matriculation level. It is also preferable to select trainees with previous adequate experience in the field of statistics, economics or sociology. The problem of selection of trainees may be one of the topics that directors of demographic centres would deal with, taking past experience of their centres into consideration. Furthermore, local universities should be encouraged by international agencies to train graduates in the field of demography.
28. The existing staff of demographic centres is not adequate to cope with training and research problems effectively. More full-time experts should be recruited, and local experts from all countries of the region served should be offered adequate incentives to collaborate with these centres. In the absence of regular
university courses in demography locally, trainees should be encouraged, through fellowships abroad and generous local research grants, to build up their knowledge in demography. In future, such an approach would partially solve the problem of scarce technical personnel.
29. Periodic meetings of the staff of demographic centres should be encouraged to exchange experiences, with a view to modifying programmes in order to improve the standard of training and research work.
30. It may be useful to experiment with the idea of mobile demographic centres. Transporting the staff of a demographic centre into another country of the region to give a short training course in demography to planners, statisticians and economists of that country may be the best approach for serving the countries where university graduates are scarce and can-
not be spared for the period of training outside their countries.
31. Governments of countries of the region should be notified of the research programme of the demographic centre. Comments should be encouraged. The idea of a mobile centre may be helpful in acquainting government officials in each host country with the possible fields of demographic research. Research having direct operational application would undoubtedly be of great value in convincing politicians and policy-makers of the direct utility of demographic research. Hence, it may be appropriate for demographic centres to devote a large part of available resources to point out and help in the type of demographic research needed to forecast necessary investments in education, housing, communications, etc. Demographic centres should also take part in providing basic data for a population policy for the countries of the region and should take part, when requested, in research in family planning.

# The Latin American Demographic Centre: an experience in international co-operation for training, research and technical assistance in demography 

Carmen A. Miró

## I. Reasons which justified the establishment of the Centre

1. The growing concern for the economic and social conditions of the developing countries has called attention to the importance of an adequate evaluation of those conditions and to the need for development programmes as initial steps in the search for measures intended to raise the levels of living in those countries.
2. If, as has been widely accepted, demographic trends and their consequences have a decisive influence upon the economic and social conditions of a given area, knowledge about the size, rate of growth and composition of the population is a prerequisite to planning and action programmes. This is even more important in the case of Latin America, with the highest demographic growth rate ever recorded and with wide-spread urbanization.
3. Unfortunately, the study of population problems was until rather recently inadequate or non-existent in most of the Latin American countries, in spite of the availability of demographic data of an acceptable quality. Lack of personnel capable of undertaking demographic analysis and research has been one of the main reasons advanced to explain the absence of population studies.

## II. Establishment of the Centre

4. Considering this adverse situation, typical of other developing areas of the world, and recognizing the urgent need to quantify and qualify the impact of demographic growth in these areas, the Economic and Social Council deemed it advisable to extend the benefits of United Nations technical assistance to the field of demography. This is why, in May 1955, it adopted resolution 571 (XIX) requesting the Secretary-General to study the possibilities of establishing regional centres in these areas, for the study of their population problems and the training of personnel specialized in demographic analysis. This initiative, favourably received by Governments and interested organizations, led, in the case of Latin America, to
the conclusion in August 1957 of an agreement between the United Nations and the Government of Chile on the provision of technical assistance for the establishment of a Latin American Demographic Centre (CELADE). This agreement stipulated that, in principle, it would remain in force "for a period permitting the completion of three training courses". It has, in fact, been extended twice and should continue in effect until December 1966. An additional extension for a five-year period with the financial support of the United Nations Special Fund is now being considered.

## III. Objectives to be met

5. The objectives of CELADE were set forth in the above-mentioned agreement, as follows: (a) the organization of courses on techniques of demographic analysis, for the purpose of training students from Latin American countries and encouraging the establishment of similar courses in those countries; (b) the initiation of studies on demographic problems, based on existing sources of information and field-work; (c) the provision of advisory services on demographic problems for the benefit of Latin American Governments or governmental organizations.
6. The activities of CELADE were organized accordingly and in order to fulfil these objectives efficiently, some other functions have been added, such as the publication of research findings and general divulgation of the interaction of demographic growth and economic and social development.

## IV. Professional training

7. The programme of professional training is implemented at three levels, namely: (a) a basic course (first year); (b) an advanced course (second year); and (c) a specialization course (third year). Research Fellows not formally attached to any course are also admitted to the Centre, under special circumstances. The teaching activities very briefly described below are also conducted outside of the Centre by its staff.

## A. Basic course

8. The seventh basic course was completed at the end of 1964, having been attended by ninety-five students from eighteen Latin American countries and from Puerto Rico. This course is designed to: (a) introduce the Fellow to the study of demography as a scientific discipline; ( $b$ ) familiarize him with the sources of demographic data and the methods of collection and processing; (c) give him an understanding of the world demographic situation and perspectives, with special reference to Latin America; (d) make him conscious of the meaning and repercussions of past and current population trends and of the economic and social consequences of these trends; (e) teach him the more fundamental techniques of demographic analysis; and ( $f$ ) make him aware of the practical difficulties of demographic research by requiring that a short project be prepared by him.
9. For attaining the preceding aims, students are submitted, during a ten-month period, to a teaching programme divided into three segments, namely: formal demography and methodology, demographic aspects of economic and social development, and applied demographic research. In the segment dealing with formal demography and methodology, the following subjects are covered: (a) mathematical and statistical methodology applied to demography; ( $b$ ) nature, methods and data of demography; (c) world demographic situation and population trends; (d) population composition ; (e) population distribution; (f) mortality; (g) fertility, reproduction and nuptiality; ( $h$ ) fundamental relationships between components of demographic change ; ( $i$ ) internal migration; ( $j$ ) evaluation of demographic data; and ( $k$ ) estimates and projections.
10. Within the segment dealing with demographic aspects of economic and social development, the students are given courses on: (a) the economically active population; (b) interdependence of economic and demographic variables; (c) social aspects of demographic growth and change ; and (e) population policy.
11. Under applied research activities, students are exposed to the research projects of the advanced Fellows and the Centre's staff, and are also required to execute a brief research project which, in some way, should reflect the degree of competence acquired by the student in applying the techniques which he has learned and in presenting his findings in adequate form.

## B. Advanced course

12. The students who have shown interest, ability and initiative in the study of population phenomena have in this course the opportunity to extend their training for an additional period of one year, in which they are expected to attain a broader understanding of the interaction of population growth and economic and social conditions; greater competence in handling quantitative data and the ability to conduct independent research. The main activities performed in complying with these objectives are: (a) direct participation in research; (b) formal courses; (c) seminars and other meetings. The formal courses include: (a) sampling applied to demography; (b) matrix analysis applied to demography; (c) methods of social research; (d) population growth and social change (II) ; (e) economic development; and (f) theoretical models of population (II).
13. By the end of 1964, a total of thirtythree students from fifteen Latin American countries had completed the advanced course.

## C. Specialization course

14. This course is open to students already having two years of training at CELADE, and its purpose is that of preparing personnel to teach specialized courses in demography and to render technical assistance in demographic analysis and population studies. Fellows in the third year of training are actually incorporated into the Centre's staff and, according to needs, they are given responsibilities in teaching inside or outside CELADE, in advising secondyear Fellows and in reviewing critically their research findings. The only formal academic activities in which these Fellows are engaged are seminars on readings of demography and allied subjects. Up to now, six students from three countries have gone through this type of training.

## D. Research Fellows

15. Facilities also exist for the training in demographic research of civil servants who have not taken the basic course, but who have acquired, either by working or studying in another institution, some knowledge and experience in demography. In general, these Fellows have the same duties as the regular advanced students and, according to their interests, can participate in some of the activities of the basic course. Only two Latin Americans (from Costa Rica and Colombia) have benefited from this programme.

## V. Research

16. The research programme comprises direct field-work, as well as analytical exploitation of the demographic information already available and the development of new techniques of analysis which are applicable to the type of demographic data available in the countries of the region. In organizing the programme, the attainment of the following objectives has been the guiding principle: (a) to serve as a training instrument in demographic research techniques for the students; (b) to provide the population studies needed for the demographic factor to be adequately incorporated into the economic and social development programmes; (c) to experiment with new methods of obtaining and analysing demographic data and to encourage the compilation of information on insufficiently studied phenomena; and ( $d$ ) to participate actively in international seminars and conferences in which aspects of population trends in Latin America are examined. In the development of the first objective, more than 170 studies have been accumulated, many of them of undoubted merit, which are not only contributing to the increase of information available on Latin American population, but also to the development of methodological solutions for analytical problems related to the type of demographic data available.
17. In fulfilling the second objective, CE LADE has been fortunate in being able to enter into co-operative working agreements with the United Nations Economic Commission for Latin America (ECLA). A series of projects has been developed for supplying essential background information to the advisory groups on economic and social planning who are sent to the various countries of the region and for investigating demographic matters of particular interest to ECLA. These studies include, among others, population projections for Argentina, Bolivia, Chile, El Salvador, Mexico, Panama, Peru, Uruguay and Venezuela, man-power analyses for Brazil and Chile, the examination of patterns of population settlement in Latin America and the geographical distribution of the population of Brazil and Venezuela.
18. CELADE has placed special emphasis on the importance of developing methods for obtaining basic demographic information not otherwise available. The research programme has included the following field operations, involving, in most cases, experimentation on methods of collection applicable to the Latin American situation: (a) 1959, survey on fer-
tility and attitudes related to family formation, Santiago, Chile; (b) 1961, experimental demographic survey, Guanabara, Brazil; (c) 1962, survey on in-migration into greater Santiago, Chile; (d) 1964-1965, comparative fertility surveys in the cities of Bogotá, Buenos Aires, Caracas, Mexico, Rio de Janeiro, San José and Panama; (e) 1964-1965, demographic survey, Cauquenes, Chile; and (f) rural fertility survey in Colina, Chile.
19. Following the desire of both ECLA and CELADE to contribute to the study of population trends in Latin America and of their consequences in the economic and social spheres, the research programme has provided for the preparation of documents supplying background demographic information for the discussions at various international conferences and seminars: Some examples are: "A demographic analysis of the educational situation in Latin America", "Demographic information required for housing and programmes with special reference to Latin America" and "Urban-Rural patterns of population distribution in Latin America and changes in this pattern during the last decades".

## VI. Techntcal assistance

20. While all activities carried out by CELADE could properly be classified under the general heading of technical assistance, those examined here correspond to that part of the programme involving collaboration with other institutions, usually outside the Centre and very frequently in countries other than Chile. This collaboration has taken diverse forms, namely:
(a) Direct technical assistance on the spot with regard to:
(i) Questions to be included in the population censuses and the best means of exploiting them analytically;
(ii) The establishment of demographic analysis units and the co-operative development of programmes of population studies;
(iii) The organization of demographic training centres;
(iv) The design of samples and solutions to methodological problems associated with the execution of certain demographic surveys;
(b) The teaching of courses in demography in several international and national institutions established in Santiago and in other organizations in the region, i.e., the Mexico Centre;
(c) The organization and direction of, or participation in, consulting status in such technical meetings as the Seminar on Evaluation and Utilization of Population Census Data in Latin America (1959), the workshop on comparative fertility surveys (1963), the Latin American Census Training Centre (1958), the Central American Seminar on Census Administration (1959), the Working Group in Teaching of Medical Demography and the Second Inter-American Seminar on Civil Registration;
(d) Advice on methodological questions to physicians working in Chile on questions related to physiology of reproduction;
(e) Co-operative execution of certain population studies;
(f) Advice through correspondence to former CELADE Fellows on specific analytical problems.

## VII. Publication programme

21. CELADE regularly issues the following four series of publications: series A (blue), reports on research projects conducted by the staff; series B (red), methodological manuals, class-notes and other teaching materials; series C (brown), reports on research conducted by the Fellows; and series D, reports prepared by visiting professors and consultants, and translations.
22. Under this programme, more than 100 different publications have been distributed to interested institutions and persons. In addition, the Centre issues, for limited distribution, a monthly bulletin in which the highlights of activities are summarized.

## VIII. Other activities

23. In order to keep abreast of professional development in the field, CELADE's staff participates very actively in seminars, roundtable seminars and conferences on population convened by professional organizations or private foundations, such as the 40th Annual Conference of the Milbank Memorial Fund in Demography and Public Health in Latin America, the Round Table on Components of Population Change in Latin America, held on the occasion of the 60th anniversary of that fund and the 1961 International Population Conference.
24. CELADE has also sponsored short visits to Santiago of distinguished foreign scholars in the field of population, to collaborate in the teaching programme and to promote interest among the general public in population problems.

## IX. Organization and sources of finance

25. There is an advisory board, headed by the Executive Secretary of ECLA, which has met twice since the inception of the Centre and which is responsible for establishing the guidelines of the programme to be developed. The general orientation of the Centre is entrusted to a director appointed by the United Nations in consultation with the Government of Chile. Five senior experts, two juniors, one associate, three research assistants and a secretary in charge of academic affairs complete the professional staff. The ECLA demographer participates very actively in the various aspects of the work of the Centre.
26. CELADE operates through the financial support of the United Nations, the Government of Chile, the Population Council, the Government of the Netherlands and, more recently, the United States of America Agency for International Development. In the past it has also received the support of the Ford Foundation.

## X. Balance of the experience of the Centre

27. The highlights of the experience of CELADE in international co-operation in demography in the period 1958-1965 can be summarized as follows:
(a) In seven years of operation, CELADE has given training to ninety Latin Americans at the basic level, to thirty-three in the advanced course and to six in the specialization course in demography. The greater portion of these former Fellows are actively working in demography and are serving in a wide variety of positions, such as international technical assistance consultants, teachers of demography, heads or members of units of demographic analysis, assistants to other professionals in execution of population studies, etc. Former CELADE Fellows have been the national directors of urban fertility surveys in six Latin American cities;
(b) Twelve surveys to collect data on vital rates, rural and urban fertility, and migration have been conducted by CELADE, either directly or in co-operation with national institutions;
(c) National demographic research units have been set up with the participation of former CELADE Fellows in ten countries of the region;
(d) Technical assistance missions to advise on matters related to population problems or
to teach demography have been sent to fourteen Latin American countries and to Puerto Rico;
(e) Population projections have been made for practically all countries of the region, for the preparation of which evaluations of censuses and vital statistics have been undertaken. Research in fertility, mortality, migration, geographic distribution of the population and manpower has received considerable attention;
(f) A seminar on the evaluation and utilization of population census results and a workshop on comparative fertility surveys were organized and directed by CELADE. Members of the staff have participated as consultants in at least four technical meetings on Latin American demography. Papers have been prepared for another four seminars concerned with population matters.

# Demography and social sciences 

Paul Paillat

[Translated from French]

1. In 1958, UNESCO published the survey by D. V. Glass on instruction in demography, ${ }^{1}$ which was based on reports from various countries and which, in part $Y$, described the nature of demography and the objectives of instruction in demography. On the occasion of the World Population Conference, 1965, the organizers thought it timely to reconsider this question in the light of changing ideas and needs. For the very progress of demographic studies it is desirable to inquire whether Glass's excellent report still reflects the facts or whether achievements or events have altered the picture presented in the UNESCO survey, without necessarily going into the same amount of detail.

## I. Observations of D. V. Glass

2. As editor of the survey, Glass emphasized that the organization of instruction in demography reflected differences in ideas about the nature of that discipline. According as demography is considered as a distinct science, a kind of synthesis of the social sciences or as a discipline associated with one or more social sciences, the programme of instruction, the basic training of the teaching staff, the type of institution providing courses and the nature and scope of the diplomas vary. This can clearly be seen from the national reports presented at that time.
3. We think that experience counsels the broadest conception. In countries where demography is treated as a poor relation, this is either because the human and material means are lacking or because the needs in this sphere are not appreciated. On the other hand, organs which have been studying population problems for many years are coming more and more to the conclusion that for a complete understanding of those problems the contribution of the other social sciences is essential, and that, from this point of view, demography holds out the possibility of a synthesis. Such a synthesis

[^178]cannot be criticized as "intellectual imperialism": if the demographer has recourse to sociology and to sociologists, this does not mean that he is annexing that science or joining the ranks of its scholars but that he understands the value of their work.
4. How then can we decide what is and what is not covered by demography? Dr. Glass replied pragmatically that the decision depended on the nature of the problem being considered. It also depends on the angle from which the problem is approached. It is the ambition of almost every demographer to study fertility, because the evolution and structure of a population are largely governed by this factor, but the doctor and the sociologist may maintain that such a study is within their competence, if the former has in mind the physiological aspect and the latter the diversity of social behaviour.
5. Such a debate, which is developed at length in the 1958 survey, is less strictly academic than appears at first sight. One may wonder whether the fact that demography has developed little and is virtually non-existent even in some developed countries is not due to a too narrow conception of its role or, conversely, to a reaction against an over-ambitious conception (as in Germany). To limit the study of population to the quantitative measurement and statistical analysis of the role of the various factors involved is to restrict greatly not only the scope of this discipline but also-what is more serious-its practical bearing and hence its value to possible users (and providers of funds). Again, by over-emphasizing the diagnosis of a particular concrete situation and concentrating on bringing the basic data up to date, however subtle the methods of situation analysis may be, one may forget that the situation in question is only one link in a long chain and that some of the keys to understanding it are to be found in the past. A demographic service too closely bound to routine taskshowever useful-cannot always see things in the right perspective or embark on work which seems superfluous or of secondary importance but which will later lead to improved methods
and a better knowledge of man in society. This example shows the pitfalls to be avoided if demographers are not to be denied suitable working conditions.

## II. Arguments in favour of greater INTEGRATION

6. Taking as a basis the report by D. V. Glass, we may ask ourselves whether the last few years have brought grist to his mill and reinforced certain conclusions implicit in his observations.
7. The demographer does not claim that his presence is always indispensable but he often regrets being absent when his methods, his information and-why not-his professional bias would be of great service. As the years go by, an increasing number of countries, without going so far as the stage of planning their economies, are drawing up partial programmes of action, e.g., in the field of education, employment and housing. UNESCO itself has just established an International Institute for Educational Planning. How can such studies be carried on without the help of demographers or at least of staff familiar with demographic projection techniques and methods of evaluation (where complete and reliable data are lacking) ?
8. The demographer can give only a partial answer, however, unless the data on which his calculations are based are supplemented by information furnished by other disciplines. The study of fertility, though a typically demographic subject, will be fully comprehensive only if it encompasses medical and sociological observation. Educational requirements are another example. They are linked with the evolution of the age-specific child and adolescent population and the age-specific teaching establishment (and of the generations from which new teachers can be recruited); they are also linked with the short-term and medium-term needs of the economy, the country's administrative and material potential, the location of human and material resources, the type of population and, last but not least, the motivations of the parents and the young people themselves. The current difficulties in higher education in France are due to the pressure exerted by the voluntary prolongation of studies, swelling enrolment after the end of compulsory schooling, whereas demographic pressure as such plays a lesser role (indeed, it is not a factor at all in the case of students over twenty years of age). The analysis of this situation and particularly of its foreseeable medium-term developments is beyond the scope
of demography in the strict sense of the word: it requires the concerted efforts of educators, administrators, economists and sociologists, not to speak of architects, employers and trade unions. Should we go so far as to seek a supervisory role for the demographer in a task of this kind? Certainly not; but social projects and even social demands would be more cogent if they were quantified before being formulated, instead of vice versa. Demography is the social science which best lends itself to quantification. In a country with an old age structure, the policy with regard to older people cannot be as generous as in a country with a younger age structure.
9. Even if this claim is rejected, it may be surprising to learn that statistics is not compulsory in the syllabus for diplomas in sociology. However penetrating the observations of sociologists may be, they will have no practical importance unless they are based on correctly quantified data, if only to avoid the risk of rash extrapolations and costly errors by a community that were to take them literally.
10. This being said, it must be pointed out that, even in highly developed countries, the public services are making increasing use of demography, if not of demographers. One might even say that a new page has been turned and that the time will soon come when demand from this sector will exceed supply, i.e., the capacity of the skilled staff, whatever the institution to which they belong. The pressure of this demand may prejudice the progress of studies unrestricted by any specific and immediate objective, but demographers have to run this risk, while doing what they can to keep it within bounds, for this is how they will at last obtain the resources they often need so badly.
11. In the countries of the Third World, however, the problem is different. The shortage of highly skilled personnel, the slow pace at which research workers are trained and the difficulty of recruiting them in countries where education is not wide spread and the educational standard is low make it impossible to borrow a solution directly from countries where the range of specialization is, so to speak, unlimited. As a first stage, it is essential to train personnel who realize the importance of research and know how to obtain the necessary technical aid and to train research workers who will not think it beneath them to co-operate in concrete tasks, including precisely the training of co-workers and ... successors. To train a demographer who is only that and lacks a good knowledge of economics and sociology may
raise the individual's professional standard but undoubtedly limits his usefulness. Similarly, to train economists or administrators who have no proper grounding in demography, in countries with a high population growth rate, is to run the risk of having them one day advocate wrong solutions detrimental to their countries.
12. Here the essential idea is not to produce complete all-rounders but personnel permanently receptive to the other points of view, the existence of other methods and the possibility of non-demographic factors intervening. A country with a large number of research workers can afford to have a whole range of specialists but it will be well advised to associate them in interdisciplinary groups; a less advanced country must erect a structure that is less highly developed, and intellectually satisfying but more useable during the long and difficult period of take-off.

## III. Obstacles to such integration

13. There are obstacles of various kinds to the application of such a policy. First of all, there are psychological obstacles. The prejudices of specialists in one branch with regard to specialists in another branch, even if both belong to the tree of the social sciences, do not facilitate research collaboration and make it difficult to establish and run any institution of higher learning.
14. In the older universities, the compartmentalization of faculties and departments hampered the introduction of new disciplines such as demography, which Alfred Sauvy for this reason calls the "sky" science. When the pressure of demand becomes too great, there is a scramble to take in the new arrival: demography then will have no mathematical foundation, if the men of letters prevail, and no window onto society, if the scientists win. The established positions, on either side, ultimately determine the content of the curricula, the type of instruction, the impetus given to demography or the scant attention paid to it: the national reports in the UNESCO survey are most enlightening in this regard. Demographers, whatever their earlier training, ought not perhaps to allow this situation to continue without opposition, if they are really convinced of the practical usefulness of their work.
15. The textbooks, of which there are in any case too few, reflect this state of affairs, since they seldom mention the interests or the work of related disciplines, if only by way of reference. Yet what is it that prevents a psycho-sociologist from making use of mathematical models or at least mentioning their
existence as a means of analysis? What prevents the mathematician from breathing life into his abstractions by using examples taken from sociology? Could it sometimes be mutual ignorance?
16. The scarcity of demographers and particularly of demographers with the time and inclination for teaching increases the difficulty, even in the developed countries, as such specialists, however distinguished, are not always given their rightful place in university systems. In the Third World, the mediumterm problem is generally insoluble at the national level: the task of training professional demographers or equivalent personnel falls to regional centres such as the Latin American Demographic Centre at Santiago de Chile or the Centre at Chembur (India).

## IV. Methods of developing and adapting the teaching of demography

17. UNESCO's inventory of existing programs and facilities, which, incidentally, ought to be brought up to date, should be supplemented by an inventory of needs, singling out:
(a) The dissemination of demographic information to national cadres;
(b) The imparting of a better understanding of demography to those destined for posts of responsibility in the civil service, the economy, tet.;
(c) The training of technicians at various levels;
(d) The training of skilled demographers.
18. The place of demography in the curricula depends on the objective sought. It should be one of the compulsory subjectsgiving entitlement to a certificate or a creditfor degrees in ethnology, sociology, psychosociology, economics, geography and economic history, although the same aspects need not necessarily be studied. In countries where overspecialization is undesirable, future statisticians should nevertheless familiarize themselves with the methods of demographic analysis, since their schooling predisposes them to be receptive to such methods; those who are to hold public office should have some grounding in economics and sociology.
19. Lastly there are those whose primary goal is to become demographers. They cannot limit themselves to analysis, however high the level of instruction.
20. Suitable courses in sociology, population history and geography, economics and economic geography and social politics will not make them expert in all those subjects but will facilitate their contact with specialists and increase their understanding of social phenomena. In the study of these phenomena they will be able to use the tools of statistics (including the theory and practice of sampling) but their work in this field will be more effective if the way has thus been paved for them. Knowledge of a widely used foreign language is essential, because translations of substantive works are rare and conferences alone cannot meet this need. Moreover, contact with foreign methods and problems is a major intellectual stimulant.
21. Here it is necessary to keep a sense of moderation and avoid the fragile gloss of inflation. The syllabus depends on requirements and particularly on the type of posts to be filled. The socio-economic part, for example, should be made more comprehensive in a developing country than in an industrialized country. This extra knowledge can be acquired during earlier studies, so that more time is left for actual demographic training, or simultaneously, which restricts the demographic training but allows the course of study to be shortened. ${ }^{2}$
[^179]
## V. Conclusion

22. The sole aim of this paper is to prompt those attending the World Population Conference to ask themselves a series of questions: what is the place of demography in their countries? What measures should be taken to expand its influence, for example by freeing it from too constricted a role and enriching it with what other social sciences have to offer? To what extent do demographers defend their discipline and its legitimate aspirations at conferences of other social sciences? To what extent do they privately recognize that theirs is a distinct branch of knowledge and do they feel capable of making an individual contribution to the building of the society of tomorrow? How many feel able to go beyond the analysis stage to the level of solutions or at least to assess scientifically the solutions proposed by others? It is not enough to measure, for example, the effectiveness of a particular contraceptive method (the studies are legion) ; it is also necessary to know the reason for the effectiveness or ineffectiveness and to find ways of reducing the latter if the object is to lower the birth rate. In this field, how can the economist alone apprehend all the medium-term and long-term aspects of a decline (or rise) in the birth rate and how, on the other hand, can the demographer alone assess all the socioeconomic implications of the new trend, whether it is spontaneous or encouraged?

## The recruitment of personnel for training in demography

## Vincent H. Whitney

## The need for demographers

1. It is being increasingly accepted that the widely held goal of improvements in the levels of the developing countries cannot be attained without proper consideration for population factors and their relation to the economic and social factors in development. Indeed, an outstanding example of this point of view is seen in the decision of the United Nations to define its Development Decade in terms not only of social and economic conditions, but equally of demographic ones.
2. These and related considerations, such as the need for improved population statistics and the rapidly growing interest in many countries in family planning, have sharply increased the demand for well-trained demographers. The specific number required, either currently or in the future, cannot be stated with accuracy. Despite the absence of firm figures, the difficulty of filling particular posts with properly qualified specialists is a reality obvious to those who are either seeking or being asked to recommend candidates. In different parts of the world, the need for persons with demographic training is increasing in varying degrees. Qualified persons are sought not only for teaching and research in universities, but also for the staffs of statistical offices and government planning organizations. Increasingly, also, they are required for action programmes aimed at some measure of control over both the size of individual families and the rates of growth of countries. The rapid increase in such activities is likely to grow rather than to lessen, over the next several years. It is tempting, but clearly dangerous, to follow the lead of an earlier scholar and predict that demographers will increase arithmetically, while positions which they might fill will increase geometrically. Nevertheless, general observation suggests that, in many areas, the supply of population analysts is currently inadequate to meet the rising need for persons with professional training. Where general levels of development are such that the demand does not yet exist or barely exists, it is logical to anticipate an increased requirement for demographers in the future. One must also recognize
that an increase in the number of trained persons will tend to increase the number of positions available. Such a circumstance is desirable in view of the unmet needs in the field, but it will ensure that recruitment problems remain substantial in the years ahead.

## Training centres in demography

3. Compared with the number of universities and other centres offering training in such fields as economics or statistics, the number providing any substantial amount of training in demography is small. These also tend to be concentrated in the developed countries, and especially in the United States of America. Following discussions at the sixth and eighth sessions of the Population Commission, two United Nations regional demographic centres for both training and research were established in 1957. In co-operation with the Governments of India and Chile, the centre for Asia in Bombay and that for Latin America in Santiago began operations then. More recently, a centre has been established at Cairo (1963) with the co-operation of the Government of the United Arab Republic, and there are proposals for the development of an additional centre at Dakar for French-speaking African countries and of a subcentre in San José, Costa Rica, for Central America. These centres are intended to provide graduates who can conduct training programmes in their own countries. In addition, the United Nations has assigned an expert to develop a university research and training curriculum in demography in Iran. With the support of private foundations, training programmes in population are beginning to take shape in several other countries, including Colombia, Ghana, India, Mexico, Pakistan, the Philippines, the Republic of Korea, the Sudan and Tunisia.
4. In addition to these centres, with their curricula in population, specialized training courses of limited duration, with emphasis on specific demographic topics, have been held in a number of countries. For example, the Government of Ghana co-operated with the United Nations in 1961, to organize a training
course for four countries in West Africa in techniques necessary to the taking of a population census. The Bureau of the Census of the United States of America, through its International Statistical Programs Office, provides a steady series of courses for students from many countries, lasting from a few days to a year and emphasizing population census topics and techniques. Some training is provided by individuals on missions to the statistical offices of other nations or to foreign universities, where they serve variously as visiting professors, experts or advisors. An example is the assignment to the National Statistical Office of Thailand of a demographic adviser from the United States Bureau of the Census. This has resulted in the organization of a demographic unit within the Office and in the establishment of a quarterly survey and other activities which are providing in-service training for staff members.
5. Finally, additional limited training occurs when population factors receive some attention in the context of another topic, such as public health or statistics. Illustrative are the many university courses in economic growth which now give some attention to population factors. Again, training in statistics may include population statistics. The newly created Asian Institute of Economic Development and Planning, which was established by the United Nations Economic Commission for Asia and the Far East in Bangkok, conducts a ten-month training programme which includes a discussion of the relation of population to economic growth and to the social aspects of population structure. A further example is provided by such a specially organized programme as the International Training Course on Vital and Health Statistics in the Western Pacific Region, cosponsored by the United Nations and the World Health Organization and held in Tokyo in 1960. This included training in the use of sample surveys in securing health and population data and in methods of estimating total population and vital rates.

## Considerattons in recruttment

6. This brief summary of training opportunities may suggest that there are already wide-spread means of recruiting potential demographers. Several comments are relevant.
7. To begin, the demand for demographers, both currently and in the future, must be thought of as world-wide. It is clear that in many areas, training facilities are either nonexistent or inadequate. At best, potential students must travel considerable distances,
often to other countries in which the medium of instruction is a foreign language. If the focus is on university training, there are only a few widely scattered places in the world outside the United States of America where curricula have been developed. One indication of this is the fact that of the 194 holders of Population Council demographic fellowships through 1964, 177, or all but seventeen, received their training in institutions in the United States. Even in the United States, however, there are fewer than ten universities with substantial training programmes in population study.
8. Thus, local training opportunities in demography are not available in most parts of the world, except for on-the-job training in some statistical bureaus and the occasional opportunity to participate in specially organized short-term training courses or seminars with visiting experts. Other important limitations exist. Students at the United Nations regional centres are almost entirely government workers who have been selected for training by their Governments. These centres are not available to the ordinary student who may wish to study demography in his home area. In the United States, where substantial training capacity does exist, it is concentrated heavily in the graduate programmes of departments of sociology, with a much stnaller number of programmes in departments of economics. A recent development has been the establishment of population study in four schools of public health, growing out of an increasing interest in family planning as an aspect of maternal and child health services. Universities in the United States are organized by departments, but there is no department of demography in any of them. As yet, only one university in the United States offers a graduate degree in demography (a Master of Arts). Thus, it is not surprising that of the 356 members of the Population Association of America reported in its January 1962 roster as holding the degree of Doctor of Philosophy or an equivalent degree, 240 held the degree in sociology. No other field approached this figure. There were thirty-six degrees in economics, fifteen in biology or medicine and thirteen in geography. Only five were in statistics or biostatistics. The remaining forty-seven degrees were in widely scattered fields. The concentration in sociology appears to be more important than the scatter of persons trained in other disciplines and indicates a need to increase the opportunities to undertake the study of demography as a separate discipline, or perhaps to include it as
a regular requirement within a larger number of allied fields.
9. In the United States, at least, existing population training centres are not generally operating at capacity. It appears that most could, without undue effort, handle an increase of one third or more in the number of students enrolled. The existence of a programme of study, then, is not the only requirement for successful recruitment. Resistances to entering such programmes can be identified. These include the failure of demography to achieve an independent status in the hierarchy of university departments, the lack of early contact with demography by students and the weak image of the field, particularly in terms of a career. In addition, demography faces severe competition from other areas in terms of fellowships and related means of providing student support.
10. The desirability of establishing separate departments of demography can be argued on academic grounds, but there is no question of its advantage from the point of view of recruitment. A department is a highly visible symbol both of a field of study and of a career area. It can be presumed to offer greater fixity than any sub-area of a department like economics, which may wax or wane with current staff interests without affecting the existence of the parent department. It will normally command a larger share of resources available for development and for student support.
11. Demography is an area of low visibility today in the school programme. Students frequently will have decided on careers before they enter college and before they have had any contact with the study of population. As college undergraduates, they will seldom have the opportunity to take more than one course (or read more than a single paper) in demography. In fact, to become a demographer, a student, in the United States at least, will ordinarily have to concentrate in sociology as an undergraduate. Still more probably, he will have to elect sociology as his field of graduate study. Next, he must attend one of the limited number of universities offering work in population. Within the department, he will find competition from several established specializations, such as community studies or criminology.
12. This competition is, at one level, financial, a reflection of fellowships and other support open to a student whose interests are still somewhat flexible. There is no question but
that the recruitment of demographers requires adequate funds for assisting students, as well as for establishing programmes and providing necessary facilities. It is fortunate that, to a degree, such funds are available, since without support most students will enter other fields or will not continue their work.
13. From another viewpoint, the competition is informational. Studies of career choices have stressed the appeal of areas which are conceived as providing adequate work opportunities of a kind which excite and challenge young persons and which, at the same time, promise ample personal remuneration and status. Such opportunities are not as great in all countries for demographers as they are for persons with better established titles. Yet they do exist in good measure, and it is unfortunate that they have received little publicity. The Population Association of America is one professional organization which is currently attempting to improve understanding.
14. This paper is intended to do no more than raise issues for discussion and further elaboration by those who are in a position to assist in meeting the growing shortage of demographers. Clearly, increasing awareness of the need for basic population data and for studies of demographic trends in relation to other social and economic factors portends a rise in the effective demand for population analysts. Equally clearly, the supply will lag behind the demand unless active steps are taken to recruit personnel. So far as the recruitment of students for training goes, it will be necessary to provide additional training facilities in many more parts of the world and probably to allow for training which centres on demography, rather than making this an adjunct to programmes in other fields. Funds for student support and better communication of the opportunities which the field provides for individual satisfaction and remuneration are, likewise, prerequisites in developing additional numbers of demographers. Governments and international agencies can provide further opportunities for in-service statisticians, economists and others to participate in special training courses or to work with demographic advisers, thus increasing the number of persons with demographic expertness. Governments may also find it useful to include the title "Demographer" in the roster of official posts as a recognition of its importance and as an assurance of its existence as a career field.

# Experience of the Chembur Demographic Training and Research Centre in international co-operation 

K. C. Zachariah

1. Nine years ago when the Demographic Training and Research Centre at Chembur, Bombay, was established to help accumulate scientific knowledge in the field of demography and to train demographic personnel, a major step in international co-operation in the field of demography was taken in the Asia and the Far East region. This Centre came into being as a result of international co-operation, is sustained by such co-operation and is now promoting regional co-operation in the field of demography throughout the region served by the United Nations Economic Commission for Asia and the Far East (ECAFE).
2. The need for demographic data and personnel capable of utilizing these data for economic and social planning became increasingly evident in this region during the past ten to fifteen years, when attempts were made to develop the economic and social conditions of the people of the area through a programme of planned development. Basic population statistics were unavailable in all but a few of the countries of the region; detailed information needed for the purpose of assessing the magnitude of the social and economic problems of these countries and for formulating targets for production and consumption were altogether lacking in a majority of them; estimates of future rate of growth of population remained inefficient; and methods of checking the mounting population pressure remained ineffective in the absence of a clear understanding of the social, economic and psychological factors affecting fertility in developing countries. It was with a realization of the urgent need of a large volume of demographic data for planning purposes and of the lack of trained demographers for producing and analysing such data that the Centre at Chembur was established to serve the needs of India and other countries in the ECAFE region.
I. The establishment of the Chembur Demographic Centre
3. It was in July 1956 that the Government of India decided to establish a demographic
teaching and research centre at Bombay in association with the Sir Dorabji Tata Trust. On the basis of previous negotiations with the United Nations, it was also decided that this centre should become a regional institution to serve the needs of other countries of Asia included in the ECAFE region. Under the agreement between the United Nations and the Government of India, the former undertook to provide long-term advisers and short-term consultants on different aspects of demography and related fields of training, as well as equipment and technical literature, and other reference materials for building up a library. The United Nations also agreed to provide fellowships for students from the countries of Asia other than India.
4. The Government of India undertook to provide permanent buildings for the Centre, to grant scholarships to trainees from India, and, in association with the Sir Dorabji Tata Trust, to establish and maintain the main unit of the Centre. The Centre consists of this unit and of a certain number of other institutions located in Bombay and in Poona. The composition of the Centre is given below:
(a) The Department of Economics of Bombay University, Bombay;
(b) The Department of Sociology of Bombay University, Bombay;
(c) Two divisions in the Indian Cancer Research Centre, Bombay, dealing with human variation and the physiology of human reproduction;
(d) The Tata Institute of Social Sciences, Chembur, Bombay;
(e) The Gokhale Institute of Politics and Economics, Poona;
(f) The main unit.
5. The main unit was originally provided with a staff consisting of a director (co-ordinating officer until 1959), a statistician, a demographer and junior technical, secretarial and clerical personnel. Recently, one deputy director, one senior professional and two junior professionals were added to the professional
staff at the Centre. The unit also has the services of experts and consultants assigned by the United Nations.
6. Administrative control of the Centre is vested in a governing body, consisting of a chairman nominated by the Government of India, the heads of the co-operating institutions listed above, the Secretary of the Ministry of Health, Additional Secretary, Department of Statistics, Cabinet Secretariat; a representative of the Ministry of Finance, the Director General of Health Services, the Director of the Indian Council of Medical Research, a representative of the Sir Ratan Tata Charities, a representative of the Dorabji Tata Trust and the director of the Centre, who is also its secretary.
7. The initial agreement with the United Nations was for a period of five years. It came to an end in 1962 but was, however, renewed for a further period of two years. At the expiry of the renewed agreement in July 1964, it was renewed for a further period of two and one-half years; that is, up to December 1966.

## II. Training and research programme of the Centre

## A. Training

8. The aim of the training programmes at the Centre, as pointed out in the aide-mémoire of the United Nations issued at the time of the establishment of the Centre, "would be to help to build up over a period of years, a nucleus of persons in each country of the region who have sufficient knowledge of demography to plan and carry out such population studies as the governments and universities may wish to sponsor, and in turn, to train other persons in this field". With this objective, the Centre offers three courses of training. These are:
(a) A certificate course, which is a basic one-year training course in demography and allied subjects, on successful completion of which the trainees are awarded a certificate;
(b) A diploma course, to which students who have received the certificate in demography and who have shown promise of making demography their main professional interest are admitted;
(c) A course leading to the degree of Doctor of Philosophy.
9. The basic first-year training course (certificate course) is the major part of the Centre's training programme. This course consists of:
(a) Classroom lectures in substantive demography, technical demography, statistics and
social research methods, economics, genetics and physiology of human reproduction;
(b) Statistical laboratory work;
(c) Seminars;
(d) Visits to institutions and organizations of interest to demographers.
10. The students working for a diploma are required to map out a reading programme, with the approval of a faculty adviser, and to carry out this programme. In addition, they have to undergo one or two research apprenticeships and to complete a piece of research work of their own.
11. The Centre has been recognized as an institution for guiding students for the degree of Doctor of Philosophy in Economics (Demography) of Bombay University.
12. During the seven-year period 1957/58 to $1963 / 64$ a total of 122 persons were trained at the Centre. These trainees were drawn from seventeen countries: Afghanistan, Burma, Ceylon, China (Taiwan), Ghana, Guinea, India, Indonesia, Iran, Japan, Laos, Nepal, Pakistan, the Philippines, the Republic of Korea, Thailand, and from Hong Kong. Of the total number of students, 116 received the Certificate in Demography and twenty-five received the Diploma.

## B. Research

13. The research programme of the Centre was developed by attempting to identify problems that are of primary importance to the countries of Asia and the Far East and which the Centre is especially well-qualified to undertake because of its international nature, the availability of United Nations experts and its library, and the qualifications and interests of the permanent staff. The research programme is divided into five major parts: (a) studies of fertility and family planning; (b) studies of internal migration and urbanization; (c) assessment of the quality of census data; (d) demographic problems of economic development; and (e) special studies, worked out in co-operation with the Government of India or of other nations in the ECAFE region, or with other organizations.

## III. Promotion of international CO-OPERATION

14. Realizing the important role which regional and interregional co-operation could play in the rapid development in this region, of demography in all its aspects-provision of data, development of training and research facilities etc.-the Demographic Centre has
endeavoured throughout its existence to promote international co-operation through a variety of methods. In the first instance, the training and research programme of the Centre is developed through international co-operation and is oriented to the promotion of such cooperation. Secondly, such co-operation is initiated and sustained by the establishment of a variety of institutional structures.
15. There are several elements in the training and research programme of the Centre which promote international co-operation. First, the trainees at the Centre live on the same campus, and they come into intimate contact with not only the internationally selected faculty of the Centre and the large number of demographers and other social scientists who visit the Centre each year, but also with the Fellows from each of the other countries in the region. The contact which the trainees thus establish with the faculty and the visitors, and with the other trainees during their stay at Chembur is maintained even after their departure from the Centre and goes a long way in the promotion of international co-operation among the demographers of the region. Secondly, the training programme at the Centre is developed to suit the needs of the students from all the countries of the region and, as a consequence, the trainees develop a regional outlook on demographic problems. The library at the Centre and the students' seminars play important roles in bringing about such an outlook. The library is well-equipped with census and other statistical materials from all the countries of the region, and even from those outside it. In the students' seminars, demographic researches on a variety of subjects pertaining to the various countries of the region are presented, and all the trainees take part in the discussion of these research papers.
16. The students' reseatch is only a small part of the total research activity of the Centre. Many of the research projects sponsored by the Centre have also contributed to co-operation between the Centre's staff and other organizations in the region. Thus, the researches on population projections for Ceylon and on the manpower resources of that country brought about close collaboration between the Centre and the Planning Secretariat of the Government of Ceylon.
17. The Centre also promotes regional cooperation by contributing research papers and acting as officials and discussion leaders in seminars and conferences organized by national and international agencies. The Centre played a very significant role in the successful holding
of the Asian Population Conference in Delhi in December 1963. In this conference, the faculty and the students (past and current) of the Centre contributed several research papers, acted as conference officials, discussion leaders, panel members, rapporteurs, etc.
18. Apart from taking part in conferences organized by other agencies, the Centre also sponsors regional seminars and conferences in collaboration with the United Nations and the Government of India. These and other institutional setups especially established for the sake of promoting regional co-operation are discussed below :
(a) Inaugural conference of the Centre: under the joint auspices of the United Nations and the Demographic Centre, an inaugural conference was held at Bombay between 5 and 9 November 1957, at which representatives from Burma, Ceylon, India, Japan, the Republic of Korea and Thailand were present. The teaching and research programmes to be promoted by the Centre were reviewed; the ways of developing co-operation between the Centre and the Governments in the region, as well as institutions and individuals interested in demographic problems, were discussed; and proposals were put forward for the establishment of a standing advisory committee on which the United Nations, India, the countries of Asia other than India in rotation and the International Union for the Scientific Study of Population would be represented;
(b) Seminar on Evaluation and Utilization of Population Census Data in Asia and the Far East: this seminar was conducted by the Centre on behalf of the United Nations and the Government of India from 20 Jume to 8 July 1960. It was attended by representatives from Afghanistan, Burma, Cambodia, Ceylon, China (Taiwan), France, India, Indonesia, the Republic of Viet-Nam, Sarawak and Thailand, in addition to representatives of the United Nations and its specialized agencies. The seminar was arranged for the purpose of aiding Governments of countries in Asia and the Far East to plan their census programmes in such a way as to provide the maximum amount of information relevant to the practical problem of policy-making and planning of economic and social development;
(c) Advisory Committee: an important step in the direction of international co-operation was taken with the establishment of a standing advisory committee, the composition and functions of which were agreed upon in the inatgural conference. It was intended that the advisory committee would meet once a year to
review the activities of the Centre and to advise the governing body on future policies and plans. So far the committee has met three times (1958, 1959 and 1961) and has made important recommendations;
(d) Directory of Demographers: at the inaugural conference, it was proposed that a directory of demographers be compiled for the ECAFE region, indicating the governmental and/or other institutional affiliations, as well as the research interests, of each person included. This suggestion was implemented in 1960. The original Directory was revised twice, first in 1962 and then again in 1963. Each new issue of the Directory was more comprehensive and up to date than its previous ones. Included in the most recent issue are: Afghanistan, Burma, Cambodia, Ceylon, China (Taiwan), Hong Kong, India, Indonesia, Iran, Japan, Laos, Malaysia, Nepal, Pakistan, the Philippines, the Republic of Korea, the Republic of Viet-Nam and Thailand;
(e) Corresponding secretaries: in order to facilitate the flow of information and exchange of ideas between the Centre and each of the Governments in the ECAFE region, one person or agency has been nominated by each Government to serve as a corresponding secretary. Through this secretary, the Centre has been able to obtain new materials from censuses and surveys as they became available. To these secretaries have been forwarded copies of reports, news-letters and other items of interest of the Centre ;
(f) News-letter: in April 1960, the Centre began publishing a news-letter three times a year. The news-letter contains information about the Centre, the students and staff members. Each year one issue is devoted to the activities of the former students. Brief summaries of the major researches undertaken at the Centre and reports about the major demographic seminars and conferences held in the region are also included in the news-letter. About 600 copies of each issue are distributed;
$(g)$ Director's visit to the region: at the first meeting of the advisory committee, it was proposed that, as a means of promoting re-
gional co-operation, the director of the Centre should visit the countries of the region periodically. During the past nine years three such visits have been made. These visits were of great benefit to the Centre in establishing contacts with Governments and with demographers in the region, thereby obtaining and exchanging information regarding the research work in progress in these countries, as well as information on matters which were of particular benefit to students coming to the Centre from these countries.

## IV. Concluding remarks

19. With the establishment of the Chembur Demographic Centre, a beginning was made in international co-operation for the promotion of demographic training and research in the ECAFE region. During the few years of its existence, the Centre has been able to make substantial contributions in the fields of training and research. It has successfully trained more than 130 men and women from the region and has played a significant part in the development of demographic research in the region. It has organized seminars and conferences, and has helped to disseminate demographic information among Governments, universities and other research institutions. It has built up a good reference library of books, journals, pamphlets and statistical materials on demography and related fields. The students trained at the Centre are now capable of initiating training programmes at the elementary level in their own countries. The Centre at Chembur is therefore in a position to develop itself into a seat of higher training and research in demography. In achieving these manifold objectives, regional and interregional co-operation played a decisive role. It cannot, however, be claimed that all that needs to be done has been achieved. Few countries in the region can boast of possessing reasonably accurate census and registration data. It is in this field that international co-operation should be extended on a larger scale to develop in each country a government organization capable of collecting reasonably accurate demographic data.

## SUMMARIES OF PAPERS

## The development of demography and demographic research in the Netherlands

S. Groenman and H. J. Heeren

General interest in demography has increased steadily in the Netherlands since the World Population Conference, 1954. Furthermore, during this period the first university chairs in demography were created-one in demography and sociography at the Roman Catholic College of Economics at Tilburg in 1960 and another in demography and physical planning at the University of Amsterdam in 1961. However, no degree in demography is obtainable thus far, as the subject is subsidiary to degrees in sociology or human geography.

Demographic research has been concentrated on problems of migration, owing to the extensive migration movements, both internal and international, that the Netherlands has experienced in recent years. With regard to internal migration, studies have been made both of migration as a mass movement and of the migrants themselves, i.e., their motivations, frustrations, assimilation and effect on the sending and receiving societies. International migration has received even greater attention. Between 1946 and 1953, there were 400,000 emigrants from, and 310,000 immigrants to, the Netherlands.

This movement has prompted some of the most important demographic studies published in recent years.

Although research on fertility is second to that on migration, such research is not as great as one would expect in view of the country's high birth rate (currently 20.8 per 1,000, the highest in Western Europe). The scarcity of research in this field is attributed to taboos (linked with the religious diversity and the "pillarization" of the country) surrounding the subject, but these now appear to be less rigid and a survey on factors influencing fertility was planned for the fall of 1965 by the Institute of Sociology, Utrecht State University.

Very few studies of mortality have been made, perhaps owing to the fact that the

Netherlands has one of the lowest death rates in the world.

In recent years the study of historical demography has received considerable attention. Research on this subject has been and is currently being undertaken.

## Translation of the Multilingual Demographic Dictionary of the United Nations into Persian

## Asdolah Moezi

Since its introduction in Iran a few years ago, the new science of demography has received much attention. The writer of this paper has translated the Multilingual Demographic Dictionary into Persian with certain considerations in mind.

There is no need to emphasize the numerous difficulties with which the translator was faced. The more important ones were: (a) similarity of terms; (b) short definitions; (c) variety of arguments; (d) innovation of words; and (e) lack of technical words.

The advantages served by the translation of the Multilingual Demographic Dictionary are as follows:
(a) Researchers will be able to comprehend the precise meaning of various demographic terms and definitions;
(b) The Persian language will be strengthened in scientific and technical words;
(c) Foreign experts will know the exact demographic Persian terms.

Furthermore, with this translation of the Multilingual Demographic Dictionary, the translator hopes to encourage demographers in the developing countries to translate the work into their own languages. Undoubtedly, making this material available in the languages of the developing countries would be a considerable contribution to the science of demography. Such translations of the Multilingual Demographic Dictionary would promote understanding of the concepts of demography in these countries.

Meeting B. 10

## POPULATION AND NATURAL RESOURCES

## PAPERS

## Utilization of renewable resources as a stimulus for socio-economic development

Lawrence W. Bass and S. J. Langley

1. Industrial development projects involving renewable resources have special significance in developing economies with mounting populations, as a means of providing employment opportunities, not only in the factories established, but also through the job-multiplier effect felt broadly throughout the economy. Current resource endowment patterns need not be unduly limiting in the long run, because utilization practices are constantly changing. Developing countries may not necessarily have to rely on the same raw materials that are being used in more mature regions. And, of course, as is widely appreciated, ways can always be found for using more effectively such resources as are available.
2. The search for more advantageous raw materials is a major concern of industrial enterprises in highly developed countries. The situation manifests itself most strikingly in the competition between industries using different starting products. In the textile industry, there is commercial rivalry among the natural fibres and the synthetics based on cellulose or on chemicals derived from organic sources or fossil fuels. In foods, there is a continual shift in consumption patterns among items derived from different agricultural products. In materials of construction, there is competition among iron and steel, non-ferrous metals and alloys, plastics, combinations involving cellulosic materials and ceramic products.

## Technological background for resource UTILIZATION

3. Dynamic change in utilization of raw materials has thus become the natural course of events in the more mature economies. The developments that have taken place have provided a background of knowledge and expe-
rience from which the technology can be modified and adapted by the newer nations to promote the most effective use of their basic products in the national interest.
4. A competitive position in raw materials is often a prerequisite for the success of a production enterprise. This fact leads many manufacturing concerns to integrate backward to ensure that there shall be an adequate supply of starting products. It also leads other operating units with good resources of raw materials to integrate forward into intermediates and even to end-products. Both processes illustrate the benefits of coordinating closely the chain of steps required to convert a resource into useful end-products.
5. Leading food companies in highly developed countries often undertake extensive agricultural development programmes in the farm territories from which they draw their raw produce. These include recommendation of varieties to be cultivated, provision for sources of selected seed or breeding stock, educational work on improved techniques to increase yield of acceptable product and even some form of assistance in arranging for financing of farm improvements. These measures are adopted to ensure a regular source of raw material of suitable quality within an area which permits economic collection and centralization of starting products at the processing site. Similar activities are carried out by some agricultural cooperatives.
6. The composite effect of agricultural development programmes on the economy is widespread. The individual farms are privately owned and operated, but the processing units aid their success by providing a steady and attractive market which is mutually advantageous. Hence, the farmers obtain greater eco-
nomic yield from their land and can enjoy a higher standard of living. The processing plants improve their efficiency as a result of better quality and integration of raw material supply. And the benefits extend to the consumer, who gets greater value for his money as a result of improved products. This chain of socioeconomic development is found, for example, in operations in dairy products, fruits and vegetables, and animal husbandry. In silviculture, too, large paper firms conduct programmes of systematic reforestation and carefully planned logging procedures to ensure sustained yield of charge stock within economic transportation distance from their mills.
7. This process of upgrading the utilization of raw materials may be looked upon as a search for optimum economic adaptation of resources, rather than as a substitution of materials, which to some may connote inferiority in the final product. Success in finding the best starting materials and adapting them to new uses often leads, as mentioned above, to interindustry competition, which, in the long run, encourages greater flexibility in use of resources. While this competition may pose difficulties for individual industries when they begin to lose certain markets, as has been the case when rayon has invaded such cotton outlets as tire cords, it nevertheless represents the impact of aggressive technology on the effective deployment of raw materials.

## Use of renewable resources in developing countries

8. The use of raw materials in the newer economies must be viewed broadly in terms of contribution to the general welfare, as well as to the individual undertaking. This evaluation must take into account not only direct costs, but also the total employment created and the impact on operation of production facilities at optimum level as a result of the quality, reliability and flexibility of supply of the more important starting products.
9. Exploitation of renewable resources from farm and forest results in greater income to non-urban workers, expansion of transportation facilities, employment in primary processing plants, encouragement of other industries to make end-products and better satisfaction of the needs of the consumer, all within the framework of enhancing national self-sufficiency. While the central plants which upgrade the natural commodities may not, of themselves, create a large number of jobs, because of mechanized operations, they generate employment in growing, harvesting and centralization,
and in the satellite industries which convert and distribute the final articles or commodities which reach the consumer or other industries.
10. Because of this broader spectrum of contributions to socio-economic development, commercial evaluation of the primary operation may not give the whole story on industrial advantages to a developing country. Through upgrading the products of the land and encouraging more efficient agriculture to supply a stable and discriminating market, an impetus is given to rural development. The establishment of a dairy industry, for example, will gradually raise the status of animal husbandry and lead to better understanding of sanitary practices. It: can also bring about better nutrition in the producing areas through improved effectiveness of home use of surplus and by-products. A wellrun village milking-shed, collecting and forwarding to the processing centre the milk obtained by a group of farmers, can become a potent force in creating a better life for the community.
11. Since agricultural resources are the main support of many developing economies, their conversion into products used in the country has many self-evident advantages. They may conserve foreign exchange by providing alternate products in place of those imported, thus permitting reallocation of these reserves to other development projects. While much of the emphasis here has been placed on endproducts for internal use or export, every step forward in upgrading the taw materials to a higher degree of concentration or purification plays its part in the total of national progress.

## Need for defining the national profile of Raw materials

12. If a successful programme of resource utilization is to be carried out, a systematic survey of current and potential raw material production should be conducted. A catalogue of agricultural products should be assembled, including not only types and volumes, but also quality, geographical concentration and potential for progressive upgrading in type, quality, yield and processing characteristics. The list should be assessed for adaptation of the agricultural system to the production of new classes, species or varieties that may have been developed in other countries, if such innovations are required.
13. This analysis of potential changes in the agricultural resource profile should take into account functional performance, rather than direct relationship to raw materials used in other countries. For example, in the search for
fibre-producing plants, it may be possible to use effectively some indigenous species, rather than to introduce the types used elsewhere.
14. While wood-pulp is generally used for making paper products, successful processes are available for converting bagasse, straw and reeds to this purpose. It may be possible to improve the lumber resources in certain countries which are poor in timber by introducing varieties of trees which give adequate shade, soil conservation and weather protection, but, at the same time, are a good source of board stock. Alternatively, the need may be filled by production of composition boards based on local cellulosic raw materials with suitable binders.
15. Such measures will reduce the requirements for costly imports and will also create employment in the cultivation, harvesting, collection and processing of the starting products. The subject offers a challenge to the joint efforts of agronomist, scientist, engineer and economist to create an indigenous technology that takes advantage of pertinent knowledge and experience from the world reservoir.

## Conservation of resources

16. It is vitally important that hard-won agricultural products should not be dissipated through avoidable losses. It is claimed that in one large country in which under-nourishment is an endemic problem, the amount of grain that fails to reach the consumer is nearly one quarter of the total production of its farms. The losses occur through faulty mechanical handling and storage, as well as through damage by pests and spoilage. Yet, grain has a comparatively high degree of self-protection, and one is horrified to think of the wastage that occurs in such perishable items as the more fragile vegetables and fruits. Here is an area that offers great opportunities for preserving the values of renewable resources. One of the most promising approaches, in addition to instituting corrective precautions against the more obvious forms of loss, appears to be in developing a technology for localized semiprocessing to reduce the produce to more stable condition as soon as possible after harvest.
17. A related situation is the wastage of materials through over-design. This is not involved to such noticeable extent in agricultural products, but it can represent important inefficiencies in the use of such scarce structural materials as wood and metal.
18. By-product utilization has special importance in developing countries, and the economic considerations may be very different
from those in industrialized countries which have wider access to raw materials. In the latter situations, adverse factors of availability, concentration, modification and complications in recovery of values from wastes and rejects often cause the failure of these projects from the standpoint of costs, and a large amount of unfruitful work has been conducted on unsuccessful projects of this type. In countries that are short of resources, a recovery system that might be uneconomic elsewhere may result in a contribution to the economy.
19. As an example of the by-product utilization that can be derived from a well-conceived primary operation, the offshoots from a sizable slaughter-house of modern design may be mentioned. Not only is the yield of meat improved in character and sanitary quality, but the useful waste parts are collected in forms suitable for efficient use. Subsidiary operations for handling them include tankage for fertilizer, blood meal for animal feed, leather tanning, glue and adhesive manufacture, gelatine, fat rendering, soap production and hair for mattresses.
20. More attention should be given to quality standards, as well as to projects for preliminary processing of renewable resources moving into export. As international transportation and communication improve, each country's economy becomes more integrated into world competition. For example, inadequate steps to counteract environmental conditions can result in lower quality of hides and skins, thus reducing their value for internal use or export. Failure to employ adequate grading of fruit and vegetables going to foreign or metropolitan markets can result in lower prices, but the culls and rejects would be suitable for local distribution or processing.
21. Even the question of suitable packages to provide residual value in the packaging materials has significance. It is impressive to see the ingenuity with which metal or textile containers can be converted to useful purposes in skilled artisan shops and households.

## Utilization of available energy resources

22. Energy sources are, of course, important in socio-economic development. Major attention has been devoted to hydroelectric potential and to fossil fuels. But solar energy and wind energy have not received the same amount of inventive study to harness their forces in ways suitable to developing regions. While this subject might superficially appear to lie outside the scope of this paper, these forms of energy are particularly pertinent to agricultural production and conservation.
23. Many developing countries lie in climatic zones in which solar energy could be put to useful purpose if suitable devices were invented to meet local requirements. For example, under conditions of low humidity, sundrying of perishable fruits and vegetables would aid in conserving these materials. Village units for carrying out the operation efficiently would add to a country's available food-stuffs. The technology is available for installations of this type.
24. In some western countries, windmills are a feature of many rural areas and serve as a continuing source of energy for pumping or irrigation, thus relieving the drain on human
or animal labour. Such devices are not employed in many developing countries, where their use would appear to be advantageous.

## Conclusion

25. Optimum use of renewable resources is an important basis for undertaking socioeconomic programmes in developing countries. The impact of such projects on employment opportunities is broad. Because they involve a co-ordinated approach to farm production, collection and centralization of raw products, and processing and distribution systems, they are best attacked by joint efforts of agronomists, technologists and economists.

# The relationship of material resources and population to economic and social development 

Joseph L. Fisher

1. The material level of living of the inhabitants of a country or a region depends on several factors: natural resources, including land; human resources, principally entrepreneurs, management and the labour force; capital resources, such as industrial plants, transportation facilities, housing and electric power; and cultural and institutional resources, for example, science and technology, the educational system, and governmental and private organizations. It is difficult to separate these basic factors. Thus, a natural resource, such as a mineral in the ground or unutilized agricultural land, must have technology, capital and labour applied to it before it becomes of economic significance. Each of the four basic fact-ors-natural resources, human resources, technology and capital, and institutions-is a necessary ingredient of economic and social development, and each has to operate in concert with the others.
2. Since a country or region must possess within its own borders the material resources on which to base its economic development, or be able to acquire them through trade with other countries or regions, the relationship between material resources and population is important as an indicator of the level of living. Speculation as to the course of movement of this material resources-population relationship has given rise to numerous propositions. The most famous perhaps is that of Malthus: that population tends to outrun the means of subsistence, subject to the constraint of positive (famine etc.) and preventive (birth control etc.) checks.
3. This relationship in its simplest form can be expressed: level of living equals material resources divided by population. The term, material resources, may be broken down into natural resources of various kinds, industrial products and related capital resources. Also, the term, population, can be broken down into the labour force, age groups and education levels. Countries whose economies are in a take-off stage of development will progress rapidly as new inputs of capital become avail-
able and are translated into large increases of consumption goods. At earlier stages, population growth may tend to outrun increases in usable material resources, necessitating aid from outside or a reduction in living levels.
4. The most important commodities in the resources-population relationship are food and energy. With respect to food consumption, the statistical evidence seems to indicate that people in most parts of the world have seen only moderate improvement in the last thirty years and progress has been least where it is needed most. In the more developed areas, such as northern America, western Europe and Oceania, calorie consumption per capita is currently about what it was in the 1930's since people in these parts of the world have been consuming all the calories they need anyway. In most of Asia and Africa, increases have been very slight, if indeed there have been any; while in Latin America, there seems to have been a modest increase. In eastern Europe and the Union of Soviet Socialist Republics, improvements reported over the past three decades have been considerable, virtually to the point where further increases in per capita food consumption will not be needed.
5. Looking to the future of 1980 and 2000 , a continuation of the consumption trends of the past decade would indicate that considerable gain is possible for the world as a whole, even on the basis of the high population projections set out by the United Nations- 4,300 million in 1980 and 6,900 million in 2000 , compared with 3,000 million in 1960 . If the first few years of the 1960's are taken as the sole basis of extrapolation, the picture is much less optimistic because the rate of increase in food production in the past few years has remained stationary or even declined in many parts of the world. However, there exists a large back$\log$ of improvements in agriculture, which have already been applied in the more advanced countries and which could, over the coming decades, be adapted to other areas and result in large increases of production in most of the farming areas of the world.
6. In the world's average diet, there are much larger and more serious deficiencies in proteins and vitamins than in calories. While the world needs only a 20 to 30 per cent increase in per capita calorie intake, it needs a 40 or 50 per cent increase in its per capita protein supply to reach the western European standards of 1960 . The increase in animal proteins (milk, eggs, meat etc.) required would be on the order of 200 to 300 per cent. ${ }^{1}$
7. Per capita food production indices, expressed in value terms, for the world, excluding China (mainland), increased by about 7 per cent during the past decade, and by about 10 per cent compared with the 1930's or with the years of the late 1940 's and early 1950 's. ${ }^{2}$ If the rate of the past decade continued to the year 2000, world per capita production would increase by 40 to 50 per cent, but would still be below the current level of western Europe by 15 to 20 per cent. Figured on this basis, in the year 2000, the gap between the level in most of the developing countries and the current western European level would be greater still, despite some absolute per capita gain in most of them. In addition, of course, western Europe continues to import food, so that consumption there exceeds production slightly.
8. The chief hope for increasing food production in the developing countries appears to lie in increasing crop yields per acre. Yields for wheat, rye, maize, rice and potatoes in northern America and Europe have been running approximately twice that for Asia, Latin America and Africa. Some increase of acres in cultivation through irrigation, drainage and land clearing is possible, but mostly at rather high cost; gains in output from this source would appear to be far less promising than from increasing yields on existing farm land.
9. To increase agricultural yields in developing countries will not be easy or cheap. Larger amounts of fertilizer, improved cultivation and harvesting practices, proper use of irrigation water, better drainage and soil demineralization, use of better seeds and pesticides, more mechanization, adequate credit for needed capital investments, more efficient marketing arrangements, changes in ownership and tenure patterns, and better management, generally, will be necessary. Particularly important will be the increased production of nitrogen and phosphate fertilizers, plus the education of farmers in their proper use. This will require

[^180]more investment in fertilizer plants and in electric power. Fortunately, there are in the world plenty of fertilizer resources (phosphate, potash and nitrate). In semi-arid places like the Indus Valley, north-eastern Brazil and many parts of Africa, water-supplies of required quality can often be increased with additional capital and energy, or can be used more effectively.
10. The trend in per capita consumption of energy in the developing regions of the world over the past thirty years permits greater optimism. The rate of increase for the world over the past twenty-five years has been nearly 2 per cent per annum, compared with 0.5 per cent for food, with higher rates, fortunately, in those countries where consumption is low. ${ }^{3}$ In Mexico, the increase from 1929 to 1960 was more than three times; in Brazil, nearly four times; in India and Nigeria, about double. Post-war trends indicate that this kind of increase is continuing and even accelerating. By the year 2000, again on the basis of the high United Nations projections of population, the world average per capita consumption of energy could well exceed that of western Europe in recent years. Since energy is a basic ingredient of industrial development and economic development generally, the rough trend projection of a five- to six-fold increase in world energy consumption between 1960 and 2000, nearly a tripling in per capita terms, is indeed a hopeful sign.
11. Since many countries are largely dependent on foreign supplies for their mineral fuels and since many other countries find their richest source of capital and foreign exchange in exports of these fuels, it will be important to economic development that the channels of world trade be unobstructed. The immense oil reserves in the Middle East, in North Africa and in the Caribbean area of northern South America, as well as in other parts of the world, can play a significant part in the general economic advance. It will, of course, be desirable that these reserves be developed as efficiently as possible, taking full advantage of latest techniques of both discovery and recovery. The investment of net earnings and royalties from oil and other mineral enterprises in the conservation and development of land and water resources, in education and health and in other beneficial lines will be important.

[^181]12. In various countries, there are large reserves of oil shale and tar sands, from which crude oil and refined products can be recovered. Oil shale in the United States of America, and perhaps in Brazil, and tar sands in Canada are close to being economically competitive with conventional liquid petroleum. The underground production of liquid or gaseous fuel from coal and oil shale, if economical techniques can be developed, would eliminate the necessity for transportation of ores, construction of refining and processing mills, and disposal of most waste materials.
13. Nuclear energy, chiefly as converted to electricity, is already becoming a factor in the total energy situation in the United States of America. By 1980, for the United States, it has been estimated that about 20 per cent of electricity consumed will come from nuclear reactors; by 2000 , about half. This would be about 5 per cent of total energy consumed from all sources in 1980, and 15 per cent in 2000. ${ }^{4}$ Undoubtedly other countries will also make progress along this line; those countries with poor conventional sources of energy have a special incentive to go to nuclear power. It should be kept in mind, however, that much capital will be required, not only for reactors, but also for generators, transmission lines and distribution facilities, plus reliable base loads of industrial, household and other uses. The fuel requirements of uranium and thorium do not appear difficult, but facilities for processing and enrichment are costly. Developing countries will want to plan to take full advantage of nuclear power in ways suitable to their own economic situations, but should take care that the problems are not underestimated, compared with obtaining additional energy in more conventional ways.
14. With respect to iron-ore, future prospects are also reasonably optimistic, because large new discoveries of high-grade deposits have been made in recent years in a number of areas of the world, including Australia, Brazil, India, Liberia and Veneztela. More difficulty will probably be encountered in certain other metals, for which reserves in sight are far less abundant. For copper, lead, zinc and certain other metals, projections of recent rates of consumption, even taking into account the reuse of scrap, rise above currently known and inferred reserves before the end of the century. Large new ore discoveries, significant technological improvements or increasing use

[^182]of substitutes will be needed if higher costs and diminished consumption are to be avoided. ${ }^{5}$ Fortunately, the outlook for aluminium is much brighter, even though obtaining sufficient supplies of high-grade bauxite may become quite costly by the end of the century. Alumina, from which the usable metal can be obtained, can also be extracted from clays which occur widely throughout the world and at costs not too much above the current ones. The critical factor in obtaining enough aluminium is electric power, for which there are, in many parts of the world, major hydroelectric potentialities, plus large sources of conventional hydrocarbons.
15. Whether the world's forests will be able to stand the drains projected for the next few decades seems uncertain at this time. One encouraging sign is that 40 per cent of the world's total wood came from northern America and western Europe in 1960, yet the forested acreage in these two areas is only a little over 20 per cent of the world total. Thus, if sustained output in the rest of the world could be brought to a European-American level, consumption could be increased substantially, perhaps doubled. This would still be less than the projected tripling or quadrupling of demand which a continuation of the post-war consumption trend would indicate. However, substitute materials are available, e.g., steel, aluminium, fibreboard and ceramic building blocks. The physical potentials for hardwoods in the tropical areas of the world are known to be great, but the problems of economic development are most difficult. Further gains could be made by the application of more efficient management and cutting practices to the large forested areas in virtually all countries of the world in which modern, scientific forestry is not currently being undertaken.
16. Whether the relationship between material resources and population will improve, stand still, or deteriorate cannot be known except with the passing of time. Recent trends and future projections afford grounds for optimism regarding energy and certain of the mineral materials. For food, the future is clouded with uncertainty, as it is also for forest products. However this may be, certain factors will be critical for the outcome. The resourcespopulation equation can be affected by events, forces and deliberate policies acting on one or both of the two elements in the equation. The

[^183]net result of these factors will determine the level towards which the relationship will tend.
17. Of great significance will be the trend in population growth itself, and this is primarily a matter of the birth rate. In the last few years the annual birth rate for most Latin American countries has exceeded 40 per 1,000, while that for much of Africa and Asia apparently has been as high. ${ }^{\text {E }}$ Total population in Latin America has been increasing recently at some 3 per cent per annum, while that in Asia and Africa, where death rates are higher, the rate of growth apparently has slightly exceeded 2 per cent. The more developed parts of the world have had lower birth rates and lower rates of population increase, especially Europe, where the population has been growing at around 1 per cent annually. It is still anticipated by many demographers that as the developing countries become more urbanized, as people there become more highly educated, and as they find a way to higher per capita incomes, birth rates will decline, as they did at an earlier time in the economically more advanced western countries. Deliberate limitation of births through wide-spread and effective use of birth control measures may enter more prominently into the picture during the coming years, as control techniques are perfected and made cheaper and as social and religious taboos are loosened.
18. Large programmes of information and education in many of the developing countries will undoubtedly be necessary to impress upon people the dangers inherent in current trends of births and deaths, and to instil in them a desire to find and to apply those policies which can alter the trends, along the lines of their own wishes. Research in the physiology of reproduction has been extremely lively in recent years and may yield important new breakthroughs in our understanding of processes upon which new, safe and more effective control measures can be based. Assertion by people of rational control over their own rate of increase can be applied in future years to births, as acceptable means become available and as the desire to do so becomes stronger.
19. Very important also will be the future levels of education, health, science and technology, investment, work skills and managerial skills in countries and regions currently regarded as over-populated. Perhaps most important of all is a strong motivation towards

[^184]economic development. Successful programmes in these fields could permit the production of food and other materials in poorer countries to surpass population increase rapidly enough to allow social forces to come into operation, which might lead to a slower rate of population increase. A decrease in the number of children, unless offset by an increase of old non-producers, would mean an increase in the relative portion of the population in the working ages. The total cost of rearing children would be less than otherwise, and the income available for educating and caring for children would be larger.
20. More strictly on the resources side, further scientific knowledge about land, water and minerals, and how to develop and use them would be helpful. An example would be the development and application of low-cost techniques for demineralizing ocean and brackish waters so that agriculture and industry could flourish in arid parts of the world. Further developments in the control of nuclear fission, and beyond that nuclear fusion, contain the promise of very large amounts of electric power and heat virtually anywhere in the world. The oceans represent an immense store of food and mineral resources about which relatively little is known. Even the land itself has not been explored in any great detail. Newer techniques for discovering underground minerals have greatly changed the former estimate of available reserves. In many parts of the world, modern mineral prospecting has not been undertaken. Added knowledge about how to increase agricultural yields seems clearly in prospect. Development of hybrid trees promises ultimately a large increase in the output of forest products.
21. Closely related to new knowledge about resources is the application of technical knowledge to the problems of resource development through capital investment and skilled management. The point has correctly been made that the application of the best-known farming techniques everywhere in the world would so increase the output of crops that no one anywhere would have to go hungry. The real problems, of course, lie in finding the investment funds, the skilled labour and the efficient management, along with other necessary items to make such improvements possible.
22. Numerous social, institutional and organizational changes will be necessary if levels of living in the poorer countries are to rise significantly and soon. In this regard, each country must experiment and innovate for itself, basing its new institutional arrangements
upon its own traditions and the possibilities open to it. The establishment and execution of resource development programmes, closely geared to economic plans generally, are proving to be effective as the means by which countries are able to move forward in developing their resources so as to support and sustain economic advancement. Successful resource development programming will involve research and development activities, careful evaluation of alternative development schemes and the setting of priorities so as best to serve social and eco-

[^185]nomic objectives. ${ }^{7}$ The strategy for resource development will probably vary from country to country, depending upon its particular situation. Aid from the more developed and wealthier countries can be helpful, but the main effort must come from within. Of particular importance will be institutional improvements to expand world trade and investment in resources, so that abundant and low-cost materials, wherever they are in the world, can flow into world markets and be purchased by those who need and can afford them.
Fisher and Roger Revelle, "Natural resources policies and planning for developing countries", Natural $R e$ sources: Energy, Water and River Basin Develotment, vol. I, papers prepared for the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, held in Geneva, 1963 (Washington, United States Government Printing Office, 1963),

## Mineral resources and rates of consumption

## M. King Hubbert

1. The context in which this World Population Conference is being held is briefly as follows: the world population by 1965 has reached a magnitude of about $3.35 \times 10^{9}$, and is increasing at such a rate as to double in about thirty-six years. Of this population, about 30 per cent live in geographical regions with moderate-to-high states of industrialization; about 70 per cent live in regions of low indastrialization with subsistence agriculture as the principal source of livelihood.
2. The fundamental characteristic which distinguishes an industrial civilization from a contemporary non-industrial one, and from all civilizations prior to three centuries ago, is that industrialized societies are completely dependent upon large-scale consumption of mineral resources, particularly those of energy and of the industrial metals. In fact, the 30 per cent of the world population who live in the industrialized areas consume approximately 90 per cent of the world production of industrial energy and mineral resources.
3. Consequently, a question of fundamental importance in any consideration of the world population problem is whether (and under what circumstances) the benefits, in terms of public health and the general well-being now enjoyed by the populations of industrialized areas, can be extended to the much larger populations in the currently non-industrialized areas of the world. This involves the further question of whether the world's mineral and energy resources are adequate for such an undertaking, and also whether a state of large-scale industrialization is a condition which can be prolonged indefinitely, or whether such a state is an intrinsically ephemeral phenomenon in the longer span of human history.
4. Since a high state of industrialization is not possible without large-scale consumption of energy and mineral resources, examination of the foregoing questions can scarcely be made without prior inquiry into the requirements and availability of the essential resources. This can be done in a preliminary way from the facts stated in the opening paragraphs of this paper. Assuming that approximately 90 per cent of
the world production of energy and mineral resources is consumed by the 30 per cent of the world population now living in industrialized areas, one can estimate how much the annual production would have to be increased in order for the average consumption of the entire world population to equal that of the 30 per cent at the current time. If one lets $M_{1}$ be the current annual rate of mineral production, $C$ the rate of mineral consumption per capita of the industrialized areas, $M_{2}$ the rate of production necessary for the world per capita consumption to equal $C$ and $P$ the current world population, then

$$
\begin{equation*}
\frac{0.9 M_{1}}{0.3 P}=C=\frac{M_{2}}{P} \tag{1}
\end{equation*}
$$

From this, it will be seen that

$$
\begin{equation*}
M_{2}=3 M_{1}, \tag{2}
\end{equation*}
$$

or that it would be necessary to increase the current world rate of mineral production by a factor of 3 .
5. This figure, however, is only a minimum figure, since it, in effect, assumes that the rest of the world has already become industrialized and so represents only the rate of mineral consumption required to sustain its operation. However, before this state could be reached, a large expenditure of energy and minerals would be required to build up the necessary stock of industrial equipment.
6. Perhaps a more informative way of seeing the magnitude of the discrepancy between the per capita mineral consumption of the industrialized and the non-industrialized areas is the following. Let $C_{1}$ and $C_{2}$ be the current per capita mineral consumption rates in the industrialized and non-industrialized regions, respectively. Let $M$ be the current rate of mineral production and $P$ the current population. Then

$$
\begin{align*}
& C_{1}=\frac{0.9 M}{0.3 P}=\frac{3 M}{P},  \tag{3}\\
& C_{2}=\frac{0.1 M}{0.7 P}=\frac{M}{7 P}, \tag{4}
\end{align*}
$$

Then, dividing equation (3) by equation (4), one obtains

$$
\begin{equation*}
\frac{C_{1}}{C_{2}}=\frac{3 M / P}{M / 7 P}=21 \tag{5}
\end{equation*}
$$

That is to say, in order to bring the operation of the non-industrialized regions up to that of the industrialized regions, without allowance for capital equipment, the average per capita
mineral consumption of the former would have to be increased by a factor of about 21.
7. For an idea of the approximate magnitudes that are involved, there is shown in table 1 the world production of some of the principal energy and mineral resources for the year 1963 and also the approximate average per capita consumption of each for: (a) the world as a whole; (b) the industrialized areas; and (c) the non-industrialized areas.

Table 1. Annual world production and consumption per capita of major mineral products, 1963

| Minera! product | World |  | Consumption per capita |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Anmual production (metrictons) | Average production per capita (kilogrammes) | Indutrialized areas (kilogrammes) | Non- industialized areas (Eilogrames) |
| Coal | $2,650 \times 10^{0}$ | 791 | 2.370 | 113 |
| Crude oil | $1,296 \times 10^{6}$ | 387 | 1,160 | 55.3 |
| Pig iron | $280 \times 106$ | 83.6 | 251 | 12 |
| Aluminium | $5.52 \times 10^{6}$ | 1.65 | 4.95 | 0.236 |
| Copper | $4.74 \times 100$ | 1.41 | 4.23 | 0.201 |
| Zinc | $3.60 \times 10^{6}$ | 1.07 | 3.21 | 0.161 |
| Lead | $2.54 \times 10^{6}$ | 0.758 | 2.27 | 0.108 |
| Tin | $104 \times 10^{3}$ | 0.058 | 0.174 | 0.008 |
| Portland cement | $374 \times 10^{6}$ | 112 | 336 | 16 |

[^186]8. These figures, however, are not particularly meaningful until they are considered both in their historical and in their geological contexts. Historically, the smelting of non-ferrous metals appears to have been initiated in Anatolia about 4000 B.C., and the smelting of iron in the same general region about 2700-3000 B.C. ${ }^{1}$ From these early beginnings the mining and smelting of metals have continued as an uninterrupted human enterprise. The use of coal for fuel was also begun at least as early as the Roman occupation of the British Isles. This, however, was discontinuous and it was not until about the twelfth century, when the inhabitants along the Northumbrian coast of north-eastern England discovered that certain black rocks found along the sea coast-and thereafter known as "sea coals"-would burn, that the digging and mining of coal became an uninterrupted enterprise.
9. It was not, however, until the eighteenth century, during which the steam-engine was developed and charcoal for the smelting of metals was displaced by coke made from coal, that the modern era of industrialization was

[^187]seriously begun. It was during this period that the rates of production of coal and of the various essential industrial metals began their exponential rates of increase which continued, with minor interruptions, until about the beginning of the First World War.
10. Supplementing coal, a second major source of industrial energy, in the form of the fossil fuels, crude oil and natural gas, was introduced near the middle of the nineteenth century, when the commercial production of crude oil was begun in Romania in 1857 and in the United States of America in 1859.
11. Although water-power had been in use to a limited extent since the Roman Empire, this source of energy and power was limited to small units of rarely more than a few horsepower, or kilowatts, each until after the development near the end of the nineteenth century of electrical means of generation and distribution of power. Hence, it has been principally within the last half-century that waterpower, with units having a range of capacity in the hundreds of megawatts, has reached a magnitude of significance in terms of modern industrial power requirements.
12. Although the rates of consumption of energy and of industrial metals began their exponential increases during the eighteenth century, it was not until the nineteenth century that their magnitudes became large by current standards. An idea of the manner of this growth can be gained from figure 1, in which the annual world production of energy from coal and crude oil, plotted on an arithmetical scale, is shown for the century 1860 to 1960. By visual inspection, it is seen that this period is divided into three distinct episodes of growth. The first, ending at the begiming of the First World War, was a steady exponential growth at about 4 per cent per annum; the second was a period of confused growth extending from the beginning of the First World War to the end of the Second World War; the last has been a period of renewed exponential growth, extending from the end of the Second World War to the current time.
13. Since energy provides the motive power for all other industrial activities, the rate of increase of industrial energy production is a composite measure of the rate of increase of the activity of the entire industrial complex. In particular, the rates of production of the major industrial metals, although differing slightly among themselves, are markedly simi-


Figure I
World production of energy from coal and crude oil during the century 1860-1960
Source: M. King Hubbert, Energy Resources, Publication 1000-D (Washington, D.C., National Academy of Sciences-National Research Council, 1962), p. 26 , fig. 8.
lar to the rate of consumption of energy. Space here does not permit the presentation of these rates of increase in a graphical form, but some of the salient statistical characteristics are shown in table 2.

Table 2. Growth rates of world production of energy and the principal industrial metals

| Resource | Growth period | $\begin{gathered} \text { Production } \\ \text { increatare } \\ \text { per annum } \\ \text { (ercentage) } \end{gathered}$ | $\begin{gathered} \text { Doubling } \\ \text { (imers) } \\ \text { (years) } \end{gathered}$ |  | $\begin{gathered} \begin{array}{c} \text { Increase } \\ \text { per century } \end{array} \\ \frac{P_{\text {Puo }}}{P_{0}} \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Energy | 1860-1910 | 4.39 | 16.1 | 54 | 73 |
|  | 1910-1946 | 1.65 | 43.2 | 140 | 5.2 |
|  | 1946-1962 | 4.88 | 14.6 | 48 | 117 |
| Coal | 1860-1914 | 4.21 | 16.8 | 56 | 62 |
|  | 1914-1954 | 0.65 | 110 | 365 | 1.9 |
| Crude oil | 1880-1930 | 7.86 | 9.2 | 30 | 1,920 |
|  | 1942-1964 | 7.60 | 9.5 | 31 | 1,500 |
| Pig-iron | 1830-1910 | 4.42 | 16.0 | 53.5 | 76 |
|  | 1910-1946 | 0.148 | 42.3 | 157 | 4.3 |
|  | 1946-1962 | 6.77 | 10.6 | 35 | 700 |
| Copper | 1815-1910 | 4.06 | 17.4 | 58 | 54 |
|  | 1815-1850 | 3.22 | 22.0 | 73 | 24 |
|  | 1875-1910 | 5.57 | 12.8 | 43 | 240 |
|  | 1910-1964 | 2.80 | 25.1 | 83 | 16 |
| Lead | 1800-1900 | 4.02 | 17.6 | 59 | 52 |
|  | 1910-1962 | 1.67 | 41.0 | 147 | 4.8 |
| Zine | 1815-1915 | 6.74 | 10.6 | 35 | 680 |
|  | 1915-1964 | 2.40 | 29.2 | 97 | 10.3 |
| Tin | 1800-1850 | 0.169 | 41.5 | 138 | 5.3 |
|  | 1850-1900 | 3.60 | 19.5 | 65 | 34.5 |
|  | 1910-1962 | 0.176 | 52.3 | 174 | 3.75 |
| Aluminium | 1910-1963 | 9.35 | 7.75 | 26 | 7,600 |

Source: United States Bureau of Mines, staff and various publications.
14. From this, it will be seen that for the period comprising most of the nineteenth century and ending about 1910-1915, the production rates of total energy and of most of the industrial metals increased exponentially at annual rates which averaged close to 4 per cent.
15. Newer components are represented by crude oil, as a source of energy, whose production did not begin until 1857; and by aluminium, as a new metal, whose commercial production was not achieved until 1886. Crude-oil production from 1880 until 1930 increased at an average rate of 7.86 per cent per annum, while the production rate of aluminium, from 1910 to 1963, has been increasing at an average rate of 9.35 per cent per annum.
16. These figures are emphasized because of their significance with respect to the future. A quantity which increases at a steady growth rate of 4 per cent per annum will increase fiftyfold in a century; a quantity which increases at a rate of 9 per cent per annum will increase 7,000 -fold per century. When the initial quantities are small, as all mineral production was at the beginning of the nineteenth century, there is no difficulty in increasing such small quantities by large factors; when the quantities have become large, however, as mineral production had become by the beginning of the twentieth century, or as it currently is, to continue a rate of increase of fiftyfold or more per century is quite another matter. It is an impossibility for any physical quantity on a finite earth to increase at a constant exponential rate greater than zero for more than a temporary period of time.
17. Limitation on the future production of energy from the fossil fuels and of metals from geological deposits of high-grade ores are imposed by the fact that deposits of these materials within exploitable depths (about two kilometres of mining and eight kilometres for petroleum) are of finite magnitude and occupy but a minute fraction of the space within these depths. The deposits of metallic ores now being exploited are the cumulative results of geological processes which have occurred during the last 3,000 million $\left(3 \times 10^{9}\right)$ years of geological history. The deposits of fossil fuels have been formed from the remains of organisms accumulated in sedimentary rocks during the last 600 million ( $600 \times 10^{6}$ ) years, and their energy content represents chemically stored energy derived by photosynthesis from solar radiation during that period. Hence, although the same geological processes are still operative, the additional new deposits of fossil fuels or
of metallic ores that are likely to be formed during the next million years would be insignificant in comparison with those which have been formed during past geological history.
18. When fossil fuels are burned, their energy becomes degraded into low-temperature heat and eventually is radiated into space. When high-grade ores are mined for the production of metals, these metals are not destroyed in a chemical sense; instead, they are wasted by scattering. One sees, therefore, that deposits of fossil fuels and of the high-grade ores of metals represent initial fixed supplies, which, by the processes of exploitation and use, are absolutely exhaustible.
19. When the rate of production of an exhaustible resource is plotted graphically on an arithmetical scale against time, the area under the curve is proportional to the cumulative production. Since the cumulative production can never exceed the amount of the resource initially present, then it follows that the curve of the rate of production must begin at zero, rise until it passes one or more maxima, and then decline eventually to zero. The area under such a curve, when multiplied by the appropriate factor of proportionality, must be equal to or less than the quantity of the resource initially present.
20. This principle is illustrated in figures II and III for the world production of coal and of crude oil, respectively. The initial world reserves of mineable coal are estimated to have been about $2,500 \times 10^{9}$ metric tons, ${ }^{2}$ of which about $110 \times 10^{9}$ metric tons have already been consumed. As figure II shows, if the

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Figure II
Ultimate world production of coal
Source: M. King Hubbert, op. cit., p. 39, fig. 19.


Figure III
Ultimate world production of crude oil
Source: M. King Hubbert, op. cit., p. 75, fig. 41.
maximum rate of world production should be only three times that of the current time, the production of coal will pass its maximum about 200 years hence.
21. A similar analysis for crude oil, shown in figure III, indicates that the maximum rate of world production of this fuel will probably occur about the end of the current century.
22. The total length of time during which an exhaustible resource may be exploited is likely to be deceptive. Thus, coal has already been mined continuously for about eight centuries and mining may continue for as many centuries into the future. However, if one disregards the first and last 10 per cent of the cumulative production, it may be determined from figure II that the time required to produce and consume the middle 80 per cent will probably be only about 350 years. A similar analysis of figure III for crude oil indicates that the middle 80 per cent will probably be consumed during the eighty-year period between 1960 and 2040.
23. Another example of the deceptiveness of the length of past time during which exploitation of mineral resources has been occurring is the following. The cumulative production of coal from the twelfth century to the end of 1964 amounts to about $109 \times 10^{\circ}$ metric tons; however, one half of this has been produced since 1933.
24. Similar statements are valid with regard to all other industrial mineral resources. In every instance, the production during the last half-century exceeds that of all preceding history.
25. The brevity of the period of exploitation of the fossil fuels in the longer span of human history, extending from minus to plus 5,000 years with respect to the current time, is shown in figure IV.
26. The metals differ from the fossil fuels in that, with the exception of nuclear fuels, they are not chemically destroyed; they are mined, used and scattered. They also occur in a wide spectrum of concentrations ranging from high-grade deposits down to their average geo-chemical abundances. Exploitable iron-ores, for example, have iron contents ranging from as high as 72 to as low as 20 per cent, whereas the average iron content of the mineable rocks of the earth-the geochemical abundance-is about 5 per cent. ${ }^{3}$ Copper in the Bingham Canyon mine in Utah is being obtained from rocks with an average copper content of about 0.6 per cent.
27. Comparative magnitudes of known ores of major industrial metals and their corresponding geochemical abundances within a mineable depth of two kilometres are shown in table $3 .{ }^{4}$ It is to be noted that the known ore deposits of grades now exploited are sufficient at current rates of production only for periods ranging from a few decades to a few centuries. The ratio of the content of these deposits to the total metal content based on geochemical abundances, however, averages, with the exception of aluminium, close to a million. It appears, therefore, that if enough energy is available, the world can continue to extract metals in industrial quantities from increasingly lower-grade ores after the high-grade ores have become exhausted. Furthermore, although space here does not permit the presentation of evidence, energy in quantities many times larger than those of the fossil fuels can be

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Figure IV
World production of fossil fuels in a time perspective of minus to plus 5,000 years
Source: M. King Hubbert, op. cit, p. 91, fig. 54.

Table 3. Comparison of 1956 world production of selected industrial metals with geochemical abundances in outer two kilometres of the earth's crust

| Element | Theoretical availability |  | $\begin{gathered} \text { Estimated } \\ \text { exploitable } \\ \text { reserve } \\ \left(10^{8}\right. \text { metric tons) } \end{gathered}$ | Ratio: theoretical to exploitable reserves | $\begin{gathered} 1956 \text { world } \\ \text { production } \\ (m e t r i c t o n s) \end{gathered}$ | Years of supply in exploitable reserve |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Total yesource (10 metric tons) |  |  |  |  |
| Aluminium | 7.48 | 58,366,000 | 2.0 | 29,000,000 | 3,500,000 | 570 |
| Iron | 4.7 | 36,674,000 | 50.0 | 700,000 | 200,000,000 | 250 |
| Zinc | 0.017 | 133,000 | 0.07 | 2,000,000 | 3,100,000 | 23 |
| Copper | 0.01 | 78,000 | 0.10 | 800,000 | 3,500,000 | 29 |
| Lead | 0.003 | 23,000 | 0.04 | 600,000 | 2,100,000 | 19 |
| Tin | 0.0005 | 4,000 | 0.007 | 600,000 | 200,000 | 35 |

Source: Elmer W. Pehrson, Man and Raw Materials; Edgar Marburg Lecture, 1958 (American Society for Testing Materials, 1959). Based largely on the study by Ferdinand Friedensburg, "The future supply of metals", Zeitschrift fuir Ersbergbau und Metallhiittenwesen (Dec. 1957), pp. 573-576.
produced, by means of the breeder reaction, from the fissioning of uranium and thorium.

## Conclusion

28. Despite the deceptively long times during which metals and energy from the fossil fuels have been exploited to some degree, the principal increases in the rates of these exploitations have occurred within the last century. As a consequence of the ecological disturbances created by the rise of technology and associated scientific knowledge, the human population has also entered its current phase of exponential increase. The nature of the situation and dilemma in which mankind currently finds itself is illustrated graphically in figure $V$, in which


Figure $\mathbf{V}$
Human affairs in time perspective
Source: M. King Hubbert, op. cit, p. 134, fig. 61.
the rate of world energy consumption, the human population and the energy consumed per capita, are plotted as functions of time for a period extending from 10,000 years in the past to 10,000 years in the future. What is most evident, when seen on such a time-scale, is that the normal state of human affairs is one of negligible rates of change. The current exponential rates of increase of human population and of industrial activity are of very recent origin, and, for reasons pointed out above, are incapable of being continued for more than a temporary period into the future. In fact, one must look forward to the achievement of a state of non-growth, but the future welfare of mankind is highly dependent upon the manner in which this is accomplished. If current rates of growth are not deliberately curtailed by mankind itself, and are permitted to continue until stopped by physical limitations, the result can hardly be other than disastrous. On the other hand, if, by considering the problem realistically, as this Conference is designed to do, effective measures can be evolved not only to stop the current growth of world population, but actually to reduce it to a more optimum size, then the world's resources of energy and essential industrial minerals should suffice to sustain its population at a very comfortable level of wellbeing for at least many centuries into the future.
29. However, since the word "growth" has become one of the most cherished in contemporary folkways, the achievement of a state of non-growth by rational foresight scarcely appears likely without an accompanying drastic revision of those folkways. Should such a state be accomplished by rational procedures, it almost certainly will be accompanied by an intellectual revolution of comparable magnitude
to those evoked by Copernicus and Galileo, and by Hutton, Lyell and Darwin, concerning the nature of the solar system, and the history of the earth and the evolution of its organisms.

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# Nuclear energy and other recent developments in the generation and distribution of energy 

J. A. Jukes

## Introduction

1. The application of nuclear energy for civil power purposes is the most significant development in the world energy economy since the emergence of petroleum as a major energy source. As a result of an immense effort in a few of the technically advanced countries, a new primary energy source has been harnessed for the service of man. In the incredibly short space of ten years or so, a new fuel technology has been created. During this period, nuclear power has passed from the research and experimental stages to full-scale industrial application. Installed nuclear power capacity now totals about $4,000 \mathrm{mWe}$ in various countries throughout the world. Large nuclear powerstations are already operating as normal parts of electricity networks. They are proving safe, reliable and flexible in operation, and there have been no problems in integrating them into existing electricity systems alongside traditional forms of electricity generation.

## Current state of nuclear technology

2. The development work of the past ten years has resulted in the establishment of two main systems for commercial application at the current time. These are the graphite-moderated, gas-cooled system, using natural uranium fuel; and the systems using water (light or heavy) as moderator and coolant, and enriched or natural uranium fuel. The costs of power from stations based on these reactor systems, and the expected costs of those under construction, have shown a marked downward tendency over time. In the United Kingdom, for example, which has the largest nuclear programme so far adopted, based on the graphite-moderated, gas-cooled natural uranium reactor, capital costs have been almost halved between the first and last stations in the eight so far ordered, partly because of an increase in size from 300 to nearly $1,200 \mathrm{mWe}$. Similar trends are apparent elsewhere-for example, in France, which has also concentrated on the gas-graphite system, and in the United States of America, which favours light-water moderated and cooled sys-
tems, using enriched uranium fuel. The generating costs of these stations, in which capital charges are the main element, have followed a corresponding trend; but they have not, thus far, shown any clear advantage (and often a clear disadvantage) compared with the cost of power from more conventional stations.
3. However, the nuclear industries in Europe and in America should now be capable of constructing large reactors which would be competitive with conventional power when they come into operation. In at least one case (Oyster Creek, in the United States), a nuclear station has already been ordered at a price which should make it competitive even with relatively cheap fossil fuel. For the next few years, most of the stations ordered are likely to be of the established water and gas/graphite types already described; but new types of reactor are ready for introduction and others are being developed. Competition should lead to a continuing downward pressure on nuclear costs.
4. Current reactors use only about 1 per cent of the potential energy in natural uranium; future reactors, such as the fast breeder reactor, may increase this figure to something like 30 per cent. Experimental fast reactors are already in successful operation and several industrialized countries have announced their intention to construct large prototypes. Reactors using thorium fuel, together with some utanium, are also being developed, which should lead to further economies in the use of natural uranium.

## Future trend of nuclear cost

5. As previously pointed out, the costs of power from reactors already built or under construction have almost halved between the earliest and latest in the series. Capital costs for the latest of the established types range from about $\$ 140$ to $\$ 280$ per kWe for large reactors ( $400-500 \mathrm{mWe}$ ) ; the systems at the higher end of this range have lower running costs than those at the lower end, so that the range in total generating costs is relatively
narrow: Generating costs per kWh will depend on costing conventions and other factors, which vary from country to country, but for industrialized countries the broad range is from 4 to 6 mills ( 1 mill $=\$ 0.001$ ). Capital costs of comparable fossil-fuelled stations are $\$ 100-\$ 150$, per kWe , and fuel costs generally range from $\$ 10$ to $\$ 20$ per ton of oil equivalent, giving generating costs of about 4 to 7 mills per kWh .
6. The continuance of the downward trend will depend mainly on further reductions in capital costs. Although these are not expected to fall so rapidly as over the last few years, there is still considerable scope for improvement through increased unit size, multiplereactor stations and large-scale production through replication of designs and standardization, quite apart from new technical developments and engineering improvements. Conventional costs may also fall, but the scope for this will be much more limited. However, as the size of station falls, the capital cost of nuclear reactors falls less rapidly than conventional stations; and it is unlikely, therefore, that nuclear reactors will be competitive much below $100-150 \mathrm{mWe}$ for at least the next decade or so, except for special uses.
7. Although fuel costs are less important in the case of nuclear than of conventional stations, there should be a possibility of significant improvement in them. Fuel fabrication costs are expected to fall as manufacturing techniques improve and the scale of production increases. Higher utilization of the fuel and thermal efficiencies will also be possible. The net value of irradiated fuel should also increase as reprocessing costs decrease with higher through-puts and as methods are developed of using the fissile plutonium contained in the fael.

## Uranium supples and costs

8. One of the main factors affecting reactor fuel costs is the availability and price of natural and enriched uranium. Current prices for uranium ore are low, compared with the levels reached in the 1950 's, but this situation may not continue long into the 1970's if nuclear capacity grows at the expected rate. Even if the price doubles or trebles, however, the effect on the price of electricity will not be pronounced, as the cost of uranium now forms only a small part ( $5-10$ per cent) of the total generating cost. Unmined reserves of uranium, at prices up to double current prices, should suffice until well into the 1980 's. By then, improved reactors should be available, which will help to conserve reserves by more efficient
utilization of uranium. More high-grade reserves may have been found; but, if not, use can be made of the very much larger low-grade deposits, which can be mined at higher costs. Thorium-fuelled reactors should also be available to relieve the pressure on natural uranium supplies. In the longer term, the sea may be a virtually inexhaustible source of uranium at costs perhaps several times the current price of mined material.
9. Enriched uranium should also be available in adequate quantities. The United States Atomic Energy Commission, which is currently the largest and cheapest potential supplier, has indicated its readiness to enter into long-term contracts linked to the United States domestic price scale for the supply of enriched uranium to specific reactors over their operating lives. The United Kingdom would expect to be able to supply material at low enrichment, given an adequate demand, at prices not much higher. Other possible sources of supply in the longer term may be France and the Union of Soviet Socialist Republics.

## Nuclear power and the developing Nations

10. As a result of the factors described above, it is estimated that nuclear generating capacity in the non-Communist countries may reach $20,000 \mathrm{~mW}$ or more by 1970 and $100,000-200,000$ by 1980. These figures are large, but they represent oniy 10-20 per cent of total forecast capacity at that date. Most of the nuclear capacity will be in the highly developed countries.
11. In considering its place in the developing countries, the most important features of nuclear power are its high capital costs, compared with fossil-fuelled generating stations, and the fact that this capital cost differential becomes more marked the smaller the size of station. It follows that, generally speaking, nuclear power will be best suited in the shorter term to countries which are short of cheap conventional fuel, but which have the capital resources to invest in large nuclear stations and the scientific and technological resources to build and operate them. As capital charges form a high proportion of total nuclear generating costs, nuclear stations must be operated at high load factors if they are to be economic; this presupposes a large and growing demand for electricity with integrated transmission and distribution networks.
12. Few of the developing countries currently meet these requirements, but this does not mean that the benefits of nuclear power at
the current stage are likely to be confined to the advanced countries. One or two developing countries, such as India and Pakistan, where conditions are specially favourable, have already embarked on nuclear power programmes. More generally, however, nuclear power has already introduced a new competitive element into the world energy market, thereby reducing pressure on fossil-fuel supplies and restraining any violent rise in their prices. This benefits all countries, developed and developing alike. It is of particular importance to the developing countries, in view of their mounting energy requirements, much of which has to be imported at a heavy cost in scarce foreign exchange.
13. Looking beyond the immediate future, the importance of nuclear energy for the developing countries can scarcely be exaggerated. Owing to the very uneven distribution of the world's fossil-fuel reserves, most of them lack adequate indigenous resources and, in the absence of nuclear power, would be faced with the prospect of having to import increasing quantities of fossil fuels. Nuclear fuel, even if it has to be imported, is much cheaper in relation to its energy content and, because of its enormous energy output per unit of weight, cheap to transport. Some of the developing regions also have indigenous reserves of uranium and thorium. The chief significance of nuclear power from this point of view, therefore, is that it marks the approaching end of the situation where a relatively small number of countries, through their access to cheap supplies of fossil fuels, have an advantage over countries not so favourably placed. This should lead in time to a greater geographical equalization of energy costs, to the great benefit of the developing nations.

## Other developments in energy production

 AND DISTRIBUTION14. Though not comparable in importance to the successful introduction of nuclear power, there have been other developments of interest to developing countries.
15. Direct conversion. The practical limit of thermal efficiency in generating plants used for both nuclear and conventional stations (now nearly 40 per cent in the most modern installations) seems to be approaching. Further improvement will depend on the progress made with various methods of direct conversion of heat to electricity, which can be used to raise the over-all efficiency of generating stations. Currently the most promising of these methods is magnetohydrodynamics, in which gas is heated to a high temperature and passed at high
speed through a magnetic field, thus generating electricity. Used in conjunction with fossilfuelled or nuclear stations, magnetohydrodynamics might ultimately raise efficiencies to 60 per cent. Although this method is feasible, its economic advantages remain to be demonstrated. In view of the complexity and high capital costs of the magnetohydrodynamics systems currently envisaged, they are unlikely to be of interest to developing countries, but simpler forms may follow.
16. Tidal power. Several projects for utilizing the ebb and flow of the tides to generate electricity are currently under way or proposed. The River Rance scheme on the north coast of France, with an ultimate capacity of 320 mWe , is due to start generating electricity in 1965. The United States of America is considering a scheme (the Passamaquoddy project) which would generate $1,250 \mathrm{mWe}$ by 1980 . The Soviet Union has a small pilot project in the White Sea which could be precursor of a vast $14,000 \mathrm{mWe}$ scheme. The capital costs of these schemes are high-about $\$ 360$ per kW for the Rance scheme, for example-though the running costs are very low.
17. Solar and geothermal energy. Solar energy is being successfully utilized in various ways. Its use for salt production has long been known, and Israel is now using fuel for the recovery of potash from the Dead Sea. Small solar water-heaters are being used in growing numbers in regions where electricity is expensive and sunshine reasonably abundant. The use of solar stills to produce potable water from the sea or from brackish water is also growing. Although most of these applications are on a small scale, they may still make a useful contribution in some countries, particularly if they are at a fairly early stage of development. Geothermal energy sources may also be worth exploiting (as has already been done in Iceland, Italy and New Zealand, for example) at locations where it is possible to make reliable estimates of the total energy available.
18. Developments in energy distribution. Transport costs are an important element in the delivered cost of fossil fuels. In the United States of America, for example, the cost of transport results, in many cases, in delivered prices for coal which are twice the cost at mine. In India, the cost of coal delivered to such cities as Bombay or Madras may be as much as three or four times the cost at mine. Improved efficiency in transporting fuel has a large part to play, therefore, in reducing the cost to the consumer. This is especially true
for the developing countries, which are so dependent on imported fuel.
19. The introduction of large tankers has reduced considerably the cost of transporting oil by sea, which is still the most economic method of transporting primary energy over long distances (nuclear fuel excepted). A more recent development is the transport of liquefied natural gas in tankers specially designed to keep it at the very low temperature necessary to prevent vaporization. This has opened up a large potential market for natural gas, much of which has hitherto had to be burnt off as waste. There have also been interesting developments in the transport of solid fuels. In the United States of America, transport of coal by pipeline has been demonstrated and the threat of pipeline competition has already led to reduced rail freights for coal. Unit trains, designed for the transport of coal from mine direct to powerstations, are another development providing lower transport costs in Europe and in the United States of America.
20. The development of high-voltage power transmission has created an alternative means of transporting energy, which may be cheaper than the movement of primary fuel. In the United Kingdom, for example, for distances over eighty kilometres, it is cheaper to transport energy as electricity over high-voltage transmission lines than as coal by rail. High-voltage transmission has also made it possible to ex-
ploit, without excessive economic penalty, remote hydro resources.

## Conclusion

21. In recent years, there have been several useful minor developments in the energy field, some of which may be of interest to developing countries. There has also been one major development-that of nuclear power. Because of its high capital cost, nuclear power currently requires large reactor sizes and high load factors to be economic. With development, these features of nuclear power may be modified, but they are unlikely to disappear altogether. The main use of nuclear power, therefore, is likely to be in areas which have been industrialized. There, however, may be special circumstances, such as the need in an arid area for the production of fresh water from the sea, in addition to electricity, which would justify its introduction. But, although the developing countries have no immediate use for nuclear power on a large scale, the development of nuclear power is of great importance as it means that, when they become industrialized, they should have no difficulty in meeting their energy requirements at an acceptable cost. Meanwhile, they will benefit indirectly, as the introduction of this new energy source will help to relieve pressure on supplies and prices of such conventional fuels as oil and coal, to the great advantage of developed and developing nations alike.

# Conservation and repeated use of water 

Yona Kahana

## Potential natural water resources

1. The most obvious and readily available water resources are freshwater lakes and perennial rivers. Less readily exploitable resources are ephemeral rivers. They are considered marginal in many cases, though often (e.g., in arid and semi-arid regions) they may be one of the few resources available. Their utilization involves complex studies, plans and operation.
2. Ground-water and surface-water are mostly interrelated. Determination of the location of ground-water, its assessment and the prediction of the effects of its utilization usually entail an involved process. Ground-water is usually of better bacteriological quality than surface-water, but its utilization may cause depletion of the resource and deterioration of its quality as, for example, by encroachment of sea-water.

## Conservation of the resources and repeated use

## Handling of the natural resources

3. Whereas the phrase "repeated use of water" is self-explanatory, "conseryation of water" is far from being so. Any means of water utilization may be termed conservation. Here, the term will be considered in the sense of augmentation.
4. The first step in the conservation of resources consists of its comprehensive handling. Consider, for example, the water from a spring. Direct utilization of the spring's water will invariably involve losses of water, especially during periods of high flow. Pumping the water directly from the aquifer prior to its discharge through the spring will either decrease or stop entirely the spring's outflow; thus, the discharge is fully utilized, as well as reserves which were otherwise in dead storage in the ground. In many cases, the water may be intercepted where its quality is better than at the spring itself.
5. High evaporation losses may be a decisive factor in the exploitation of resources requiring relatively large storage capacities. The solution may be underground storage. In general, the
total amount of usable water may be increased by co-ordinated exploitation of surface and underground water resources.
6. Another example of manipulation of natural resources is the case of a coastal aquifer. In such an aquifer, a certain flow seawards is necessary, if sea-water intrusion is to be checked. This flow correspondingly decreases if sea-water is allowed to intrude inland. The "safe yield", i.e., the quantities of fresh water which can be permanently withdrawn from the aquifer without undesirable effects, may thus be increased by allowing some inland intrusion of sea-water, and further increased by additional withdrawal of residual quantities of fresh water near the coast. It has been demonstrated, in recent experiments in Israel, that this scheme would permit an almost complete recovery of the total net recharge of the coastal aquifer. This method also constitutes an efficient mining of reserves; an "operating yield" is obtained, which is composed of the safe yield plus usable reserves.

## Underground storage and artificial recharge

7. In an underground storage system, the water, which is constantly moving, may be almost completely recovered by proper location and operation of the recharge and pumping facilities. The main advantages of such a storage system are : no evaporation losses, no pollution, less land requirement, saving in costs of structures and quality control, which may be attained by mixing in the aquifer. Disadvantages of this method include additional costs of pumping installations and the dependence on favourable geohydrological conditions.
8. Water reaches the undergound by artificial recharge, which can be accomplished by infiltration from the surface or through wells. Choice of method depends mainly on the quality of the water, the type of soil and aquifer, and the availability of land. The sources of water for recharge will generally consist of excess fresh water, floods and reclaimed domestic and industrial sewage.

## Evaporation control

9. In arid or semi-arid regions, considerable annual quantities of water evaporate from free
water surfaces. Construction of new reservoirs further augments evaporation losses. Reduction in evaporation losses results in improved water quality, since evaporated water is pure. The most advanced method to date is the introduction of monomolecular layers which reduce the diffusion of water vapour into the atmosphere. However, investigations are still being carried out on the application and maintenance of such layers. The introduction of reflective layers, which cut down the amount of radiant energy entering the water and, consequently, reduce evaporation, has not been investigated to the same extent. However, there is a promise in their application.
10. Monomolecular layers cause a rise in water temperature. As a result, an increased rate of evaporation occurs through openings in the layer, reducing their efficiency. Conversely, reflective layers may reduce the amount of energy entering the water, so that the temperature is lowered. Consequently, for the same coverage one may expect greater water savings from using reflective rather than monomolecular layers. The efficiency of any cover will be affected by its resistance to such natural phenomena as wind, waves and currents.

## Forest and brush

11. Forest and brush consume large amounts of water, which might otherwise reach surface or underground interception facilities. Research has shown that replacement of forest or brush by grazing vegetation may save large amounts of water.

## Storage in upper soil layers

12. Water may be conserved by saturating the soil for direct use by vegetation. This may be achieved by soil conservation techniques and proper farm management.

## Repeated use of water

13. With only few exceptions, the salt content of water is increased after it has been used for agricultural, industrial or domestic purposes.
14. In agricultural use, return irrigation water may enter the ground-water, thus permitting more extensive application (as required for flushing salts). Drainage water may be either directly used, returned into a reservoir or recharged to ground-water.
15. In industry, used water is commonly suitable for further use. In those cases where it cannot be recirculated repeatedly, it can be used in processes which can accommodate progressively degraded water. Considerable water
savings may thus be achieved. In many cases, industrial wastes can be economically treated, particularly in arid and semi-arid areas, where disposal of such effluents may involve considerable investment. Common requirements for separate industrial waste-disposal facilities may increase the feasibility of the waste treatment.
16. Domestic sewage water is a source of large quantities of reusable water. In modern towns, nearly 75 per cent of the total water consumption reaches municipal sewerage systems. Unless contaminated by industrial wastes, most of it may be used profitably. Treatment of sewage may be done to several degrees, the basic being: primary treatment (settling); secondary treatment (biological process); and tertiary treatment (additional biological action).
17. The standard of the effluent, the need for skilled labour and the land requirements depend on the specific method, by means of which every degree can be obtained. Raw sewage may be applied directly for irrigation of a small variety of crops and, in some cases, may even be successfully recharged into the ground-water. The higher the degree of treatment, the larger will be the variety of crops which may be irrigated, the closer the allowable proximity to inhabited areas and the more extensive the possibilities for ground-water recharge. Water recharged by infiltration may be of a poorer quality than that recharged through wells.

## Efficient use of water

18. Waste of water is common in domestic, industrial and agricultural usage. Water savings of up to tens of per cent have been achieved when appropriate steps were taken towards waste control.
19. In domestic use, water can be saved without lowering sanitary standards by such measures as making improvements in home fittings, reducing losses in supply lines, recirculating cooling water (or using brackish water) ; encouraging suitable gardening practices (choice of plants, time of irrigation); and applying progressively higher rates for higher water consumption. New developments, such as vacuum disposal of excreta, may significantly lower domestic water demands.
20. Efficient use of water in industry requires proper planning at all levels.
21. In agriculture, efficient use of water depends mainly on adequate farm management. Introduction of crops which have a high cash value and which consume small quantities of water may be equal in importance to correctly
measured and adequately distributed water. The most important considerations are: (a) optimal water quantities and distribution of application; night irrigation (for sprinklers) ; (b) irrigation of relatively large areas in order to reduce losses along boundaries and oasis effects; (c) flexible annual crop planning according to distribution of precipitation; (d) selection and development of crops and varieties having low water requirements and high drought tolerance; (e) selection and development of salt-tolerant crop varieties; development of means to reduce evapotranspiration (such as spraying with antitranspirants) ; (f) introduction of hydroponics; (g) elimination of leaks in lines; and ( $h$ ) decrease of evaporation losses from the soil (by adequate agro-techniques, drainage and selection of crops).
22. The importance of dissemination of information, for example, by means of extension services, cannot be over-emphasized.

## Planning for conservation

23. Conservation of water resources is usually a part of a socio-economic effort and should be planned integrally with other phases of development. Conservation interferes with the natural hydrological cycle and produces various effects, not all of which are necessarily desirable. Therefore, watersheds should be analysed and planned as a whole.
24. Water requirements are influenced by habit and may change as the availability of water changes; educational efforts may materially affect consumption. A suitable water law is imperative to successful implementation of any conservation plan.
25. Planning flexibility necessarily decreases as development progresses; the freedom of choice available to the planner in virgin areas no longer exists in developed areas where existing structures, vested interests and land costs may seriously interfere with water resources development. An increased water requirement usually results in an increase in its cost. To offset this, however, the ability to pay for water increases in conjunction.
26. At advanced stages of development, especially in arid and semi-arid countries, quality of water becomes increasingly important. This is the direct result of utilization of a higher percentage of available water, of repeated use and of exploitation of brackish resources. The mere extension of towns may deplete resources by significantly decreasing local natural infiltration to the ground-water. Similarly, the establishment of modern sewerage systems may deprive local aquifers of water
that might otherwise have been recharged through local cesspools. Proper town planning should provide both for recovery of rainfall and for sewage reclamation.
27. These considerations emphasize the need for an integral approach to water resources and their conservation. As the development of a region proceeds, the interrelation between the various resources and the different utilization projects, which, together, form an over-all system, becomes more apparent. If related projects are not treated as such at an early enough stage, they may become prematurely obsolete or even become obstacles to future development. The mutual influences between water resources and other forms of development (e.g., urban, agricultural etc.) should be recognized and given proper attention. Provision should be made for changes in water usage as a result of urbanization of agricultural areas etc.
28. Systems analyses should be employed at an early stage (based on reasonable assumptions), so that alternative courses of action can be considered, even before complete data are available. Such studies will reveal what important data are missing and to what accuracy and in what order they should be collected.
29. Particular attention should be paid to the use of one-time reserves, which might be used in "non-rainy days", such as periods of consecutive drought or gaps between demand and supply. Intelligent use of reserves may permit the postponement of important decisions or of heavy investment until such time as crucial data can be collected and necessary local experience gained without development being hindered.
30. In developing areas, the construction of major water-supply projects may be a prerequisite for further general development. However, the implementation of such projects may require many years of study, planning and construction, while the pertinent data for such studies are those obtained through actual exploitation. When a project is completed, its capacity may exceed current consumption and a considerable proportion of its lifetime may elapse before it reaches full operating capacity, especially in developing regions. Utilization of reserves permits the implementation of projects at such time that their operation at full capacity can be provided.
31. Developing countries are characterized by the accelerated rate at which the basic socioeconomic processes take place. The main processes which affect water conservation are: (a) shift of the labour force away from agriculture; (b) introduction of modern farm and
soil management techniques; (c) urban and industrial development; (d) improvement of educational standards; (e) improvement in health conditions and consequent immediate (though perhaps temporary) rise in the growth rate of the population; and ( $f$ ) gradually loosening of traditional ties and behaviour.
32. The interference of conservation in the natural hydrological cycle is accentuated by the accelerated development. There may be a tendency to embark on undertakings because of considerations of prestige rather than of actual need. Grandiose projects may be preferred to smaller, carefully conceived, gradual development. Tackling problems at too rapid a pace may deprive the planners and executors of vital experience. Adaptation of theories and methods of local conditions can be achieved only by experience gained locally.
33. The promises inherent in desalinization of sea-water and brackish water, and in artificial rainfall must affect the planning of water resources and their conservation, and no plan can be complete without taking into account these possibilities.
34. Regional systems should permit more efficient conservation of resources than a multiplicity of individual projects, should provide better facilities and should allow more efficient use of reserves. Such systems should be expected to provide better-controlled storage facilities than smaller local projects. On the other hand, regional projects require better organization, operation and maintenance, and presuppose a centralized supply-control.
35. Regional projects should be analysed for their over-all benefits and judged on these merits. In order to do so, a master plan must be envisaged as early as possible. The plan should be based on known or assumed trends of development, possibilities of its exploitation and conservation.
36. A master plan should be considered a process rather than a product. It is a dynamic effort to combine all relevant facts, figures or anticipations, so as to produce a plan which continuously satisfies current requirements.
37. Long-term considerations require the preparation of an inventory of resources, however tentative, at an early stage, together with a forecast of anticipated development, consequent trends and modes of consumption.
38. It is also imperative that future possible technological developments should be anticipated and given due consideration.
39. The resources should be evaluated, in progressing order of accuracy, in terms of time, space, quality and costs. A general outline should be drawn up at the earliest possible stage. This should reveal what data are lacking and what obstacles are likely to be encountered, and indicate what investigations will be necessary. A data-collecting system should be established and operated as early as possible.
40. The data, together with the experience gained from operating existing installations, should be continuously fed back to improve the plan and to adjust it to changing conditions.
41. Assistance from other countries may be required in developing countries. However, adaptation of known methods to local conditions produces the greatest benefits. This can be best achieved by dedicated, well-trained local personnel who will gain experience with planning and execution.
42. An adequate conservation plan and its successful implementation require a high sense of duty, together with sound technological knowledge, on the part of those entrusted with its execution.

## Conclusions

43. With regard to the conservation of water, the following conclusions may be drawn:
(a) Conservation of water consists of comprehensive exploitation of resources, their correct manipulation, use of reserves, artificial increase of water yield and repeated and efficient use of water;
(b) To achieve this goal it is necessary to tackle the problem integrally. A master plan, drawn up at the earliest possible stage, should be continuously adjusted to changing conditions;
(c) The master plan should encompass all needs in the foreseeable future, and should envisage the necessary research, pilot plants and investigations;
(d) Measurement networks, research and investigation programmes should be established at the earliest possible stage;
(e) The master plan should encompass the training of skilled manpower and the establishment of extension services;
(f) Suitable water legislation is imperative to successful implementation of a conservation plan;
(g) Arousal of favourable public opinion is essential.

## Population growth and power resources

S. M. Lisichiin

[Translated from Russian]

1. During this second half of the present century, a relatively rapid population growth has been observed in many countries. At the beginning of 1964, the world population stood at 3,200 million. During the preceding fourteen years, i.e., from 1950 to 1964 , it had increased by 700 million. The mean annual rate of increase during this latter period was about 1.9 per cent, 0.7 per cent greater than for the preceding fifteen years. It is generally agreed that this rapid growth has been due to the improvements in health and sanitation in the less developed countries which have brought about a sharp decline in mortality while birth rates have continued to be high.
2. Some writers, failing to take into account all the factors, and in the first place the social and economic factors, affecting fertility, make projections of future population trends through the extrapolation far into the future of the growth rates of the more recent past. An example of this is the assumption that by the year 2000 the world population will have reached 6,000 million to 7,000 million or, in other words, will be about double what it is today. In this connexion, increasing attention is today being given in journals throughout the world to the problems of providing the population with the means of subsistence. Some writers say that the earth does not have enough cultivable land to produce the necessary food and that all its power resources will be exhausted. These assertions are all unwarranted and unsubstantiated.
3. Many widely known scientists of progressive outlook in a number of countries have said, on the basis of a thorough analysis of the various aspects of this question, that the possibilities for increased food production are virtually unlimited. As regards the world's power resources, the situation is as follows.
4. Among the great variety of minerals today being extracted in the world, a large share is represented by fuels. In 1960, the world output of all minerals in terms of value amounted to $\$ 52,000$ million, of which $\$ 34,000$ million was accounted for by fuels. Over the
past 100 years the gross consumption of energy resources has increased approximately ten-fold, the per capita consumption of energy resources in terms of comparison fuel being about 1.6 tons in 1960 as against 0.4 tons in 1860. According to United Nations statistics, the 1960 world consumption of mineral fuels and hydroelectric power, in terms of the equivalent in coal, was 4,238 million tons.
5. It is predicted that by the year 2000 the world consumption of energy will have increased five-fold; the consumption of energy in western Europe, North America and Oceania will then be 45 per cent of the world total as compared with 57 per cent in 1960, and the share of the countries of Asia, Africa, Latin America and the Far East will rise from 24 to 35 per cent. An expansion in world energy consumption of this magnitude has not only aroused the interest of scientists but has given them cause for alarm over the future of energy resources and the possibility of an "energy famine" on our planet. According to information submitted to the World Power Conference, the total world deposits of mineral fuels the extraction of which is economically feasible will be exhausted in about seventy-five years. Hence, the alarm over being able to supply future generations with energy from the customary sources.
6. What precisely is the situation regarding the present stocks of the various kinds of primary fuels?
7. Let us first take coal. Over a long period of time, coal held its place as the world's main source of energy. Thus, in 1913 it accounted for 80 per cent of the total world consumption of energy and in 1938 for 63 per cent. Of the total consumption of mineral fuel and hydroelectric power in western Europe, coal accounted for 92 per cent in 1929 and 87 per cent in 1937.
8. According to Mr . Paul Averitt of the United States Geological Survey, the world deposits of coal to a depth of 900 metres are now estimated at $2,320,000$ million tons. The consumption of coal up to the end of the present
century will amount to 435,000 million tons. Thus, in his opinion, the present coal deposits will be ample for the next 100 years. According to data compiled by various Soviet scientists, the world coal supplies will be adequate for the next three to four centuries.
9. The estimates regarding petroleum reserves are extremely contradictory. Many scientists consider that the petroleum deposits will be exhausted before the end of the present century. The proponents of this view point to the trend in energy consumption since the end of the Second World War, viz., the relative decline in the use of coal and the relative rise in the use of petroleum and natural gas in
almost every country of the world. In 1959, the world consumption of energy from the conventional sources was, on a percentage basis, as follows: coal - 43 per cent; petroleum - 25.7 per cent; natural gas - 11.2 per cent; wood and agricultural waste- -13.8 per cent; and hydroelectric power - 6.3 per cent. The rise in the consumption of petroleum products after the Second World War was especially great in the highly developed industrial countries. For example, in the period 1929-1937 the annual rate of increase in the consumption of petroleum by the countries that are now members of the European Economic Community was 0.4 per cent, but from 1948 onwards it was 5.4 per cent.

> Percentage distribution, by sources, of energy consumed by the capitalist countries of western Europe

|  | 1948 | 1955 | 1960 | $\underset{\text { (estimated) }}{1965}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Coal | 79.7 | 69.8 | 64.6 | 51.7 | 42.3 |
| Petroleum | 10.4 | 19.6 | 30.3 | 34.1 | 41.5 |
| Natural gas | 0.1 | 0.9 | 1.8 | 3.2 | 8.7 |
| Hydroelectric power | 6.2 | 7.2 | 3.3 | 8.7 | 9.0 |
| Atomic energy. | - | - | - | 1.6 | 2.5-5.0 |
| Other | 3.6 | 2.5 | - | 2.1 | 1.7 |

10. Between 1948 and 1960, the relative importance of petroleum among the various forms of energy consumed in western Europe increased almost three-fold. According to forecasts by the Energy Committee of the European Economic Community, the consumption of energy in the countries of western Europe will have increased by 65 per cent by 1975, and petroleum and gas will comprise 50.2 per cent of all the energy consumed. Among all forms of energy that will be used by the entire capitalist world between 1963 and 1975, the consumption of petroleum will rise from 46 to 49 per cent, and the consumption of gas from 15 to 18 per cent. Petroleum and gas will thus constitute two thirds of all the energy consumed by the capitalist countries. It is important to note that this trend is also typical of countries which have little or no petroleum of their own. Thus, the petroleum output of the countries of western Europe in 1962 was 15.6 million tons, whereas their consumption of petroleum products was 206 million tons.
11. What petroleum resources are now available to mankind, and how long can these be expected to last?
12. The United States geologist Wicks estimates the total world petroleum reserves to be 270,000 million tons, of which 20,000 million
tons have already been extracted and 205,000 million tons are still to be discovered. He also believes that an additional 200,000 million tons could be obtained by secondary methods. Other experts put the petroleum reserves at 180,000 million tons, and still other at 570,000 million tons. That these estimates are merely tentative is quite apparent from the wide differences between them. Some experts say that the coal age has come to an end, that the petroleum age will be of short duration and that a new form of power, atomic energy, will soon supplant the traditional sources of primary energy. This conviction is obviously based on the latest achievements of science and technology. It is our view that these achievements tend rather to confirm the importance of petroleum, as is apparent, for example, from developments in the field of jet propulsion.
13. In recent years, some of the experts who have conducted research into the state of fuel and energy reserves have contended that the world reserves of the traditional fuels are not so great as had been thought and will soon be exhausted. For example, one of the outstanding scientists of India says that the conventional sources of energy will be exhausted within less than forty years in Latin America, within less than sixty-five years in the Near East, within
less than thirty years in southern Asia and the Far East, and within less than 133 years in Africa.
14. Our views on this subject are as follows.
15. The discovery of petroleum deposits in various countries and continents within the last fifteen to twenty years convincingly demonstrates that the age of the extensive discovery and use of petroleum resources is just beginning. Pre-revolutionary Russia was one of the world's leading petroleum-producing countries, even though its petroleum output in 1913 was only 10.3 million tons. During the years of the Soviet régime the discovery of many new deposits in the USSR made it possible to increase the petroleum output to 31.1 million tons by 1940. After the Second World War, the centre of petroleum production in the Soviet Union shifted from the Caucasian oilfields to the UralVolga area-the "Second Baku"-where more than 70 per cent of all the petroleum produced in the Soviet Union now originates. When these oilfields, which enabled the Soviet Union to raise its petroleum output to 206.1 million tons by 1963, were discovered, it appeared most unlikely that any new deposits rivalling them in capacity and volume would ever be found. Now, however, there is every reason to say that the area with the greatest petroleumproducing potential in the USSR is not the Ural-Volga area but the western Siberia lowlands, where deposits of a unique kind have been found. The latter area will eventually become the main petroleum-producing region in the country. Furthermore, it can be confidently said that this will not be the last discovery of such petroleum deposits in the Soviet Union. The same is probably true of other countries.
16. In the last twenty to twenty-five years, the world supply of petroleum has rapidly expanded. At the beginning of 1939, the known reserves of petroleum in the capitalist countries alone were estimated at 4,000 million tons, but by the beginning of 1964 they had reached 40,900 million tons (United States of America $-4,700$ million tons; Venezuela-2,400 million tons: Kuwait- 8,700 million tons; Saudi Arabia- 8,100 million tons; Iran- $-4,900$ million tons; Iraq- 3,400 million tons). There can be no doubt that this increase will continue. Petroleum output is also rapidly expanding.

## World output of petroleum (million tons)

| 1900 | 1925 | 1950 | 1960 | 1963 |
| :---: | :---: | :---: | :---: | :---: |
| 20 | 147 | 521 | 1,053 | 1,300 |

17. In the first quarter of the present century, the world petroleum output increased by 127 million tons, in the second quarter by 374 million tons, and in the subsequent thirteen years (up to 1963) by 779 million tons.
18. After the Second World War, petroleum production was begun in countries where previously it had been virtually non-existentFederal Republic of Germany, Italy, Netherlands, Algeria, Libya and so on. The petroleum output of some of the "older" petroleumproducing countries, although rising in absolute terms, is declining each year in relation to the total world output of petroleum. Thus, in 1950 the United States of America accounted for 51.2 per cent of the world output, but in 1962 for only 29.8 per cent. Africa and western Europe, which until very recently were not even included in the world statistics of petroleum production, accounted for 3.1 per cent, and 1.3 per cent, respectively, of the world total in 1962. The rapid expansion in petroleum output in all the continents in recent years does not in any wise mean that the petroleum deposits are being pumped dry of their last remnants. It indicates rather that mankind is merely embarking on the large-scale utilization of the earth's petroleum resources.
19. Some geologists say that mankind has used up only one tenth of the total world resources of petroleum. In these circumstances, there is no basis whatever for reviving the "theory" of the declining importance of petroleum and the exhaustion of petroleum resources in the 100 or so years. An additional fact to bear in mind is that in the course of the past century, only 15 to 25 per cent of the petroleum was extracted from some deposits, after which they were declared "exhausted" and were then abandoned. Even at the present state of tech-nology-when wide use is made of artificial methods of maintaining stratum pressure, hydraulic cracking of oil-bearing strata and secondary methods of exploiting deposits-the average petroleum extraction coefficient is 30 per cent in the United States of America (although in some fields it is as high as 85 per cent), less than 25 per cent in Venezuela and about 30 per cent in most of the countries of the Near and Middle East. It is thas apparent that much petroleum remains in the ground in these abandoned deposits. Secondary methods of exploitation have made it possible to raise the extraction coefficient considerably, and there is reason to believe that even tertiary methods will be applied, with the result that the world's petroleum resources will be increased still further. Any calculation of future petroleum resources should take account of the
theory that one sixth of the world's land area contains petroleum and natural gas deposits and that up to the present time only 5 per cent of this area has been the subject of intensive prospecting.
20. As a result of improvements in drilling technology, bore-holes can now be sunk to depths of 3,500 to 5,000 or even more metres, whereas even as late as 1935 the average depth of oil-wells in the United States of America was only 841 metres and by 1962 was only 1,311 metres. At the present time the average drilling depth in a number of countries, for example Mexico, exceeds 2,000 metres, and in several countries a maximum drilling depth of 6,000 and even 7,830 metres has been attained. Borings of this depth provide a means of discovering petroleum deposits in areas where none were formerly thought to exist.
21. On the strength of the discoveries of recent years, we are becoming increasingly convinced that the achievements of modern science and technology will enable man to expand his petroleum resources to a still much greater extent through the discovery of hitherto unknown deposits. It is very possible that by comparison with today's standards the extent of these resources will be astronomical. This conviction of ours is further strengthened by the discovery of unusually large petroleum deposits in the Soviet Union (Ural-Volga area and western Siberia lowlands), Algeria, Libya and other countries. There is also reason to believe that huge petroleum deposits may be discovered along the coasts of oceans and seas.
22. Some experts, in referring to the development of the petrochemical industry, are inclined to exaggerate the scale on which petroleum is being used for the manufacture of petrochemicals. Such concern, however, is unfounded despite the rapid growth of that industry. This is amply demonstrated by the fact that in the countries of western Europe in 1962 the consumption of petroleum for the manufacture of petrochemicals amounted to only 6 million tons whereas the total consumption of all petroleum products amounted to 206 million tons. At the present time, the consumption of petroleum as a raw material by the chemical industry amounts to only 2 per cent of the world output (in the United States of America, to about 5 per cent of that country's output). There is accordingly no reason to fear that the development of the petrochemical industry will make "inroads" on the petroleum needed for energy-producing purposes.
23. What has been said above applies in even greater measure to natural-gas resources.
24. At the beginning of this century, natural gas accounted for only 1 per cent of the total world consumption of the primary sources of energy, but by 1963 the figure was 15 per cent (in the United States of America, 34 per cent). The world reserves of natural gas are now estimated at from 110,000 million to 600,000 million cubic metres (of which 60,000 million cubic metres are situated in the Soviet Union). In recent years abundant supplies of natural gas have been discovered in areas where none was known to exist. The deposits at Slochteren in the Netherlands are alone estimated at 400,000 million cubic metres and those at Hassi-R'Mel in Algeria at about 900,000 million cubic metres.
25. The prospecting for natural-gas resources has been conducted with varying intensity in the various parts of the world. Among the capitalist countries, the largest known reserves-about 8,000 million cubic metresare in the United States of America. When probable deposits are taken into account, that country's share is 65,000 million cubic metres.
26. In many countries the natural-gas resources have not yet been put to use. Thus, in Venezuela the natural-gas reserves are estimated at 935,000 million cubic metres, but in 1962 the natural-gas output there including by-product gases from petroleum was only 36,000 million cubic metres, of which 15,000 million cubic metres was burnt off in the flambeaux of the refineries. The value of the gas lost in Venezuela since 1937 has been calculated at about $\$ 450$ million. Venezuela is by no means an isolated example, for the gas reserves of Africa, Asia and the countries of the Near and Middle East are likewise little used. In the petroleum-producing countries of the Near East alone in the single year of 1961, the natural gas burnt off in refinery flambeaux was equivalent, in calorific value, to 19 million tons of petroleum and, in monetary terms, to $\$ 247$ million. During the entire period of petroleum exploitation in that region, the gas that has simply been burnt away has amounted to the petroleum equivalent of 440 million tons, representing a monetary value of $\$ 5,700$ million. The gas losses in the countries of the Near and Middle East, in Africa and in Venezuela are currently running as high as the petroleum equivalent of 33 million tons a year. It is, of course, unthinkable that this squandering of one of the most valuable sources of energy will be allowed to continue. Huge quantities of natural gas are used in the United States of America. In 1960, the world consumption of natural gas was about 460,000 million cubic metres, the United States accounting for almost

80 per cent of this figure. All of this serves to prove that mankind is just beginning to make use of the reserves of natural gas.
27. It should be further noted that in most petroleum-producing countries the prospecting for deposits consisting of natural gas alone has only very recently begun, and in some of them nothing along these lines has been done at all.
28. For some reason or other, many of the experts concerned with research on world energy resources completely ignore oil shale and bituminous rocks, the world reserves of which, even on the basis of rough surveys, are estimated at 200,000 million tons of comparison fuel. In some countries these reserves are very large, and there appear to be no insurmountable technical obstacles to their industrial exploitation.
29. The known world resources of peat are estimated at 225,000 million tons, which is the equivalent of 100,000 million tons of comparison fuel. Except, however, in certain areas, little use is made of peat.
30. At the present time, less than 10 per cent of the world's hydroelectric resources are being utilized. The experience of some countries with a large hydroelectric potential shows that they prefer for the time being to use petroleum. Of the total energy produced in western Europe, hydroelectric power accounted for 6 per cent in 1937, 8 per cent in 1955 and 8.5 per cent in 1962.
31. Is it possible that in the coming decades -let us say, before the end of the present century-atomic energy will become the dominant source of power while resources of coal, petroleum, gas and other primary sources of energy continue to be available?
32. In the first years after the Second World War, extremely optimistic views on this subject were expressed in the scientific and technical literature of a number of countries. Thus, in the 1953 report of the United States Atomic Energy Commission it was stated that all economically exploitable sources of the conventional forms of energy would be exhausted by the year 2000. The Suez Canal incidents provided further support for those who were in favor of the rapid development of nuclear power. However, the discovery of new petroleum and gas deposits brought about a change in these views. The early predictions concerning the development of nuclear power were over-optimistic. One of the most important among the various peaceful uses of atomic energy is, as we know, the generation of electricity. According to the statistics of the International Atomic Energy Agency, nineteen
atomic-powered generating plants with a total capacity of 1,600 megawatts had by 1962 been set up in six countries of the world. It was considered likely that by the beginning of 1965 the number of such plants would rise to fiftyfive and their total capacity would be 4,500 megawatts, and that by 1970 the total capacity of the atomic-powered plants that would then exist would be 15,000 to 18,000 megawatts. The magnitude of these capacities is not so great as was predicted by some writers a few years ago.
33. In the capitalist countries, the construction of atomic-powered generating plants is opposed by the oil and coal monopolies, although this is by no means the only obstacle to the introduction of such plants. Various problems connected with their operation still remain to be solved. These explain, for example, why the cost of generating electricity in atomic-powered plants constructed in the years 1957-1960 was five to ten times higher than that generated in thermal plants. It is true, of course, that even the atomic generating plants built in 1961 were two to three times more economical than the earlier ones. Although there can be no doubt that the cost of atomic energy will gradually be reduced and that it may, in the not too distant future, become as cheap as or cheaper than thermal power for the generation of electricity, it is hardly likely that atomic generating plants will be suitable for all countries, particularly those where cheaper sources of conventional energy are available.
34. At the present time, the cost of atomic energy is determined by the basic capital expenditure that is required and to a lesser degree by operating costs. In the United States of America over $\$ 1,000$ million has been spent on atomic energy research during the past twenty years, but the goal of making atomic energy competitive with the conventional sources of energy has not yet been achieved. It is therefore not surprising that the predictions concerning the possibilities of atomic energy have become more subdued in the past two or three years. According to the latest estimates, the total energy requirements of the United States in 1980 will be approximately 2,850 million tons of comparison fuel, which is 75 per cent higher than that country's energy consumption in 1960. However, of the total electric power produced in 1980, only 5 per cent will originate from atomic generating plants.
35. Also in the countries of western Europe, it is not expected that more than 5 per cent, or at the utmost 7 per cent, of the total energy requirements in 1980 will be met by atomic energy. Another point to be borne in mind is
that in some branches of industry it is cheaper to use petroleum. The prospects for the use of atomic energy in transport are especially limited, and in many cases there is no possibility of it replacing petroleum at all.
36. The experts who see only a limited range of possibilities in the use of nuclear energy over the next twenty years seem to us to be near to the truth. This does not, of course, mean that there is any basis for a pessimistic view of the future of nuclear energy. On the contrary, it may be confidently said that the successes of modern science and technology will also make it possible to solve the economic aspects of atomic energy production. Although there can be no doubt, on this score, it does seem that in the present century atomic energy will merely supplement coal, petroleum and gas as a source of power. Even when cheaper atomic energy becomes available, petroleum is likely to continue to play an important role in the energy field for a long time to come and gradually to expand its range of uses in other directions, including those to which we shall now briefly refer.
37. At the Sixth World Petroleum Congress held at Frankfurt am Main in 1963, French experts presented a paper entitled "The deparaffinization of petroleum products by microbiological methods and the derivation of protein-vitamin concentrates". It was stated in that paper that at the present time there is a world shortage of edible meat products, which is estimated at 15 million tons a year. Under favourable conditions of economic development it would take at least forty years to overcome this shortage, but during that same period there
would be a considerable expansion in the world population. Thus, even under favourable conditions of economic development it will be impossible to eliminate the shortage of meat products in the next forty years. Mankind must therefore seek effective means for solving the problem of meat production or the production of substitute products. According to the authors of the paper, this problem could be quickly and economically solved if protein concentrates could be obtained from petroleum products. The cost of food concentrates derived from petroleum would, they say, be fifteen and possibly even thirty times cheaper than meat products. According to their calculations, the world shortage of protein products could be overcome through the utilization of only 1 per cent of the world output of petroleum with a paraffin base.
38. Although at first glance the conclusions of these French experts may seem to border on the fantastic, there can be no doubt that even in the next few years petroleum will be used on an even broader scale for the production of substitute food products such as alcohol and industrial fats and of animal feed products and that in the somewhat more distant future it will very likely be used for the production of various food concentrates.
39. We have not in this paper concerned ourselves with the utilization of solar, tidal or other sources of energy that require a large capital expenditure. Their large-scale use is not a matter of any urgency in this century, especially, as the conventional sources of energy are more than ample for the next few hundred years.

# Can natural resources and manpower be used more efficiently? (the outline of an answer based on Romania's experience) 

Costin Murgesco

[Translated from French]

1. The most disturbing feature of underdevelopment is that it generally affects countries which have valuable natural resources and abundant manpower. This paradoxical situation is traceable to imperialism, but although its causes are thus of a historical order, we do not intend to dwell on them here.
2. The paradox becomes a tragedy as many under-developed countries, coming onto the stage of history as independent States, find the premises of their well-being transformed into brakes on their progress. Their economic substance is drained away as their natural resources in the form of raw materials are exported under unfavourable conditions. Birth control is advocated in order to reduce the growth of population, the main factor of production and consumption in every country.
3. In theory, various quantitative relationships can be and have been established between population increase, the rate of economic growth, the share of national income allocated to investment and so on. The problem with which we, however, are concerned is to determine the specific directions of economic policy that are the most appropriate for making these relationships lead to a better utilization of natural resources in the interest of improving the living conditions of a growing population.
4. We shall try to find the answer to this problem on the basis of Romania's experience. There can be no doubt, however, that the determining factors in a country's economic policy and the effectiveness of that policy are indissolubly linked to the social and economic system, to the institutional framework in which the policy is carried out and to the creation beforehand of the conditions necessary for the achievement of the proposed aim.
5. In some regions of the world, the system of land ownership results in large areas of land remaining untilled while at the same time great numbers of peasants are unable to find work in agriculture. What this means, in effect, is that society is wasting not only one of its important means of production, the land, but also immense
quantities of human energy. We mention this aspect of the problem because we believe that the transformation of the land-tenure structure in the interest of the peasantry represents one of the necessary conditions for the efficient use of natural resources and manpower. In Romania, a radical programme of land reform carried out in 1945 made it possible, by eliminating the last vestiges of a semi-feudal system of agriculture, not only to meet the demands of social justice but also to contribute to the expansion of the home market for industry. During the period 1950-1960, the conversion of peasant holdings into co-operatives gave an even stronger impulse to this development. The bringing of the land-tenure system into conformity with the demands of agricultural progress resulted in a veritable economic chain-reaction that was needed to start the economy in motion: an increase in the rural demand for industrial products, an expansion of industrial production resulting in the absorption of part of the rural labour force, and an increase in the urban demand for agricultural products, which in turn stimulated a further expansion of agricultural production and brought about an increase in farmers' income.
6. In some parts of the world, not only the land but also mineral, forest, water and other resources are wasted in a variety of ways. This abnormal situation can be eliminated and the transition to conditions of efficiency in the use of natural resources can be achieved only on the basis of a carefully co-ordinated and graduated policy of economic development. The first condition for drawing up and, especially, carrying out such a policy is to ensure a country of permanent sovereignty over its natural wealth and resources. Studies made by the United Nations throw light on the measures taken by various countries in this regard. ${ }^{1}$ In
[^190]Romania, the policy for the development of natural resources is based on State ownership of the principal means of production, the nationalization of which in 1948 preceded the transition to the planning of economic development and made such planning both possible and necessary.
7. The principal instrument of a policy for the efficient use of raw materials and manpower is industrialization.
8. In Romania, the comprehensive and enlightened development of natural resources has been the main factor determining the trend of industrialization. The result of this has been an increase in the number and range of final products per unit of raw material and, in turn, an expansion of foreign trade and an improvement in the international terms of trade.
9. The intelligent utilization of raw materials depends on the adoption of a comprehensive system of measures such as: the taking stock of all natural resources; the introduction of natural resources into the economy on the basis of a sound relationship between quantities exploited and known reserves; determination of the most suitable rates of consumption of each raw material in the various sectors of the economy; and correlation of productioncapacity growth rates for the various stages of the production process (extraction, primary processing, secondary processing, etc.).
10. The following example is indicative of the results that can be achieved in this way. In the Romanian petroleum industry, the amount of crude oil brought to the refineries was 7 per cent higher in 1963 than in 1959, the number of employees was 18 per cent higher and the value of gross output was nearly 57 per cent higher. Similar increases in the volume of raw materials processed, the number of employees and the value of output, which are encountered in all the other branches of Romanian industry, are characteristic of this process of intelligent development of natural resources and improved utilization of manpower.
11. The intelligent development of natural resources implies an organic relationship between the various branches and sub-branches of the economy and between the various products and sub-products. Hence, it can be effectively achieved only on the basis of a system of multisectoral industrial development, the structure of which will be mainly determined by the varied requirements and the raw-material base of the economy in question and the possibilities afforded by an expansion of international trade.
12. The standard for evaluating and justifying the efforts demanded by industrialization is the extent to which the resulting products will be competitive on the world market. An essential condition in this regard is the introduction of modern technology in industrial enterprises. Some specialists object to this on the ground that modern technology demands a capital investment out of proportion to the manpower that is absorbed. Recent studies warn against attaching too much importance to this argument. Furthermore, the cost of investment for each newly created post varies considerably from one branch of industry to another. Classic examples are electric power, the development of which is vital to industrial development as a whole, and the chemical industry, which is essential for the proper development of such important natural resources as petroleum, gas, salt, reed and so on. If the amount of investment required for the creation of one new post in Romania over the past seven years is taken to be 1.00 in the textile industry, the corresponding figures will be found to be 1.26 for the basic metal and metal products industries, 2.55 for the wood products industry, 2.70 for the building materials industry, 6.23 for the chemical industry and about 9.50 for electric power. Where the intelligent development of natural resources has become possible, multi-sectoral development is again the only means of reconciling certain apparently contradictory demands within the national economy, e.g., the development of industries that require a relatively larger investment but are vital to the economy as a whole and the development at the same time of industries that absorb a relatively larger amount of manpower.
13. The observation has been made that in many developing countries there is an excessive centralization of industry which results simultaneously in unemployment and under-employment in the rural areas and in a labour shortage in the urban centres. ${ }^{2}$ It is our view that multisectoral development facilitates the location of new enterprises according to a wider variety of criteria conforming to the specific character of the different industries. This, in turn, creates conditions for a more rational territorial distribution of industry which makes it easier to draw into the economy raw material and manpower resources from various regions of the country.
14. Industrialization can at no time be divorced from the need to diversify and inten-

[^191]sify agricultural production in conformity with the natural conditions of a country, its national pattern of consumption and the role of agriculture in its foreign trade.
15. Diversification of agriculture is intended to make it easier to meet the growing and more diversified demand for food and for industrial raw materials. It therefore prevents some of the foreign exchange earned by exports from being used to pay for food imports and enables more of it to be used for industrial investment which creates new employment opportunities.
16. Through the diversification of agriculture, not only can better use be made of such natural conditions as soil, climate and terrain in the various regions of a country, but the manpower resources of agriculture itself can be more fully employed. In Romania, for example, on the basis of the man-days required for growing a hectare of wheat, twice as much manpower is needed for sunflower cultivation, 5.8 times as much for sugar-beet cultivation and 9.2 times as much for grape-growing. This demonstrates how important-in addition to
the efforts made to increase the per hectare output of cereals-has been the expansion of areas used for the cultivation of industrial crops, grape-growing, market-gardening and so on.
17. We shall try to sum up the results of Romania's experience in a few figures. During the period 1951-1963, the national income increased at an average annual rate of more than 9.5 per cent. The main impetus came from industrial production, which in the same period increased at an annual average rate of 13.2 per cent.
18. Whereas the working-age population increased by 12.8 per cent from 1951 to 1963, the gainfully-occupied population, owing to the rapid pace of economic development, increased by 14.6 per cent during the same period. This means that employment was provided not only for the increased number of persons of working age but also for part of the manpower that was available during the period preceding the transition to a planned economy.

## Minerals and living standards in the developing countries

Zafer A. Sawaf

## Role of minerals

1. The material needs of life are of varied types: food, clothing, shelter and a host of others more or less important. Services are also needed and are paid for by material rewards. To create material goods and satisfy needs and to improve standards of living, raw materials must be processed and turned finally into consumption goods.
2. Raw materials are classified into three categories: (a) mineral resources (including fuel); (b) plant resources; and (c) animal resources.
3. Mineral resources are important in themselves as starting raw materials and as the means for developing, both plant and animal resources. The increasing use of fixed nitrogen, phosphates and potash is the basis for increasing crop yields. The use of steel plows and tractors for increasing agricultural productivity is made possible through the availability of iron-ore and other minerals. The food derived from agricultural production is used for growing animal resources and deriving other essential foods and products from the animal kingdom. The increasing use of fuel is the basis for the tremendous increase in human productivity in the three domains of production: primary (raw materials) ; secondary (manufactured products); and tertiary (services). It is apparent that the increasing production and use of mineral resources is one of the greatest factors for improving the standard of living.

## Long future availability of minerals

4. The continued availability of mineral resources for the long future has been a constant source of worry for the large consumers of industrial minerals and the Governments concerned. It seems that the problem is not currently as alarming as it was before the development of atomic energy. The reserve of uranium may provide nearly inexhaustible fuel supply through synthesis from common inorganic substances. With such quantities of energy available, fossil fuels may be saved to be used more effectively as a raw material, and
further, it would be possible to work lower grades of minerals. This would forestall otherwise imminent shortages of many of the industrial minerals, because the total amount of each mineral occurring within mineable depths is almost a million times the amount contained in the currently exploitable grades of ores. ${ }^{1}$ J. Gottman thinks that the notion of "natural resources" is dangerous to spread; before asking where nature would stop, he asserts, one should try to expand the field of knowledge. ${ }^{2}$ Raw materials are today in ample revolution. Markets are getting organized, and on their organization will depend the degree of comfort and security available for humanity in the future.
5. Thus, world mineral needs for the near future seem assured through more search and better use. The long needs are assured through the use of atomic energy for exploiting common minerals and poor minerals, and for going deeper into the earth.

## Mineral resources prospects in developing countries

6. Mineral resources in developed countries have been much more thoroughly searched than those of developing countries. Geological surveys of the developed countries have been working for long years and detailed geological maps have been drawn. In spite of this, the search is not complete. More minerals are being discovered. Developing countries cover larger areas. Many of these areas have either never been surveyed geologically or have only been surveyed on a large scale, and provide now greater opportunity for finding mineral resources. The task of surveying these large areas in the needed detail and thoroughness required to find the bidden minerals, and then making the detailed prospection, is not an easy one. It requires long and continued efforts and modern scientific methods.

[^192]7. The author used to teach a course in industrial chemistry, and when speaking (around 1950) about mineral resources in Syria, used to say, "We do not know of important mineral resources", rather than, "We do not have important mineral resources". Since that time, oil has been discovered in north-eastern Syria, and important phosphate deposits have been discovered also, as a result of a geological survey of the country. One still cannot say that there are no more mineral resources. Mineral resources are available for those who look for them and find ways and markets for using them. This example is most probably true for most of the developing countries. The low exploitation of mineral resources is not owing to the lack of these resources as much as it is to the lack of search and interest in using them.

## Actual production

8. In spite of the fact that the less-indus-
trialized countries number 2.38 times the industrialized countries, ${ }^{3}$ their mining production in 1958 was only 25.2 per cent of the total value added in mining. ${ }^{4}$ The production in mining in the industrialized countries is thus 2.96 as much as in the less-industrialized countries, and the per capita production is 7.06 times greater. The real situation may be understood better by examining the following table:
[^193]Table 1. Contribution of coal, minerals and petroleum extraction to value added in mining, manufacturing, electricity and gas, 1958

|  | Mining, manufacturing electricity and gas | Total | Mining Coal | (Selected industries) Minerals Petroleum |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Weight (percentage) | 100 | 9.3 | 2.4 | 1.4 | 4.2 |
| Weight in world index (percentage) : |  |  |  |  |  |
| Industrialized countries. | 89.6 | 74.8 | 92.1 | 69.5 | 63.8 |
| Less-industrialized countries | - 10.4 | 24.2 | 7.9 | 30.5 | 36.2 |
| Ratio industrialized countries/ less-industrialized countries. |  | 2.96 | 10.8 | 2.27 | 1.77 |
| Per capita ratio industrialized countries / less-industrialized countries |  | 7.06 | 25.7 | 5.41 | 4.18 |

9. In the domain of petroleum production, the less-industrialized countries make the best showing, and it is even better in 1962, when the production index of the less-industrialized countries increased from 100 in 1958, to 182 against 114 for the industrialized countries. It should be noted, however, that the main production is concentrated in few countries whose population is only around 50 million.
10. In the domain of minerals, the per capita production of the industrialized countries is 5.4 times as large as the per capita production of the less-industrialized countries. Three points may be noted here. The first is the small weight ( 1.4 per cent) for minerals in the world index. It is clear that minerals, as such, are not adding much to the world income. Their role is rela-
tively larger in the less-industrialized countries, but it does not amount to more than approximately 4 per cent ( $1.4 \times 305 / 10.4$ ).
11. The second point is that minerals production in the less-industrialized countries is increasing at a lower rate than in the industrialized (1962 index of production, 120, compared with 122 for the industrialized, 1958 production $=100$ ). This rate of increase is even lower than the population increase of the less-industrialized countries between 1958 and 1962, which was 21 per cent.
12. The third point is that the production of minerals in the less-industrialized countries is generally for exportation. It was actually developed in most cases by industrialized countries and very often for consumption in indus-
trialized countries. Thus, the less-industrialized countries are not benefiting from these minerals in developing industrial production. Modern methods and machinery in mining are also decreasing the role of the local people in mining itself.
13. As to coal, it plays a meagre role in the less-industrialized countries. An important difference from oil is that most coal produced is for local use and not for exportation to industrialized countries.
14. Table 2 gives the share of the less-industrialized countries in mineral production. It is clear that the role of the less-industrialized countries is important, as suppliers of some vital minerals.

## Table 2. Production of minerals, contribution of less-industrialized countries, 1961

 (Percentage)| Coal | 9.3 |
| :---: | :---: |
| Lignite | 7.4 |
| Natural gas | 5.6 |
| Petroleum | 57.5 |
| Manganese ore | 72 |
| Iron ore | 34 |
| Copper ore. | 52 |
| Lead ore. | 50 |
| Zinc ore | 37 |
| Tin ore. | 95 |
| Bauxite | 77 |
| Chrome | 65 |
| Molybdenum ore | 6 |
| Vanadium ore. | 16 |
| Tungsten ore. | 61 |
| Nickel ore | 24 |
| Cobalt ore | 91 |
| Antimony ore | 44 |
| Mercury ore | 41 |
| Diamond | 90 |
| Asbestos | 14 |
| Salt | 37 |
| Sulfur | 36 |
| Phosphates | 45 |
| Potash | 42 |

Source: computed from figures in United Nations Statistical Yearbook, 1963 (United Nations publication, Sales No.: 64.XVII.1), table 12.

## Contribution of minerals to the standard of living in the less-industrialized countries

15. Mineral production in the less-industrialized countries may be disposed of in two different ways or a combination thereof: (a) exportation; and/or (b) local processing to various degrees. The exportation of minerals is confronted with the problem of fluctuations in price and demand. Generally, the price of
the exported mineral is not controlled by the exporting country, and it is equal to the local price in industrial countries, minus transport charges and any import duties that may existif such importation is freely permitted. In most cases, the price is not determined on a free market, according to the law of supply and demand, and is controlled by private and/or government organizations, which have the power to foresee the fluctuations in supply and demand and which can even initiate such fluctuations. This problem was discussed at length in the last United Nations Conference on Trade and Development, and recommendations that may ameliorate the situation have been made. ${ }^{5}$.
16. The real value of minerals is not the market value. The real value is their use as raw material for industrial production, as a source of fertilizers for increasing crop yields and as a source of energy for increasing human productivity. The less-industrialized countries are not taking proper advantage of the use of minerals. Considering the advantage taken of mineral resources in increasing agricultural yield, the following table indicates how much fertilizer consumption in the less-industrialized countries is below that in industrialized countries:

## Table 3. Per capita fertilizer consumption, 1961/1952



Source: United Nations Statistical Yearbook, 1963 (United Nations publication, Sales No: 64.XVII.1), tables 141-143.
17. It is gratifying to note, however, that the rate of increasing consumption of fertilizers in the less-industrialized countries is faster than that of the industrialized countries, as seen in table 4.
18. The use of fuels as a source of energy was the basis of the industrial revolution in Europe and in other industrialized parts of the world. The great increase of the standard of living that has taken place in the world would not have been possible without the increasing use of coal and petroleum as sources of energy.

[^194]Table 4. Consumption of fertilizers in industrialized and less-industrialized countries
( 1,000 tons)

|  | Nitrogenous ( $N$ ) |  |  | Phosthatic ( $\mathrm{P}_{7} \mathrm{O}_{6}$ ) |  |  | Potash ( $\mathrm{K}_{\mathbf{1}} \mathrm{O}$ ) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} 19556 \\ 1956 \end{gathered}$ | ${ }_{1961 /} 1962$ | $\begin{gathered} \text { Yn } \\ \substack{\text { cease } \\ \text { (pert } \\ \text { cent } \\ \text { gepe) }} \end{gathered}$ | $\begin{aligned} & 19556 \\ & 1956 \end{aligned}$ | $\begin{aligned} & 1961 / \\ & 1962 \end{aligned}$ | $\begin{gathered} I_{n} \\ \substack{\text { crease } \\ \text { (pere. } \\ \text { sent. } \\ \text { afee) }} \end{gathered}$ | $\begin{aligned} & 1955 / \\ & 1956 \end{aligned}$ | $1961 /$ | $\begin{gathered} \text { In } \\ \text { ceave } \\ \text { (pere } \\ \text { (pert. } \\ \text { agee) } \end{gathered}$ |
| Industrialized countries. | 4,422 | 6,863 | 55 | 5,930 | 7,351 | 24 | 4,827 | 6,283 | 28 |
| Less-industrialized countries | 1,205 | 1,205 | 119 | 830 | 1,545 | 86 | 413 | 823 | 99 |

Source: United Nations, Statistical Yearbook, 1963 (United Nations publication, Sales No. : 64.XVII.1), tables 141-143.

Assuming that the average power that could be generated by man is one-seventh horsepower, and a conversion efficiency of heat to work is 35 per cent, one finds that one ton of oil consumed per annum is equal to the muscular work of seventeen persons, working eight hours
per day, 300 days per annum. With this figure in mind, it is possible to appreciate the role of fuel consumption in increasing productivity and in improving the standard of living of mankind. Table 5 shows how much the less-industrialized countries are lagging in fuel consumption:

Table 5. Energy consumption
(Million tons of coal, equivalent)

|  | 1959 | 1962 | $\begin{aligned} & \text { Inve } \\ & \text { crease } \\ & \text { (pert } \\ & \text { ceme } \\ & \text { agee } \end{aligned}$ | Per capita, 1962 (Kg, coal, equiv.) |
| :---: | :---: | :---: | :---: | :---: |
| World | 3,940 | 4,555 | 15.8 | 1,465 |
| Industrialized countries | 2,340 | 2,690 | 15 | 4,710 |
| Centrally planned economies. | 1,237 | 1,417 | 14.5 | 1,540 |
| Less-industrialized countries. | 363 | 448 | 23 | 274 |

It is gratifying to note again that fuel consumption is increasing at a faster rate in the lessindustrialized countries than in the industrialized countries.
19. As to the use of minerals as raw materials for industrial production, the less-industrialized countries are lagging greatly, as table 6 illustrates:

Table 6. Per capita production, 1962
(Kilogrammes)

|  | Sulphuric <br> acid | Nitric <br> acid | Caustic <br> soda |
| :--- | :---: | :---: | :---: |
| Industrialized countries..... | 67 | 10.9 | 14.3 |
| Less-industrialized countries. | 1.13 | 0.09 | 0.36 |

## Conclusions

20. The less-industrialized countries are not getting enough benefit from mineral resources available to them. Under-development of mineral resources is actually taken as a characteristic of poor countries. The reasons and
vicious circles connected with this under-development are fully treated in some excellent textbooks on the subject. ${ }^{\text {. }}$ The problem is that under-development brings under-development, and the only way to break the vicious circle is through the will of the people concerned and the help of organizations interested in a lasting peace for mankind.
21. Special principle two of the United Nations Conference on Trade and Development stated: "Developing countries should ... fully mobilize domestic resources and carry out the necessary reforms"; "Developed countries should supplement the efforts ... through the supply of know-how, technical and financial assistance ...". It is the duty of all concerned to see to it that the principle is fulfilled by both developing and developed countries. It is to the interest of both for a healthier relationship among all countries.
[^195]
# Chemistry and the vital resources of mankind (the use of substitutes and their industrial and economic significance) 

N. M. Zhavoronkov

[Translated from Russian]

1. Providing people with enough to eat has been the most important problem in life since the appearance of man on earth, and remains so to this day. The health, physical state and development of man depend, in the first instance, on food. His food consists of proteins, fats, carbohydrates, mineral substances and vitamins in the form of various products of vegetable and animal origin. In the graphic definition of K. A. Timiryazev, the food used by man and by animals is "canned sunshine", manufactured through photosynthesis by plants as they fulfil their cosmic role of intermediary between the sun, the central source of energy in our planetary system, and life on earth. With the aid of the vegetable kingdom, the reserves of organic matter on earth expended by man in the form of food, clothing, fuel and other materials are replenished and the sun's energy is stored as the chemical energy of organic matter. Agriculture is the link that connects man and his creative activity, through the intermediary of cultivated plants, with the sun and the radiant energy it sheds on the earth.
2. Unfortunately, the basic problem of agriculture in the modern world, the search for ways of providing everyone with enough food now and in the near future, has yet to be solved in practice. There are still enormous areas of the world where millions of people do not get sufficient, or sufficiently nourishing, food. At the same time the world population is constantly growing. In 1964, it was about 3,283 million. The rate of annual increase is now about 65 million.
3. The problem of providing this growing population with food is extremely acute. According to rough estimates, 10 to 15 per cent of the population are starving and almost half are under-nourished as a result of nutritionpoor food and the lack of proper proteins.
4. The daily intake of food should contain an average of 3,000 calories and good protein content. Today, according to Food and Agriculture Organization data, this standard is on the whole met among the populations of Europe,

North America and Oceania, which comprise only 29 per cent of the world population. The populations of Latin America, Africa and the Near East ( 17 per cent) receive an average of 2,400 calories a day. The general protein content is satisfactory here, but it is of poor quality. The population of the Far East and South-east Asia, comprising approximately half the world population, gets 2,000 calories or fewer a day, with insufficient protein content. The situation is aggravated by the fact that the greatest population increase is observed in those countries which are hardest hit by lack of food. But even in the countries with an "abundance" of food products, millions of people are not properly fed. The late President of the United States, John Kennedy, was once obliged to admit that 17 million Americans went to bed hungry every night. According to the wellknown English scholar John Boyd-Orr, up to 50 per cent of the population of pre-war England suffered a greater or lesser degree of malnutrition.
5. All this can be traced to social causes, not to the impossibility of feeding the population of our planet. Nevertheless, in the past 100 to 150 years there has been no lack of pessimistic forecasts and pronouncements to the effect that over-population is the sole cause of hunger and all social ills, and that the vital resources of nature are nearing exhaustion.
6. In the second half of the 19 th century, when it was established by science that the satisfaction of human and animal protein requirements depends on the extent to which the need of plants for nitrogenous compounds is satisfied, the problem of combined nitrogen rapidly emerged as one of the most serious obstacles to the supply of mankind with protein substances.
7. In 1887, the English scientist Thomas Huxley predicted the end of modern civilization in fifty years' time because of nitrogen star-vation-depletion of nitrogen in the soil and complete exhaustion of natural reserves of combined nitrogen, Chilean saltpetre, suitable
for use as mineral fertilizer. The same idea was repeated in the eighteen-nineties by the wellknown physicist William Crooks. As long ago as 1898, the distinguished Russian scientist K. A. Timiryazev gave a public lecture entitled "Is mankind really facing extinction?", in reply to the pronouncements of Crooks concerning the danger of world-wide nitrogen starvation and of Lord Kelvin who prophesied general asphyxiation as a result of the gradual exhaustion of nitrogen in the atmosphere. In this lecture, K. A. Timiryazev, with characteristic passion and conviction, not only advanced strictly scientific arguments to show the mistakenness of the positions taken by these distinguished scientists (with which they themselves agreed), but also expressed deep confidence in an early solution to the problem of fixing atmospheric nitrogen and creating a nitrogenous fertilizer industry. In fairness, it should be noted that William Crooks himself, as was to be expected of a true scientist, leavened his gloomy forecasts with a ray of hope in the power of science. At the beginning of our century the scientific principles and methods of fixing atmospheric nitrogen were worked out, and the door was opened to the nitrogen industry.
8. The world production of combined nitrogen has grown from year to year, and in 1963 stood at about 17 million tons. From its beginnings to the present day (including the period 1963-1964), the nitrogen industry has produced over 150 million tons of combined nitrogen (in terms of pure nitrogen), an amount which is equivalent to 2,250 to 2,500 million tons of grain.
9. The most pernicious of all the pessimistic pronouncements concerning the fate of mankind was the theory put forward in 1798 by the English clergyman and economist Malthus. According to this theory, the population is increasing by geometrical progression, but the means for its existence are increasing by arithmetical progression. Malthus thought that it was essential to restrict the birth rate. Hunger, poverty, pestilence, and war, which increase the death rate, were elevated by Malthus to the status of laws of nature whose purpose is to restrain the growth of population. This misanthropic "theory" became the emblem of reaction. Malthus was the intellectual predecessor of the modern neo-Malthusians, who are again trying to prove that over-population is the sole cause of all social ills.
10. One of the first critics of Malthus' theory was his famous contemporary, David Ricardo. The theory was sharply criticized by the progressive circles of many countries.
11. Malthusianism was completely unmasked in the work of the founders of scientific communism, above all K. Marx and V. Lenin.
12. Of the many modern works devoted to criticizing and unmasking of the reactionary essence of Malthusianism, we should note the researches of the distinguished Brazilian biologist Josué de Castro, summarized in his book The Geography of Hunger, and the work of Jacob Oser, the well-known American economist and professor of Syracuse University, Must Men Starve?
13. It is not our intention to adduce further arguments against the ideas of Malthus. Enough have been put forward already. As far as the potential vital resources of mankind are concerned, if the achievements of science are properly utilized they are practically limitless.
14. In a book by the Soviet scientist K. M. Malin, The Vital Resources of Mankind, estimates are presented of possible food resources based on the resources of solar energy. Just by raising the average level of food-crop harvests to the level attained by countries most advanced in this respect, the actual yield from the areas at present under cultivation could be increased to a level sufficient to feed over 9,000 million people. If all the vegetation growing on dry land were replaced by forage and food crops, given the modern scale of photosynthesis it would be possible to produce sufficient food for 41,000 to 58,000 million people. Extension of these same propositions to the entirety of marine vegetation would open the way to food resources sufficient for 290,000 million people. According to available data, the energy assimilated in photosynthesis by the earth's entire vegetation averages no more than 0.3 per cent of all the solar energy reaching the surface of the earth. Agricultural plants make fuller use of solar energy than the earth's vegetation as a whole. The amount of solar energy used averages 0.5 to 1.5 per cent, and in the case of such crops as rice, soya beans, sugar cane, sugar beet and a number of others, it is as much as 4 or 5 per cent of the solar energy falling on the crops during the vegetative season. There is reason to believe that once science fully understands and can control the process of photosynthesis, it will be possible to increase the coefficient of use two- or three-fold and more.
15. If we consider all the solar energy reaching the surface of the earth in one year ( $5.5 \times 10^{20}$ calories) we find that solar energy with an average of $1.08 \times 10^{12}$ calories falls on one square kilometre of the earth's surface ( 510 million $\mathrm{km} .^{2}$ ). Calculations show that if 10 per cent of this amount is used in photosyn-
thesis, given a vegetative season of not less than six months and bearing in mind that about 5 million calories must be fixed in order to create a year's supply of food for one man, nourishment for 10,000 people can be obtained from an average of one square kilometre, or 100 people per hectare.
16. If we take the potential cultivable surface of the earth as 100 million $\mathrm{km} .^{2}$ ( 10,000 million hectares) and assume that plants utilize solar energy to the degree indicated above, agriculture on dry land can provide full-value nutrition for 1 million million people. If the Pacific Ocean were brought under the same degree of cultivation as the land areas, the food resources of the earth would be sufficient for 3 to 4 million million people. These figures are more important in principle than in practice. The size of the world population is not determined by food resources alone. On the other hand, it should be stressed that even the above figures for food resources based on the utilization of solar energy are not the maximum possible. We cannot preclude a profound change in the nature of plant life enabling it to harness considerably more of the sun's energy than is assumed above. As long as the sun shines and thought glows in men's minds, they have no cause to tremble for their future. There is no doubt that man will eventually learn how to synthesize all the components of food by purely chemical means and obtain food products without recourse to the photosynthesis of plants, just as he will find a means of directly transforming solar energy into electricity with a higher coefficient of utilization, learn to control thermonuclear energy and make many other discoveries, increasing his mastery over nature.
17. The continuing substantial growth in the world's population and the fact that a considerable part of this population does not have enough to eat means that we must urgently and systematically single out the most important food problems and set about their planned solution. A sharp increase in food resources now and in the near future is an urgent necessity.
18. According to Food and Agriculture Organization data, the per capita production of food is increasing. During the decade 19521961, when the average population growth was 1.9 per cent a year, food production increased by an average of 2.75 per cent. However, because of the rapid growth of population in the developing areas, this increase was unevenly distributed among different areas.
19. How can food production be increased?
20. The quickest way is to bring new areas under cultivation. Thus, for example, the opening up of the virgin lands played an essential role in solving the food problem in the Soviet Union. Today, man cultivates about 10 per cent of the land surface, or 1,430 million hectares. Some experts think that from 6,500 to 10,500 million hectares could be used for agriculture. Thus, in the opinion of John Bernal, 2,670 million hectares could be brought under cultivation right now, that is, almost double the area now being farmed. With some capital outlay on the adaptation of free areas to modern farming methods, a further 2,820 million hectares of the earth's surface could be included in the sphere of agricultural production. The use of new agricultural methods will make it possible to use yet another 3,840 million hectares. However, in the judgement of various specialists, the next few years will probably see the addition of only 500 to 1,000 million hectares to the land now under cultivation, and an increase in food production of no more than 25 to 50 per cent. Opening up the remaining lands will require time and capital investment.
21. The best way of rapidly increasing food production and replenishing inadequate food supplies is the application of chemistry to agriculture and stock-breeding and, in the first instance, the expansion and the correct use of chemical fertilizers, together with other agricultural techniques and improvements. The replacement of food and other agricultural raw materials used for industrial purposes by synthetic chemical products derived from mineral raw materials is of substantial importance for increasing food resources.
22. Of a total quantity of 28 million tons of plant nutrients (pure nitrogen, phosphorus pentoxide and potassium oxide) used in the period 1959-1960, only 23 per cent fell to the lot of the food-poor countries, whose peoples constitute 71 per cent of the world population. The areas where food is abundant-Europe, North America and Oceania-used 77 per cent of all fertilizers.
23. According to calculations by Dr. Russell Coleman, the world demand for mineral fertilizers is expected to reach 49 million tons (in terms of nutrients) by 1970. This does not include the population of China mainland. On the basis of supposed population growth and the estimates of calorie requirements prepared by the Food and Agriculture Organization, mainland China's nutrient requirements will be at least 5 million tons by the period 1969-1970 ("Chemical and Engineering News", Vol. 41, No. 48 , pp. 84-94, 1963).
24. The possibilities opened up by the use of fertilizers are truly colossal. One need only compare the yield of a number of crops in various countries with and without fertilizers. The use of chemical fertilizers in conjunction with good agricultural engineering, irrigation, melioration, chemical mutagens, cultivation of the best strains, soil erosion control-all these and other improvements could raise the world yield to the Western European level, which would mean at least a twofold increase in world agricultural production. In the Soviet Union the production of mineral fertilizers in 1963 was 19.9 million tons in conventional units, or 4.6 million tons of nutrients. In the same year, in connexion with the targets for increased agricultural production, the December Plenum of the Communist Party of the Soviet Union's Central Committee decided that by 1970 the production of mineral fertilizers is to be raised to $70-80$ million tons in conventional units, or $16-19$ million tons of nutrients.
25. Another important condition for raising the agricultural productivity is the use of chemical means of weed, pest and plant-disease control. According to data provided by the AllUnion Institute for the Protection of Plants (Soviet Union), the annual losses from pests, plant diseases and weeds average about 10 per cent of the gross harvest of agricultural crops. Rough calculations show that the annual losses in the Soviet Union on the basic agricultural crops amount to about 5,500 million roubles. Numerous examples from all agricultural areas testify to the economic effectiveness of chemical pest, disease and weed control. According to data provided by the Scientific Research Institute for Fertilizers and Insecto-fungicides (Soviet Union), each rouble spent on plant protection gives an average return of twelve roubles in the very same year, and in the case of a number of high-cost crops the return amounts to as much as 100 roubles.
26. Of considerable importance for increasing food supplies is the application of chemistry to stock-breeding. With normal fodders, the coefficient of energy transfer into stock-breeding products is 10 per cent for beef, 20 per cent for pork, and 20 per cent for milk and eggs. In recent years, stock-breeders in a number of countries, including the Soviet Union, have increased the amounts of proteins, vitamins, hormones, antibiotics, mineral substances and rare elements in cattle fodder, which leads to a substantial increase in productivity, heightens the assimilability of fodders, promotes growth, lowers morbidity, and so forth. Wide use is starting to be made in stockbreeding of mineral supplements in the form of
synthetic urea, phosphates, cobalt preparations, and fodders derived from non-fodder raw material. Urea in the stomach of a ruminant (a cow, a sheep) is transformed by bacterial action into proteins which to a certain extent ( 25 per cent) replace proteins from fodder. By this means we may supplement the protein content of fodder. The standard dose of urea added to cattle-feed yields 1.8 kilogrammes of meat per kilogramme or up to ten litres of milk. The output of cattle products obtained through the use of urea is worth about ten times the cost of the urea.
27. The next important means whereby food production may be increased is the substitution of synthetics for the food-stuffs used as raw materials in industry, and the release of land now taken up by crops grown for industrial purposes as a result of the substitution of synthetic for natural products.
28. The successful development of modern engineering, the basis of our comprehensive mechanization and automation, is founded on the broad use of chemical products, including plastics, rubber, artificial and synthetic fibres and other chemical materials. It is not only, and not so much, that these synthetic materials are cheaper and require less labour to produce, as that many things used today simply could not be made without them (for example, aircraft tires without cord made of synthetic fibre).
29. Electrical insulating materials derived from vegetable and natural raw materials can no longer satisfy the increased requirements. Indeed, the chemistry and technology of new synthetic products and materials, including epoxy and organic silicon resins, etc., has created the necessary prerequisites-and unlimited scope-for the manufacture of insulating and other special materials with set properties.
30. Chemical fibres account for about 23 to 24 per cent of the world production of textile raw materials. But if we take into account their lower specific gravity, the fact that they lose less in processing, and the greater durability of articles made of such fibres, their share in the world textile balance is now about 30 to 35 per cent. Cotton now occupies the first place in world production, while chemical fibres have firmly established themselves in second place, leaving wool far behind, not to speak of natural silk. The use of artificial and synthetic fibres releases the areas set aside for cotton and the production of food-stuffs.
31. The expansion of the natural rubber industry has now come to a complete halt, while the production of synthetic rubber approximates that of natural rubber ( 2.5 million tons
of synthetic and 2.1 million tons of natural rubber).
32. An enormous quantity of vegetable oils and animal fats is used in the world for industrial purposes. At the same time, synthetic cleaning agents are three to four times cheaper than substances for the same purpose manufactured from natural fats. The latter should be freed to serve their direct purpose, which can do much to improve food supplies. Food products are expended in acetone-butyl fermentation plants. Enormous quantities of nutritive starch, casein, etc., are also used for industrial purposes.
33. An important way of increasing food production is to make use of non-nutritive vegetable raw materials. With modern chemical technology and industrial microbiology, nonnutritive vegetable raw materials can be used to produce monosaccharides (hexoses, pentoses), ethyl alcohol, sorbite, xylite, glycerine, glycol, protein-vitamin substances (food preparations, nutrient yeasts, amino-acids) and a number of other products. These products can be used:
(a) Directly, as food products;
(b) As substitutes for nutritive raw materials used in industry;
(c) As fodder supplements for use in stockbreeding.
34. The sources of non-nutritive raw materials from which the above products may be derived are very extensive. For instance, there are enormous, annually renewed resources of polysaccharide containing materials in the form of waste from logging saw-mills and woodworking, the wastes produced by industrial processing of corn-cobs, sunflower and cottonseeds and a number of other types of agricultural raw materials, and also wild growing grasses and bushes. Thus, for example, in 1965 in the Soviet Union the wastes of the timber and wood-working industry will amount to about 60 million cubic metres, including about 20 million cubic metres of soft wastes most suitable for production by hydrolysis. The volume of these wastes will continue to increase. A further major source of raw materials for chemical and biochemical processing is the tens of millions of tons of sawdust produced in timber-felling.
35. The oil-extracting plants which process cotton seeds in the Soviet Union turn out over 400,000 tons of cotton husks a year, and the pressing plants about 200,000 tons.
36. The amount of these wastes will exceed one million tons a year in the near future. The quantity of sunflower seed husks turned out
at oil plants amounts to about 700,000 tons a year. The wastes produced in the processing of corn-cobs-the corn-cob cores-are reckoned in millions of tons.
37. The basic process whereby monoses are obtained from non-nutritive vegetable materials for further chemical and biochemical processing is the catalytic transformation (hydrolysis) of polysaccharides in plant tissues. The monose yield in relation to the dry weight of raw material using hydrolysis with diluted sulphuric acid is 48 per cent in the case of wood pulp, 50 per cent in the case of corn-cob husks, and 39 per cent in the case of sunflower husks. In the hydrolysis of wood pulp with concentrated hydrochloric acid with a view to obtaining nutritive glucose, the sugar yield rises to 60 per cent. The hydrocarbons in oil can serve as a new form of raw material for the fodder of farm animals.
38. The main petroleum-based raw material used for the production of protein-vitamin concentrates is refined liquid paraffins of normal structure, containing not more than 0.5 per cent aromatics and with a melting point not higher than 30 to 32 degrees. These paraffins are separated from diesel fuel when it is processed to reduce the freezing temperature (to obtain winter and arctic fuels). In the deparaffining of diesel fuels with average paraffin content, the yield of liquid paraffin is 14 to 16 per cent of the raw material, and in the deparaffining of tail fractions of diesel fuels from high-paraffin oils (Stavropolsk and Mangyshlaksk types) the paraffin yield reaches 30 to 40 per cent.
39. In the Soviet Union, the quantity of liquid paraffins suitable for the microbiological manufacture of protein-vitamin substances potentially available for separation will be about 3 million tons by 1970, sufficient for the production of over 2 million tons of protein-vitamin concentrate.
40. In the next five years it is planned to construct a number of plants for carbamide deparaffination with a capacity of 500,000 and 1 million tons a year (raw material). The cost of producing one ton of refined paraffin at such plants will not exceed 10 roubles.
41. The production of protein-vitamin substances is of particular importance for the national economy. Soviet scientists have bred highly productive strains of yeast which can effectively assimilate the pentoses and hexoses produced in the hydrolysis of vegetable wastes. New types of yeast have also been bred which can make effective use of the hydrocarbons in paraffins of normal structure. Industrial methods of cultivating yeasts have been devised
and organized which ensure the continuity of the whole production process. New and highly productive types of equipment have been introduced: yeast-growing devices, flotators, separators, spray dryers, and so forth. The introduction of advanced processes and equipment has brought about a decline in proportional expenditure of chemicals, steam and electricity on the manufacture of yeasts, and a consequent decline in production costs.
42. Nutrient yeasts and protein-vitamin concentrates derived from petroleum hydrocarbons are a high-value fodder product. The product contains up to 50 per cent digested protein, including almost all the most important aminoacids an animal needs. The yeasts and concentrates are extraordinarily rich in vitamins and in this respect represent a considerable advance over all other fodders and protein supplements of either animal or vegetable origin.
43. Many years of experience with the use of hydrolyzed yeasts in stock-breeding have shown them to be highly effective. According to data provided by the All-Union Scientific Research Institute for Stock-breeding, the admixture of one ton of nutrient yeasts to cattle and poultry feed yields an additional 0.75 tons of pork (live weight) or two tons of poultry (live weight), or 30,000 eggs, or 4,000 to 6,000 litres of milk. The sale value of the additional produce is four or five times greater than the cost of the yeasts used. Such is the effectiveness of protein-vitamin concentrate derived from petroleum hydrocarbons as used in agriculture.
44. We should also note the importance of the mechanization of agriculture for increasing food supplies. The substitution of vehicles for draught animals in agriculture and transport, in addition to increasing the productivity of labour, in itself considerably increases food resources. The grain previously used to feed draught animals can now be used in part to feed people; land taken up by fodder crops can now be sown with food crops; the wastes from food crops and fodder from uncultivated land can be used entirely to feed productive animals. In the period 1951-1952 there were reckoned to be 128.1 million horses, mules and asses in the world. In addition, a considerable proportion of the 809 million head of cattle were being used as draught animals. Calculations show that under 1951-1952 conditions the full mechanization of agriculture and transport could provide additional food for 335 million people.
45. We shall now consider a number of other possible ways of increasing the production of materials suitable for use as food. Let us turn once again to the problem of photo-
synthesis. The total output of photosynthesis in green plants is tens and hundreds of times greater than is necessary to feed the human race. Only an insignificant part of the photosynthetic output of plants is used as food. The photosynthetic activity of arboreal vegetation alone creates about 35,000 million tons of organic substances every year. Only fractions of a per cent are used as food-stuffs. Man makes even less use of the photosynthetic output of aquatic flora. Aquatic plants create about 200,000 million tons of organic substances every year. These products, directly or through complex food chains, serve as food for the entire aquatic population. But only an infinitesimal fraction of it falls to the lot of animals used for food.
46. Fuller use is made of cultured plants, the coefficient of utilization being about 20 per cent of the total biomass.
47. If we take into account the animal intermediaries, man still uses only about 5 per cent of the organic substances initially formed through photosynthesis by fodder plants. The total proportion of the biomass of food and agricultural fodder plants used may be considered as 7 or 8 per cent.
48. It may seem from these data that the initial output of terrestrial flora is very great. However, it is very far from fully used.
49. Increased food production should not be limited by traditional methods. Here we should note in the first instance the problem of extracting and concentrating nutritive substances, particularly proteins from the green mass of plants, trees and marine vegetation, and also, as noted above, the chemical or biochemical transformation into food products of organic material not suitable for food. In principle, all substances contained in plants are suitable for food-if not for animals, then at least for mushrooms and bacteria, which may then be transformed into food.
50. A thorough solution to the problem of providing enough food for the growing human race means, in addition to the cultivation of plants, the search for new ways of using the photosynthetic activity of plants for the production of food and nutrient biomass. One might be the mass cultivation of unicellular aquatic organisms, which in recent years has attracted attention in many countries. The potentialities of such an approach are very great. In the cultivation of chlorella, for example, a combination of carbonic acid gas, mineral salts and water can yield a "harvest" of up to 20-40 tons per hectare. It is theoretically possible to obtain up to $150-200$ tons per hectare of dry biomass
per year. In the view of Japanese scientists, the cost of chlorella proteins is already comparable with that of other proteins. Chlorella protein may be used to feed animals and, after appropriate thermal and fermentation processing, human beings, too.
51. With the development of industrial processes for the cultivation of unicellular aquatic organisms and the discovery of ways to use them for food, tens and hundreds of times less surface area will be sufficient to produce the same quantity of food as is produced today.
52. Another means of increasing food production is the direct chemical synthesis of nutritive substances from carbonic acid gas, water and atmospheric nitrogen. Such processes require enormous quantities of energy. If the problem of supplying the human population with carbohydrates is to be solved by means of chemical synthesis, it will be necessary to produce for a population of 5,000 million 750 million tons of sugar, equivalent in energy to 30 million million calories or 350,000 million kilowatt hours. Supposing a chemical synthesis of $\mathrm{CO}_{2}$ and $\mathrm{H}_{2} \mathrm{O}$ with a 10 per cent energy output to be possible, the process would require about twenty power stations like the one at Bratsk in the Soviet Union ( 3.6 million kilowatts).
53. To begin with, the artificial synthesis of food-stuffs will probably be useful in cases where there is need for individual food com-
ponents (amino-acids, vitamins, certain protein preparations, etc.).
54. The use of petroleum and coal as fuel is already insufficient to satisfy man's needs. These types of fuel minerals are already close to exhaustion in a number of countries, and they are needed as raw material for the chemical industry and for the direct manufacture of nutrients and foods. The primary source of power must in future come to be atomic energy, using both natural uranium and, in the long term, thermonuclear fuel.
55. There is enough fuel to provide atomic power for many years, no matter how great the consumption of electricity. According to data in the literature, no less than 40,000 tons of uranium are now mined every year throughout the world. Half this quantity would be sufficient to fuel atomic power stations with a total capacity of $15,000-20,000$ megawatts. In the long term, thermonuclear synthesis can and will be a practically inexhaustible source of energy. Practically unlimited resources of thermonuclear fuel are contained in the world's. oceans.
56. The realization of these possibilities will require great efforts. However, man has now attained a level of knowledge and technology sufficient, if not criminally squandered for military purposes, to open up magnificent prospects for enhancing the welfare of mankind and above all providing it with adequate nourishment.

## SUMMARY OF PAPER

## World energy and energy resources in the

 United Arab RepublicF. M. Ebeid and T. I. Rihan

The remarkable growth of petroleum industry in the world has been partly owing to the displacement of other sources of energy, coal in particular, but chiefly to the magnificent progress in petroleum technology. Crude oil, with its large reserves, is currently a growth industry with long-range prospects throughout the world.

Coal could be satisfactorily substituted for oil and gas in most applications if a serious shortage were to develop in oil supplies.

The world's total energy requirements will increase during the next twenty to fifty years. However, the world reserves of the various energy resources from fossil fuels are sufficient to meet these requirements.

Other resources of energy, such as nuclear power, hydroelectric power and solar energy, are outlined briefly.

The recent development in the petroleum industry in the United Arab Republic, the hydroelectric power which will be generated from the Aswan High Dam and the utilization of nuclear power as an additional source of energy are also discussed.

## Meeting A. 7

# DEMOGRAPHIC ASPECTS OF AGRICULTURAL DEVELOPMENT AND FOOD SUPPLY 

## PAPERS

## Relationship between population pressure (or growth) and systems of land tenure, the fragmentation of holdings, and customs affecting fertility in rural areas

Michel Cépède

[Translated from French]

1. As population pressure grows, man compels the same land to produce more and more until finally he exhausts it. The customs which maintain fertility are no longer respected. The "interests of the future race", 2 are sacrificed in order to satisfy immediate needs. The forest, the sacred grove itself, is cleared in order to provide land.
2. This logical pattern may be illustrated by examples taken from regions which were once inhabited but which man has had to surrender to the desert. As early as $1905, \mathrm{~A}$. Woiekoff ${ }^{8}$ pointed out that more than half of mankind then lived between latitudes $20^{\circ}$ and $40^{\circ}$ North in a zone which contains the principal deserts of that hemisphere. This fact leads naturally to the conclusion that it was the multiplication of mankind, in this biologically favourable zone, that caused the desert to spread. ${ }^{4}$ Conversely, it appears that the soil in England has become more fertile since that country's agriculture has been required to produce less. ${ }^{5}$

[^196]3. In an advanced agricultural economy, however, existing fertility bears very little relation to natural fertility. Even the most fertile land must be drained and cleared before it can be brought under cultivation, and this calls for a fairly high population density. Where population density is below a certain level, man is condemned to live in a food-gathering, hunting and fishing economy which can support only a sparse population. The "green desert" of the Amazon, with population densities in the order of one inhabitant per square kilometre, is "over-populated" in places. Similarly, Henri Prat ${ }^{\text {* }}$ reminds us that during the middle palaeolithic period the earth was over-populated, with a total of a few hundred thousand inhabitants, or a million at the most, leading a wretched existence.
4. Over-population is a phenomenon which does not depend on the insufficiency of natural production; it results from man's inability, at a certain level of technology and population density, to appropriate enough of the fruits of the land for his needs. ${ }^{7}$
5. Large-scale drainage schemes have, moreover, rarely been carried out by peasant communities. The early war lords, on the other hand, who could afford to "use up" the wealth represented by slaves acquired as the prize of battle, were willing to take over the unhealthy

[^197]land in the plains, which, after being drained and cultivated by the abundant manpower at their disposal, proved to be more fertile than the mountain slopes where the peasants had first settled. Much the same thing occurs whenever new land is settled; after the heavy investment made at the outset is no longer remembered, the peasants discover that they own the poorest land. They feel that they have been "robbed" or, at all events, that they are the victims of injustice. ${ }^{8}$ If they wish to farm better land, they must either rent it or buy it. A system of land tenure may also result from outright plunder, with no attempt made to justify it in terms of "investment"; an invading people may force the indigenous peasants to pay tribute or rent in order to go on farming the land of their ancestors and compel them to provide various services on those lands which the conqueror has set aside to be farmed for his own exclusive benefit.
6. This system of land tenure is to be found in any heterogeneous agricultural society. If they are to have the means of subsistence and be able to devote themselves to their duties as priests, soldiers or public administrators, the non-peasant classes must receive part of the income from agricultural production-either as rent by virtue of their proprietary rights or as tribute by virtue of their sovereign rights. Whatever their origin, these land rights give rise to a system of cultivation by slaves or wage labour or to a system of land tenure.
7. Furthermore, population growth leads to the fragmentation of the limited agricultural land available-either through the periodic redistribution of collectively held land or through the inheritance of individual or family holdings. Where crop rotation is obligatory, the fact that everyone must have a plot in each field and each type of soil leads to parcelling in addition to fragmentation. Rather than simply enumerate the various problems to which this gives rise, this paper will confine itself to the relationship between population pressure (or growth) and soil fertility.
8. Rural areas with the highest population density are characterized by agriculture which is intensive in nature, i.e., which results in a high yield per unit of land area and is nonmigrant and perennial. The formerly inhabited deserts, which in most cases are areas where the destruction of soil fertility went furthest, seem never to have had a comparable level of population density. ${ }^{9}$ They could have been

[^198]"over-populated" only under the conditions of a food-gathering or a pastoral economy-the latter of which is merely a gathering economy based on the use of domestic animals-but not under the conditions of a genuinely agricultural economy.
9. The laws governing human development in a food-gathering or pastoral economy are those which Vito Volterra laid down for parasitism. ${ }^{10}$ They are not very favourable to the predatory populations of which mankind was made up at that stage in its development. The parasite which is most dangerous to the population on which it lives is the one which can seek elsewhere tomorrow what it has exhausted here today. The nomadic shepherd, who lives "in space" ${ }^{11}$ is unable, in the demands he makes on the land, to observe the moderation which the non-migrant peasant, living "in time" ${ }^{12}$ finds natural. It is when man makes an investment in the soil in order to increase its natural output that agriculture is born. Thus, agriculture came about as an effort to improve the land: "After each crop-rotation cycle, the manure which is used leaves in the soil a deposit, or surplus, of fertilizer which, since it is not immediately assimilable, represents a kind of fixed capital of humus or compost which enhances the physical properties of the soil and prepares well in advance elements to be assimilated by future crops". ${ }^{13} \mathrm{P}$. Gourou observes that "While a small barbarian tribe sees no other means of meeting the needs of its increased numbers than to seize its neighbours' lands, the Far Eastern peasant, who is civilized, copes with population growth by improving his agricultural techniques and raising the yield". ${ }^{14}$ A society based on intensive agriculture attempts to find an answer to population growth in further intensification and, if it cannot achieve this, will make every effort to limit its population. ${ }^{15,16}$
10. Of course, agriculture may, like a foodgathering or pastoral economy, extract more than can be restored by natural production; ${ }^{17}$ it is then exploiting nature like a mine, which, as R. J. Turgot ${ }^{18}$ has said, does not bear fruit

[^199]but is itself a fruit which can be plucked only once. This "mining agriculture" 18 is "antiagricultural"; it is the very opposite of peasant cultivation. Extensive agriculture, especially if it is nomadic, is more likely to be of the "mining" type; the destruction it causes is apparent in the areas occupied by more or less settled nomads or by nomads who, having conquered peasant peoples and taken over the making of decisions, force upon them a type of agriculture which they themselves would not have chosen. Although they have become "tillers of the soil", these shepherds have not become "peasants" but "shepherds of peasants", 20 and they introduce into agriculture the "farming" of those who live "in space". While the food-gatherer and the peasant have respect for trees and often worship them (many examples of this have been reported by Sir James G. Frazer), ${ }^{21}$ the "shepherd of peasants" destroys the trees in order to provide land for "his peasants", just as the shepherd provides grazing land at the expense of shrubbery or even forest in order to feed his flock.
11. Where changes in the system of production have been noted in peasant societies, i.e., where farming based on conservation and improvement has given way to a type of farming which is less concerned with preserving soil fertility, such changes have occurred following contact with pastoral civilizations. ${ }^{22}$ They have been accompanied by revolutions in customs, attitudes, family and social structure, religious beliefs, etc.-by, for example, the replacement of women by men as the chief cultivators, the loss of respect for the sacred grove or for the ritualistic abstraction which replaces it by a single tree or a piece of wood at the village gate, or the substitution of a god of fire and deforestation for a goddess of fertility as the protector of agriculture. All this opens the door to chance and to the destruction of fertility, but there is no proof that population pressure or growth has played a decisive role in such changes.
12. Do these observations apply to what has happened in the United States, where modern man's attention has been drawn to the destruction of fertility and the deterioration of the soil ? ${ }^{23,24}$ Agriculture in the United States

[^200]remained extensive in nature until very recently; it is still characterized by yields per unit of land area which are about one third of those recorded in the European Economic Community. ${ }^{25}$ The concept of infinity ${ }^{28}$ favoured the establishment of "mining agriculture" of a type suited to a people living "in space". ${ }^{27}$ The continent was plundered, and within a few decades its riches, which had been considered inexhaustible, had been squandered. The population density of the forty-eight States south of Canada has, however, remained below the average density for the world.
13. In this case, however, the nature of American society must also be borne in mind. With important exceptions, especially as regards agriculture, ${ }^{28}$ its characteristics are those of a "capitalist" society, based on markets and profits, which has contempt for what is "free", especially the natural resources whose conservation is essential to economic life and, indeed, to human life itself. As Karl Marx commented on this very example: ${ }^{29}$ "Capitalist production thus develops the technology and organization required for the process of social production only by exhausting at the same time the two sources from which all wealth springs: the land and the worker".
14. It is surely striking that agriculture in the United States was able to become more intensive ${ }^{30}$ only after the need to conserve natural resources had resulted in the establishment of organizations like SCS and AAA which went counter to the market philosophy. The market economy leads to the disappearance of peasant agriculture, for economic crises promote extensive rather than intensive farming. ${ }^{31}$ Intensive agricultural economies, unless they are protected by an adequate domestic market, inevitably disappear or are led in their turn to "exhaust" the two sources from which all wealth springs: the land and the worker. In the developing countries, which supply the world's agricultural markets, the competition of extensive agriculture often forces intensive agriculture, contrary to its

[^201]inherent tendencies, either to destroy apparently free natural resources or to disappear. ${ }^{32}$
15. When a system of intensive agriculture disappears, the resulting exodus reduces the population which had gradually provided the enormous investment required; reduction of the population below the minimum essential for the maintenance of soil fertility is another cause of the destruction of fertility.
16. Once abandoned, the terrace is worn away by erosion unless it is taken over in time by the forest or, at least, the bush; the irrigated zone becomes a swamp, and malaria is more likely to occur there than in the primitive plain. There are many examples of degraded areas which were once heavily populated and whose destruction was brought about not by population pressure but by the reduction of that pressure, which set in motion the process of deterioration and, thence, the population exodus.

[^202]17. Contrary to the pattern outlined at the beginning, we are thus led to believe that, at least in a peasant agricultural economy, population growth leads to intensification of the system of farming and that this has the effect of increasing rather than destroying fertility. The deterioration which has been noted is the work of low-density, nomadic, pastoral populations, practising at the most a system of extensive agriculture. This deterioration is all the more serious in that the products provided for the market by these economies, with their contempt for what is "free", are highly competitive in price and that there is no limit to the desire for gain in economies of this type. Contrary to what had appeared logical a priori, it would seem that low and/or falling population pressure is a greater threat than high, rising pressure to the customs which safeguard fertility in rural areas.
18. Those who are shocked by this conclusion may find it a profitable avenue of research to unearth and analyse facts which lend themselves to a different view.

## Role of food aid under conditions of rapid population growth

## V. M. Dandekar

1. In the current discussion regarding the development of food surpluses in some parts of the world and food deficits in other parts, sufficient attention should be given to a circumstance which is very likely at the root of this problem. This circumstance concerns the unequal distribution of the world's population in
relation to the agricultural land. Relevant data are available, and an examination of these data in the context of this particular discussion ought to be worth while.
2. In table 1, the world is divided into twenty-two regions, which are then grouped

Table 1. Share of different subregions in world population (mid-point 1959-1961) and agricultural land; their man-land ratios and estimated annual ratios of population growth, 1960 -1970

| Subregion | Population 1959-1961: worlid share (percextage) (percentage) | Agricult ralland: (percentage) | $\begin{gathered} \text { Mar-land } \\ \text { ration } \\ \text { (numberpet } \\ 100 \text { acreses) } \end{gathered}$ | $\begin{aligned} & \text { Anvual } \\ & \text { Qrowth } \\ & \text { trath } \\ & 1960.1970 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: |
| Oceania | 0.4 | 12.3 | 1 | 2.0 |
| Southern Africa | 0.6 | 5.1 | 4 | 22 |
| River Plate countries. | 0.7 | 4.0 | 6 | 1.7 |
| Subtotal 1 | 1.7 | 21.4 | 2.5 | 2.0 |
| United States | 6.0 | 11.5 | 16 | 1.5 |
| Canada | 0.6 | 1.6 | 12 | 2.5 |
| Mexico | 1.2 | 2.4 | 15 | 3.1 |
| Union of Soviet Socialist Republics | 7.1 | 15.3 | 15 | 1.3 |
| Subtotal II | 14.9 | 30.6 | 15 | 1.6 |
| Northern Europe | 7.0 | 2.5 | 88 | 0.7 |
| Southern Europe | 3.2 | 1.4 | 70 | 0.7 |
| Eastern Europe | 3.9 | 2.0 | 61 | 0.9 |
| Jayan .......... | 3.1 | 0.2 | 527 | 0.9 |
| Subtotal III | 17.2 | 6.1 | 87 | 0.8 |
| Central America and Caribbean area | 1.1 | 0.6 | 61 | 2.7 |
| Brazil | 2.3 | 3.2 | 23 | 3.1 |
| Other, South America. | 1.7 | 2.1 | 25 | 2.8 |
| Subtotal IV | 5.1 | 5.9 | 27 | 2.9 |
| North Africa | 2.8 | 4.7 | 19 | 2.2 |
| West Central Africa.......... | 3.6 | 6.6 | 17 | 2.1 |
| East Africa | 1.6 | 5.0 | 10 | 2.3 |
| West Asia | 2.7 | 5.1 | 16 | 2.4 |
| Subiotal V | 10.7 | 21.4 | 15.5 | 2.2 |
| India | 14.3 | 4.4 | 100 | 2.2 |
| Other, south Asia. | 4.2 | 1.2 | 108 | 2.5 |
| Other, east Asia.............. | 3.2 | 1.6 | 154 | 2.5 |
| Communist Asia | 23.7 | 7.4 | 100 | 1.7 |
| Subtotal VI | 50.4 | 14.6 | 107 | 21 |
| Worid | 100.0 | 100.0 | 31 | 1.8 |

[^203]under six major categories. The regions grouped under the last category include the whole of south and east Asia, except Japan. This area contains half the world's population, subsisting on barely one seventh of the world's agricultural land. Agricultural land per person in this area is less than one acre. At the other extreme are the regions grouped under the first two categories. The first category contains those regions which are sparsely populated, namely, Oceania, southern Africa and the River Plate countries of South America. This category holds less than 2 per cent of the world's population with more than 20 per cent of the world's agricultural land. Per capita agricultural land in this category amounts to over forty acres. In the second category are Canada, Mexico, the Union of Soviet Socialist Republics and the United States of America. They account for 15 per cent of the world's population and 30 per cent of the world's agricultural land. Even though this group of countries is not so sparsely populated, it still has 100 acres of agricultural land for every fifteen persons, amounting to a little less than seven acres of agricultural land per person. If one adds the first two categories, they account for less than one sixth ( 17 per cent) of the world's population, with more than half the world's agricultural land at their disposal. This situation is in direct contrast to that of the last category, where half the world's population has access to only one seventh of the world's agricultural land.
3. It is only in Europe and Japan that the average density of population comes anywhere near that in south and east Asia. The density in Europe and Japan together is eighty-seven persons per 100 acres, as compared with 107 persons per 100 acres in south and east Asia. Africa (other than southern Africa) and west Asia together have densities which are nearly the same as those in Canada, Mexico, the Soviet Union and the United States of America, namely, about fifteen persons per 100 acres. The density in South America, other than in the River Plate countries, is much higher, with about twenty-four persons per 100 acres. The density in Central America (other than Mexico) and the Caribbean area is approaching Asian levels, with sixty-one persons per 100 acres.
4. The intensity of use of agricultural land adequately reflects the population density of several regions of the world. In general, the more densely populated a region is, the more intensely it uses its agricultural land. This is observed by comparing the value of agricultural food production per acre among the various
regions. Even though it does not take into account the areas of non-food cultivation, it should provide a useful indicator of the intensity of land use. The World Food Budget, 1970 gives estimates of the agricultural production of the main items of food in different regions of the world, ${ }^{1}$ as well as the value of such production on the basis of uniform export unit values (average 1959-1961). ${ }^{2}$ Table 2, column 2 , shows the per capita value of agricultural food production, excluding fish, gross of nonfood use of some of the food items. Table 2, column 3, shows the per capita value of agricultural food production net of non-food use. By multiplying the per capita production figures by the density of population per acre of agricultural land (table 1), the value of agricultural food production per acre is obtained. Table 2, column 4, shows the value of agricultural food production net of non-food use per acre.
5. A comparison of these estimates for different regions is instructive. The average value of agricultural food production per acre the world over is 13.5 United States dollars. It varies from under $\$ 2$ in Oceania, which is the least densely populated, to over $\$ 150$ in Japan, which is the most densely populated. In the most densely populated region besides Japan, namely, in south and east Asia, the value of agricultural food production is $\$ 26.6$. In Europe, with comparable, though somewhat lower, density, the value of food production is almost one and one half times in southern and eastern Europe, and more than double in northern Europe. The difference between south and east Asia, on the one hand, and Europe, on the other, is the difference that improved agricultural technology has made. Food production in Japan is a miracle both of technology and of human diligence.
6. The striking fact brought out by this comparison is that, in spite of all the advantages of technology, the value of agricultural food production per acre in the less densely populated, but developed, regions is not only not on a par with the same type of area in Europe, but is, in fact, much below the levels even in south and east Asia. In the United States of America, the value of food production per acre is below $\$ 20$ and in Canada it is only $\$ 13.3$, i.e., only half of the level in south and east Asia. In the Soviet Union it is only $\$ 9$; in the River Plate countries and in Mexico, it is about $\$ 7$; and in southern Africa and in Oceania, it is only about $\$ 2$. It is obvious that

[^204]Table 2. Value of food consumption per annum per capita and value of agricultural food production per capita gross of non-food uses and per capita and per acre net of non-food uses, 1959-1961

| Subregion | Valse of food consumption per an**m per capita | Vahue of agricultural food production |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Gross of thon food use per capita | Net of non-food uses |  |
|  |  |  | Per capita. | Per acre |
|  | (In United States dollars) |  |  |  |
| Oceania | 117.2 | 346.9 | 183.2 | 1.8 |
| Southern Africa | 57.4 | 71.3 | 61.6 | 2.5 |
| River Plate countries. | 97.2 | 131.1 | 120.2 | 7.2 |
| Subtotal I (average) | 88.8 | 147.6 | 115.8 | 2.9 |
| United States of America.... | 109.2 | 160.4 | 119.9 | 19.3 |
| Canada | 104.0 | 172.6 | 110.9 | 13.3 |
| Mexico | 43.7 | 50.2 | 46.5 | 7.0 |
| Union of Soviet Socialist Republics | 64.5 | 93.4 | 59.5 | 8.9 |
| Subtotal II (average) | 32.4 | 120.2 | 84.9 | 12.7 |
| Northern Europe | 93.2 | 107.8 | 68.9 | 60.6 |
| Southern Europe | 67.1 | 70.7 | 55.4 | 38.8 |
| Eastern Europe | 66.0 | 109.9 | 58.0 | 35.4 |
| Japan | 51.2 | 36.1 | 29.5 | 155.4 |
| Subtotal III (average) | 74.6 | 88.4 | 56.8 | 49.4 |
| Central America and Caribuean area | 47.5 | 70.3 | 66.2 | 40.4 |
| Brazil | 55.5 | 63.8 | 53.7 | 12.4 |
| Other, South America | 49.4 | 54.4 | 47.0 | 11.8 |
| Smbtotal IV (average) | 51.8 | 62.0 | 54.1 | 14.6 |
| North Africa | 35.4 | 38.5 | 32.2 | 6.1 |
| West central Africa | 31.3 | 39.3 | 33.2 | 5.6 |
| East Africa | 40.9 | 43.6 | 40.4 | 4.0 |
| West Asia | 42.4 | 48.3 | 32.6 | 5.2 |
| Subtotal V (average) | 36.6 | 41.9 | 33.9 | 5.3 |
| India | 29.8 | 28.1 | 26.0 | 26.0 |
| Other, south Asia. | 35.5 | 32.2 | 28.6 | 30.0 |
| Other, east Asia | 35.8 | 37.5 | 34.9 | 53.7 |
| Communist Asia | 23.5 | 24.6 | 20.1 | 20.1 |
| Subtotal VI (average) | 28.3 | 28.4 | 24.9 | 26.6 |
| Wormo (ayerage) | 47.5 | 57.6 | 43.4 | 13.5 |

Source: The World Food Budget, 1970, tables 4, 22 and 36.
there is too much land in these countries for it to be put to intensive use.
7. In Africa, other than southern Africa, and in west Asia, the population densities are comparable to those in Canada, Mexico, the Soviet Union and the United States, but the value of food production per acre is much lower, ranging between $\$ 4$ and $\$ 6$. This is evidently owing to lack of technological progress. In South America, including Brazil, the value of food production per acre is above that of the River Plate countries alone, though still below those in Canada and the United States. In view of the higher densities of population in these regions, the lower value of food production must be attributable to lack of technological progress on a sufficient scale. In Cen-
tral America and the Caribbean area, where the density is comparable to, though still below, that in south and east Asia, the value of food production per acre is one and one half times that of Asia. Part of the reason is, of course, the large cultivation of sugar in this region.
8. In spite of the very low intensity of use of their agricultural land, some of the regions produce food in excess of their needs, while other regions, in spite of considerably higher intensity of land use, cannot produce enough. This is because of the differences in the densities of the populations which the regions have to support. To see this, one must compare per capita food production and food consumption in different regions. These are shown in table 2, columns 3 and 1, respectively. Thus, the world
per capita average value of agricultural food production, net of the non-food use, is \$43.4, while the value of average per capita food consumption is $\$ 47.5$. The difference between the two is mainly owing to the fact that the agricultural food production excludes fish and fish products. The value of per capita food consumption in Japan is $\$ 51.2$, and it is known to be nutritionally adequate. One may, therefore, for convenience, assume per capita food consumption of the value of $\$ 50$ to be nutritionally adequate and examine the situation in different regions of the world.
9. At the top of the nutritional scale are four regions, namely, Oceania, the United States, Canada and the River Plate countries of South America. Value of per capita consumption in these regions is $\$ 117.2, \$ 109.2$, $\$ 104.0$ and $\$ 97.2$, respectively. On the other hand, the value of per capita agricultural food production in these regions is $\$ 183.2, \$ 119.9$, $\$ 110.9$ and $\$ 120.2$, respectively. Thus, all four regions are able to sustain their populations at a very high level of nutrition and also to produce a surplus. They are able to do this, in spite of the low intensity of land use, because of the extensive agricultural lands at their disposal. The problem in these regions is how to discourage further intensive land use and thus to keep the surplus down. Incidentally, the per capita food production in the River Plate countries is the same as in the United States, namely, about $\$ 120$. Nevertheless, the per capita food consumption in the River Plate countries is only $\$ 97.2$, compared with $\$ 109.2$ in the United States. The reason must be the existence of a larger section of poor population with considerably lower nutritional level in the former countries, which brings down the national average.
10. The only other region which has attained nutritional levels comparable to those existing in the four regions mentioned above is northern Europe. The value of per capita consumption there is $\$ 93.2$. This has been possible because of very intensive land use and the capacity of this region to buy the balance of its requirements from abroad. The value of agricultural production per acre in northern Europe is above $\$ 60$, which is over three times as large as that in the United States. Nevertheless, the per capita food production in northern Europe works out to be only $\$ 68.9$, which is not sufficient to maintain the high level of nutrition reached. But northern Europe, because of the general economic development and high national per capita incomes, can afford to buy the balance of its food requirements. That is what it does.
11. The situation in other parts of Europe, namely in southern and eastern Europe, is similar, but both the land use and the nutrition are at lower levels. The value of per capita consumption in southern and eastern Europe is $\$ 67.1$ and $\$ 66$, the value of agricultural food production is $\$ 38.8$ and $\$ 35.4$ per acre and $\$ 55.4$ and $\$ 58$ per capita, respectively. Both can afford to buy the balance of their food requirements from abroad. The Soviet Union has about the same levels of per capita consumption ( $\$ 64.5$ ) and per capita food production ( $\$ 59.5$ ), but the available agricultural land is much more extensive than in either southern or eastern Europe. Consequently, the land is much less intensively used. The value of agricultural food production per acre in the Soviet Union is $\$ 8.9$, which is only a quarter of that in eastern Europe.
12. At a still lower, but nevertheless adequate, level of nutrition are southern Africa and Brazil, with values of per capita consumption at $\$ 57.4$ and $\$ 55.5$, respectively. Southern Africa has a small surplus of production, while Brazil has a small deficit. But the intensity of land use is very different in the two regions. The value of agricultural food production per acre in southern Africa is $\$ 2.5$, which is only one fifth of that in Brazil (\$12.4). In the rest of Latin America, the nutritional levels are inadequate. In South America (other than Brazil), the value of per capita consumption is $\$ 49.4$, while in Central America and the Caribbean area, and in Mexico, the values are $\$ 47.5$ and $\$ 43.7$, respectively. Mexico has a small surplus of food production over consumption, while South America has a small deficit. Here again, the intensity of land use is very different between Mexico and South America; the value of agricultural food production per acre in Mexico is only 60 per cent of that in South America. In Central America and the Caribbean area, as already noted, the intensity of land use and the value of agricultural food production per acre is high, but much of it is owing to the large share of sugar in the food production. Of course, it helps to maintain nearly two and one half times as large a population at more or less the same nutritional level as that in South America.
13. In Africa, the pressure of population on the agricultural land is not much less than in Canada or the United States. But the intensity of land use is comparatively very low. The value of agricultural production per acre is only about one third that in Canada or the United States. That explains the low level of agricultural food production per capita and also the low level of per capita food consumption.

Eastern Africa is somewhat better off in both respects, because of the comparatively smaller population it has to support. Population pressure and intensity of land use in west Asia are not very different from that in north and west central Africa. However, because of the oil resources of this region, it can afford to supplement its food production with a certain amount of imports and thus maintain a somewhat higher nutritional level.
14. Though larger parts of Latin America and Africa suffer from nutritionally inadequate diets, from the long-term point of view, the problem in these regions is not too acute in spite of the rather high rates of population growth. In the first instance, in Latin America, the inadequacies in diet are marginal and can be made up by greater intensive use of the land resources. In Africa, the diet inadequacies are larger but, correspondingly, the land resources are also ample. Finally, the two regions together account for less than one sixth of the world population, so that if it is thought necessary and desirable to extend to these regions adequate food assistance in the transitional period, the problem should not be beyond the existing food-producing capacity of the world.
15. The problem of inadequate diet is indeed the most acute in south and east Asia. The food gap is great and a large population is involved. As mentioned above, the region accounts for half the population of the world with less than one seventh of the world's agricultural land on which to subsist. The rapid rate at which the population in this region is currently growing may make the ratio even more unfavourable. The agricultural land is
already being used intensively, the value of agricultural food production per acre in this region being double that of the world average. Nevertheless, the productivity of land must be at least doubled and thus brought to European levels if the growing population in this region is to earn a nutritionally adequate diet. To achieve anything more would require raising the productivity closer to the Japanese levels. Presumably, this is technologically not impossible. However, obviously this could come about only as a consequence of general economic development.
16. Over the last decade, much thought has been given to the possibility of promoting economic development in the poorer countries through food aid. ${ }^{3}$ However, while assessing what may in fact be achieved through food assistance, the crucial fact of pressure of population seems to have been neglected. The fact of the situation is that half the population of the world has been confined to less than one seventh of the world's agricultural land, while less than one sixth of the world population enjoys more than half the world's agricultural land. It is natural that the former should have a food deficit and the latter a food surplus. It is admirable that the latter should offer food aid to the former. Clearly, however, the role of food aid under the circumstances cannot be much more than palliative. The United States has the largest programme of food aid, which it calls Food for Peace. Evidently, the title is not only modest, but also realistic.

[^205]
# Population growth in relation to the agricultural labour force in developed and some developing American countries 

Louis J. Ducoff

1. The trends in the agricultural labour force in the developing countries are distinct from those in the developed countries. In the United States of America, Canada and the western European countries, the technological, agronomic and biological advances in agriculture have enabled a diminishing agricultural labour force to produce the food and fibre requirements of the expanding population in their countries. A pronounced acceleration of these demographic, manpower and productivity trends has occurred in the past fifteen years among the developed countries. The workers released from agriculture and other migrants from the rural population have been absorbed into the urban-industrial sectors of their economies. The agricultural labour force has thus decreased both in absolute size and in the proportion that it comprises of the total labour force in the developed countries. In conjunction with the reduction of the agricultural labour force, there has been a reduction in the number of farms and in the size of the farm population.
2. In the United States and Canada, the technological revolution in agriculture had proceeded by 1964 to a point where only about 6 and 9 per cent, respectively, of the total labour force in each country was engaged in agriculture, and their farm populations comprised 7 and 11 per cent of their total populations in 1961. Nor has this process of sharp gains in productivity per man-hour and per worker in agriculture spent itself. Further shrinkage in the size of the agricultural labour force and the farm population is most likely. In the western European countries, the decline in the agricultural labour force has not been as steep as in the United States and Canada but, nevertheless, substantial decreases have occurred. The available evidence for more recent years indicates a speeding up of this process as an accompaniment to the fairly rapid mechanization and modernization of agriculture in the countries of western Europe. ${ }^{1}$

[^206]3. In the developing countries of Latin America and elsewhere, there is evident the earlier phase of agricultural and industrial development which manifests itself in a steady downward movement in the proportion of their labour force engaged in agriculture and a corresponding rise in the proportion engaged in non-agricultural activities. For Latin America as a whole, the agricultural labour force-as a proportion of the total economically active population-declined from 59 per cent in 1936 to 47 per cent in $1960 .{ }^{2}$ In Asia and Africa, the agricultural proportion declined from about 75 per cent in 1937 to about 60 per cent in $1960 .^{3}$ The rate at which the relative size of the agricultural labour force is decreasing varies considerably among the individual countries in these regions, depending on the degree of agricultural and industrial development of their economies.
4. The distinguishing trend in the agricultural labour force of the developing countries, in contrast to that of the developed countries, is the continuing increase in the absolute size of the agricultural labour force. Two factors are producing this sustained increase. One is the record upsurge in population growth which has been occurring in the developing countries. Mortality rates have sharply declined and birth rates have remained at a steady and high level. The increasing total population and population of working age, in the rural (and urban) sector has more than offset the loss of rural population through migration - heavy as this rural to urban migration has been. The second factor is the insufficient rate of productivity gains and modernization of agriculture

[^207]to bring about a net reduction in number of workers in agriculture.
5. One might examine a little more closely the pattern of demographic growth among developed and developing countries in the western hemisphere, in order to pin-point more precisely the rural-urban population growth and redistribution in response to the economic and social forces in these countries. This factor may be illustrated by drawing on data from the United States and Canada, and from Mexico and Central America. Some of the Central American countries are in an earlier stage of economic development than Mexico and provide a range of conditions that vary from early stages of economic development to the highly developed situation in the United States and Canıada.

Trends in the United States of America and Canada

## United States

6. The population of the United States increased from 152.3 million in 1950 to 180.7 million in 1960, and reached a level of 192.1 million in 1964. This is an annual rate of increase of 1.7 per cent for the entire period. The increment in total population since 1950 of nearly 40 million was greater than in any previous period of equal length and was characterized by a heavy concentration of growth in metropolitan areas. Thus, the fifty largest metropolitan areas accounted for 59 per cent of the total increase. The rural population (including farm and rural non-farm) remained virtually unchanged between 1950 and 1960, at a little more than 54 million. The unchanged level of the rural population implies a very substantial out-migration, since it means the loss of the natural increase that the rural population has had during the entire fourteen year period. Assuming fertility and mortality rates in the rural population equal to those in the population as a whole, this would mean an outmigration (and a reclassification from rural to urban, owing mainly to annexation of previously rural territories to cities) of about 12 million.
7. The stable size of the rural population resulted from a pronounced decrease in the farm population and a corresponding increase of the rural non-farm sector. Between 1950 and 1964 the farm population declined by 43 per cent. From a 1950 level of 23 million, when the farm population represented 15 per cent of the total population, it had dropped to 13 million in 1964 and made up only 7 per cent of the total. The net decline of 10 million is considerably less than the out-migration that
occurred during this period, as the excess of births over deaths in the farm population partially offset migration losses. Allowing for the natural increase that probably occurred, the out-migration from the farm population may have amounted to 13.3 million persons between 1950 and 1964.
8. As had been suggested earlier, this dramatic change in the farm population of the United States was a result both of technological and other conditions within agriculture and of economic and social factors outside agriculture. The push factors in a rapidly advancing technology in agriculture (which has led to wide-spread substitution of capital for labour and to farm consolidations), as well as the pull factors of urban employment and living conditions, have operated to produce the ruralurban population redistribution.
9. The impact on agricultural employment in the United States has also been dramatic. Agricultural employment declined from an annual average of 7.5 million in 1950 to 4.8 million in 1964. The proportion that agricultural employment represented of the total civilian labour force declined from 11.9 per cent in 1950 to 6.4 per cent in 1964. The productivity gains in agriculture have been of such a nature as to permit the labour force in agriculture in 1964 to produce a volume of output of agricultural commodities that was 30 per cent greater than in 1950, and a gain in output per man-hour of 125 per cent. Each worker in agriculture in 1963 was producing enough food and other agricultural commodities to meet the needs of thirty-one persons (including himself) compared with fifteen persons in 1950 and seven in 1910.

## Canada

10. Although the total population of Canada is only about one tenth that of the United States, its trends since 1950 in rural-urban population distribution and in agricultural employment have paralleled those in the United States. The 1961 Canadian Census of Population showed a rural population of 5.5 million, or 30 per cent of the total, as in the United States. The Canadian farm population in 1961 of 2.1 million represented 11.4 per cent of the total, compared with 8.1 per cent in the United States. Ten years earlier the Canadian farm population represented 20.2 per cent of the total population, compared with 15.3 per cent in the case of the United States. Agricultural employment in Canada declined from an annual average of $1,018,000$ in 1950 to 641,000 in 1963 - a relative decrease identical with that
in the United States. Agricultural employment made up 19.7 per cent of the total civilian labour force of Canada in 1950 and 9.5 per cent in 1963. ${ }^{4}$ The decline in the number of farms was a little less sharp in Canada than in the United States, registering a decrease of 23 per cent between 1951 and 1961, compared with a 30 per cent decrease in the number of farms in the United States. ${ }^{5}$

## Latin American countries

11. In contrast to the economically developed countries, those of Latin America show, with few exceptions, the demographic and economic characteristics typical of developing areas - high rates of natural increase and the predominance of rural and agriculturally dependent populations. While Latin America has a much lower density of population in relation to agricultural land area than such areas as east or south Asia, the average productivity per worker in Latin American agriculture is low. The pressure of population on resources is therefore marked and is becoming increasingly so with the region's very high rate of population growth, which tends to equal or outpace achievable economic growth rates.
12. Population censuses were taken in 19601963 in fourteen countries of Latin America. On the basis of these and 1950 census results, the United Nations Economic Commission for
[^208]Latin America (ECLA) estimated the population of all Latin America to have grown at a mean annual rate of about 2.8 per cent between 1950 and 1960. The rural and urban populations are estimated to have grown at annual rates of 1.6 per cent and 4.6 per cent respectively. The size and urban-rural distribution of the population and of the labour force in Latin America for 1950 and 1960 are shown in table 1.
13. Preliminary results on the rural-urban population distribution from the latest census are available for twelve countries and are shown in table 2 with comparisons from earlier censuses. All twelve countries show a rising proportion of urban population and a corresponding decrease in the proportion of rural. For the decade ending around 1960, nine of these countries showed annual growth rates of 2.8 per cent or more in their total populations. The urban populations have increased at a much higher rate than the rural in all twelve countries. Since their rural birth rates are generally higher than the urban rates and the mortality rates are certainly no lower, the more rapid urban population growth rates are owing very largely to extensive internal migration from rural to urban areas. This is further indicated by the much higher growth rates of the capital and larger cities than of the urban population as a whole. Despite the extensive out-migration, the rural populations in those countries continue to increase at rates that are as high or higher than those of the total populations in such developed countries as the United States of America and Canada, where the population upsurge has been comparatively rapid.

Table 1. Urban and rural, and economically active population of Latin America, 1950 and 1960

| Population sector | Population (milhons) |  | Distribution (percentage) |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 1950 | 1960 | 1950 | 1960 |
| Total population | 155.6 | 204.9 | 100.0 | 100.0 |
| Rural | 94.9 | 110.3 | 61.0 | 53.8 |
| Urban ${ }^{\text {a }}$ | 60.7 | 94.6 | 39.0 | 46.2 |
| Economically active population. | 53.0 | 68.6 | 100.0 | 100.0 |
| Agricultural b | 28.2 | 32.3 | 53.2 | 47.0 |
| Non-agricultural | 24.8 | 36.4 | 46.8 | 53.0 |

[^209]Table 2. Percentage of rural population in last two censuses and of inter-censal rates of population growth by residence category in specified Latin American countriest

|  | Rurat population |  | Intercensal annual rate of growth ${ }^{\text {b }}$ |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1950: | 1960 : | Total | Urban | Rural | Catisat city |
| Brazil | 63.8 | 54.9 | 3.1 | 5.2 | 1.6 | $3.2{ }^{\text {c }}$ |
| Chile | 39.8 | 33.5 | 2.5 | 3.7 | 0.5 | ... |
| Costa Rica | 66.5 | 65.5 | 3.8 | 4.0 | 3.7 |  |
| Dotninican Republic | 76.2 | 69.5 | 3.4 | 5.7 | 2.5 | 7.3 |
| Ecuador ... | 71.5 | 65.2 | 3.1 | 4.6 | 2.3 | 4.7 |
| El Salvador | 63.5 | 61.5 | 2.8 | 3.3 | 2.4 |  |
| Mexico | 57.4 | 49.3 | 3.0 | 4.7 | 1.5 | 4.9 |
| Nicaragua | 65.1 | 57.1 | 3.3 | 4.9 | 2.2 |  |
| Panama | 64.0 | 58.5 | 2.9 | 4.1 | 2.0 | 5.2 |
| Paraguay | 65.4 | 64.6 | 2.6 | 2.8 | 2.5 | 3.3 |
| Pera | 63.9 | 52.9 | 2.4 | 3.5 | 1.5 |  |
| Venezuela | 52.1 | 37.5 | 3.9 | 6.3 | 0.7 | 6.6 |

Sounce: C. A. Miró, "The Population of Latin America", Demography, vol. 1 (1964), pp. 15-41, tables 6 and 7.
a In Chile, the penultimate census was in 1952; in Peru, it was in 1940. The most recent census in Costa Rica was in 1963; in Ecuador, Nicaragua and Paraguay, in 1962; and in El Salvador and Peru, in 1961. In the other countries, 1950 and 1960 were the dates of the last two censuses
b Geometric rates.
c Refers to Rio de Janeiro, former capital of Brazil.
14. Corresponding to the rural-urban population changes in Latin American countries, there have been some shifts in the occupational distribution of the economically active population. Data for Mexico and some Central American countries may illustrate these trends. The proportion of the population that is economically active in agriculture continued to decline during the most recent inter-censal period in each of these countries. The absolute number in the agricultural labour force increased in each country by percentages roughly corresponding to the relative increase in the rural population of working age. The share of the labour force in all non-agricultural occupations combined increased, as did the absolute numbers, but by considerably larger increments than in the case of agriculture, as is to be expected in view of the much greater gains in the urban population.
15. In Mexico the agricultural labour force accounted for 54.1 per cent of the total labour force in 1960, compared with 57.8 per cent in 1950. In El Salvador, agriculture's share of the total labour force declined from 63.2 per cent in 1950 to 60.2 per cent in 1961; while in Nicaragua, the decrease was from 67.7 per cent in 1950 to 59.4 per cent in 1962. In Panama, the agricultural proportion was 50.3 per cent in 1950 and 46.2 per cent in 1960. Sample results from the 1963 Census of Population of Costa Rica show the agricultural proportion of the economically active population
to have been 48.9 per cent, compared with 54.7 per cent in 1950.
16. The industry mix of non-agricultural employment in Mexico and the above-mentioned Central American countries has not shown any marked change since 1950. The percentages of employment in the various non-agricultural industries in the period 1960-1962 were not very different from those in 1950. Trade and services (other than in public utilities, transportation and communication) still accounted for a disproportionately large share of all nonagricultural activities in these countries. Conversely, manufacturing, mining, construction and public utilities (including transportation and communication) represented in total a disproportionately small share.
17. Of the total gain in employment recorded during the decade ending around 1960 in Mexico, El Salvador, Nicaragua and Panama, non-agricultural industries accounted for 53 to nearly 70 per cent. But half or more of these wet gains in non-agricultural employment were in the trade and other service sectors. In Panama, three fourths of the net increase in non-agricultural employment was in these sectors. Substantial proportions of such employment are in domestic service, very smallscale retail trade and a variety of marginal services, all of which are characterized by very low levels of productivity and considerable under-employment.

## Significance and implications

18. In the light of the demographic and labour force trends discussed for North America and some Latin American countries, what can be said with regard to the interrelationship between population growth and the agricultural labour force? In developing countries that are mainly agrarian in economic structure, as is the case in most Latin American countries, the rapid growth of population owing to high birth rates and declining mortality results in a continuing pressure of population on economic resources. The consequent surplus labour supply in the rural population is partly relieved through heavy rates of out-migration from rural to urban areas, particularly to the larger cities. The rate of out-migration, however, is not large enough to siphon off all the increase in the rural population and, consequently, the agricultural labour force continues to increase in absolute numbers.
19. Transfer of human resources from agricultural to non-agricultural types of employment is an integral part of economic diversification and development. Since agricultural development must precede, or at least occur simultaneously with growth of the industrial and other non-agricultural sectors of the economy if the development process is not to stop short, the level of productivity per worker in agriculture must continue to rise along with increasing levels of productivity in the urban and industrial sectors. ${ }^{6}$ In the Latin American situation, economic growth is being slowed down by internal imbalances between the rates of population growth in the various countries and the ability of their economies to absorb manpower in the agricultural and non-agricultural sectors at progressively rising levels of productivity. The unfavourable terms of trade that Latin American countries have been experiencing since the years immediately following the Second World War have been an

[^210]important external factor in preventing a more rapid rate of economic growth.
20. The impact of the population growth factor can be gauged by noting that during the period 1955 to 1961 aggregate real income in all of Latin America grew at an annual rate of 3.8 per cent. Since population increased during the same period by 2.8 per cent per annum, real income per capita rose only 1 per cent per annum. In Mexico, where population grew at an annual rate of 3.1 per cent during this period, real income per capita rose only 0.5 per cent per annum. In Central America, real income during the period 1957-1961 failed to keep pace with population growth and the per capita average declined by 0.5 per cent per annum. ${ }^{7}$ In the rural population of Latin American countries, there continues to be a large surplus of underemployed labour resources in agriculture. At the same time, the rapid growth of the urban labour force, arising from natural increase of the urban population and augmented by the heavy influx of rural migrants, has resulted in much underemployment or employment in retail trade and service occupations of very low productivity. There is little doubt that the heavy inflow of rural migrants to urban areas in Latin American countries causes serious social and economic problems, particularly when urban industries are not growing sufficiently to absorb the available labour supply. The problem is deeper than this, since much of the migrant labour is either completely or functionally illiterate and without experience or training that fits them for productive urban occupations.
21. In such developed countries as the United States of America and Canada, the interrelationship between population growth and the agricultural labour force is very indirect. Agriculture in these countries accounts for a very small proportion of the labour force and of the gross national product. Population increase is occurring entirely in the urban areas, and the size of the farm population is declining. The continuing shift of manpower resources out of agriculture is made possible by the increasing productivity in agriculture and continuing growth in the non-agricultural sector of the economy. Despite progressively rising levels of living in the United States and Canada, there continues a marked differential between farm and non-farm incomes per capita in favour of the non-farm population which, together with other advantages of urban con-

[^211]ditions, continue to attract population from rural to urban areas.
22. Thus, even in highly developed countries, there exist regional or sectoral imbalances in rates of economic growth and in markedly uneven income distributions and wide differences in level of living among various sectors of the population. In the rural, as well as in the urban, population of the United States, there are substantial numbers of people whose economic conditions are so far below the level attained by the majority of the population that they can be said to be in the poverty sector
of the population. In this respect, the developed countries must pursue policies to mitigate and eventually eradicate the causes of lagging social and economic development that affect certain sectors of their populations policies that in their essential nature are similar to those which developing countries must pursue on a much more generalized basis. In the pursuit of such policies, the developing countries have a special responsibility to reduce their very high rates of population growth to levels which will not tend to frustrate their own and their internationally-aided efforts at economic growth.

# The possibilities of expanding food production by 1980 

O. E. Fischnich

## The task ahead

1. Many Governments, as well as many prominent persons, are becoming increasingly exercised at the rapid growth of the world population compared with the slower rate of increase of food production. If the current development trends continue, by 1980 there will be another 1,000 million people to be fed.
2. As Wright points out, any realistic assessment of food requirements for the future must take account of not only the increased number of mouths, but also the improvement of existing diets, which fall deplorably below the minimum standards of nutritional sufficiency. ${ }^{1}$ Working from the first base line, it has been calculated that for every increase of 100 million in the population an additional 13 million tons of cereals and more than 14 million tons of meat, milk, eggs and fish will have to be produced to meet their pressing needs. It thus seems that the world's farmers will be facing a minimum food production increase in the order of 130 million tons of cereals and 140 million tons of animal products. If the need to improve the present nutritional standards of the peoples of the developing countries is also taken into account, then the aim must be an increase in world cereal production of 33 per cent and an increase of not less than 100 per cent in world production of meat, milk, eggs and fish. It seems inconceivable that increases of this magnitude could be achieved unless drastic and far-reaching changes were made in the world's agricultural production policies, especially in those countries already feeling the heaviest pressures.

## The possibilities of achieving the task

3. In proceeding to examine the possibilities of securing sufficient food to satisfy man's growing need, it is tempting to take into con-

[^212]sideration means whereby food surpluses, which have built up largely during the past decade in the major exporting countries of the world, could be utilized. The attractions of this prospect substantially diminish when the facts are taken into consideration; these surpluses, mainly of grain, have built up over a succession of years, and even now, if distributed in the areas of greatest need, would represent little more than an amelioration of current low diets for a brief period. The annual increment thereafter, being only about 1 per cent of the world's annual cereal output, would make little impact on the problem in future years. Secondly, in addition to food-stuff providing calories, there is an acute need for diets which are nutritionally more sufficient, the overwhelming need being for proteins of high biological value. Thirdly, the movement of very large tonnages of cereals about the world may discourage local cereal production and seriously disturb the international cereal market, with grave consequences both to exporting and importing countries. One is thus driven to the conclusion that the only effective and long-term solution of the world's need for increased food must be sought in the countries where the deficits are greatest.

## Conventional means of increasing agriCultural production

## Increasing output from crops

4. Increases in the output of agricultural crops can be achieved by two principal means: first, by increasing the area under cultivation; and secondly, by improving the yields of the crops which are grown. Throughout man's history as a cultivator, increases in food production have come primarily as a result of increasing the area which he tilled. With the bringing into cultivation of large areas of the world's land surface in the past century and the increasing cost of clearing much of what remains, it seems probable that additions to the world's food supply must, in future, pre-
dominantly come as a result of raising the yield, both of crops and of stock.
5. In other words, capital must be substituted for land and new techniques must be used: this is a comparatively new approach to the problem, and Brown states that in the period 1948-1952, four fifths of the gains in
grain output have come from yield increases. ${ }^{2}$ The scope for doing so is amply illustrated in the table given below.
[^213]|  | Eutope | Sowth America | Asia * | Africa |
| :---: | :---: | :---: | :---: | :---: |
|  | (Kilos per hectare) |  |  |  |
| Wheat | 1,830 | 1,060 | 870 | 730 |
| Barley | 2,270 | 1,120 | 1,040 | 590 |
| Maize | 2,050 | 1,380 | 920 | 980 |
| Rice | 4,500 | 1,780 | 1,680 | 1,470 |
| Potatoes | 14,810 | 6,280 | 9,570 | 8,480 |

[^214]6. Unquestionably, the marked differences in yield in the regions quoted are the result of the interplay of many factors, both ecological and technical.
7. Pawley suggests that the use of hybrid or improved varieties on the 50 million hectares of the world, excluding the United States of America, could result in an increased production on the order of 20 to 30 million tons of grain in Europe, Africa, Asia and Latin America. ${ }^{3}$
8. Though the use of better-yielding varieties of seed is a highly significant factor in increasing food production, other aspects of crop culture must receive attention if the results are to be fully achieved. Modern science and technology have highlighted the necessity for building and maintaining the fertility of the soil, for providing adequate supplies of water and plant-food, for securing a suitable environment through the establishment of shelter belts and wind-breaks, for carrying out cultural processes at the right time, for protecting the growing crop from pest and diseases and, finally, for the control of pests where the grain is stored, as local investigations have shown that here as much as 50 per cent of what has been grown may be lost.

## The use of water

9. A factor of great significance to crop production, especially in arid or semi-arid countries, would be the more effective control of water. In many areas of the world, rainfall

[^215]is concentrated in one season of the year and the heavy seasonal precipitation often creates great devastation to unprotected soil. When adequate conservation measures are taken, the physical damage can be minimized; better moisture conditions for plant growth can be created; and, where irrigation is possible, the growing of two or three successive crops in one season becomes a practical measure. However, unless such areas are properly drained, the increasing salinity renders the soil unsuitable for crop growth.

## The increased use of fertilizer

10. With the availability of adequate supplies of water, a greater exploitation of the world's increasing knowledge of plant nutrition becomes possible in attaining the potential yield of improved seed. During the last two years, out of a world total of almost 30 million tons of plant nutrients applied as fertilizers, nearly 27 million tons were used in the industrial countries and only 3 million tons in the developing areas. As a result of many thousands of fertilizer trials carried out in developing countries, man's knowledge of these matters has immeasurably increased and with it the conviction that chemical fertilizers have opened fruitful avenues for the development of food and forage production.

## Mechanization and use of improved tools

11. In vast areas of the world, over 90 per cent of the power on farms is generated by human beings and animals. Much of the equipment which they handle and pull could be improved, for the efficiency of the tools the
farmer uses determines the amount of land which he can cultivate, the quality of his tillage work and hence the yield of his crops. Thus, any forward-looking policy for increased food production must clearly contemplate their modernization.
12. For the time being, however, the general use of powered implements would be neither economically nor socially feasible, but even the improvement of the design of handor animal-operated implements could make a noteworthy contribution. The rising population of the world is causing Governments to embark on land reclamation schemes, many of which involve forest and brush clearance, and the preparation of the rough terrain for cultivation. Specially designed and thoroughly tested equipment could open up large areas of the world which are currently unproductive.

## Improving livestock production

13. Equal opportunities of expanding food production by 1980 exist in the field of animal husbandry. Available statistics indicate that the average aninual production is only 20.5 pounds in the case of beef and veal, 4.2 pounds for mutton, lamb and goat meat, 20.3 pounds for pork, 8.6 pounds of eggs per hen and 250 pounds of milk per cow. ${ }^{4}$ Statistics available from countries with an advanced livestock industry may illustrate the reserves which may be realized through well-planned efforts, for yields in these areas are a hundred-fold higher in the case of mutton, tenfold as far as beef is concerned, sixfold for eggs and almost twentyfold in the case of milk. Most developing countries are still applying traditional methods of livestock production and utilization which do not allow the efficient use of existing resources.
14. Experience indicates that livestock output depends on individual productivity rather than on numbers alone. Large areas of the world are considerably overstocked with underfed animals of poor quality, a reduction in the numbers of which would be a first step to increasing the productivity of those which remain. Overstocking, underfeeding, the prevalence of disease, haphazard breeding practices, poor management and the lack of marketing or processing facilities bring about an over-all situation which cannot be improved by the universal application of techniques used in advanced countries. Each of these interrelated problems and potentials has to be examined to determine the most seriously limiting factor

[^216]before a logical plan for livestock development can be prepared.
15. It is illogical to initiate the development of feed supply through ley farming methods or improved range management, for instance, if, at the same time, measures are not taken to control the unthriftiness of stock caused by disease or parasitism. Similarly, genetic improvement would be wasted without the simultaneous improvement of animal nutrition, and the final success of all livestock improvement programmes would depend upon the establishment of appropriate processing and marketing facilities.
16. Some spheres of production can be dealt with as relatively independent of natural environments, for instance, intensive poultry, pig and dairy industries have been established in many developing countries, based on appropriate marketing facilities and the utilization of a number of agricultural by-products. Vast areas of the world's surface could, however, be utilized exclusively by grazing animals and the efficiency of production would be determined largely by the integrated development of the animal and plant industries. Hence, one of the greatest needs in livestock production improvement programmes is for more and bettertrained personnel.

## Improving the output of the sea and of inland waters

17. Since seven tenths of the surface of the globe is under salt water, and yet man draws from it only one hundredth of his food, there would appear to be an immense potential for the development of the world's fisheries to increase the protein supplies for the human diet. Technical advances have improved the harvest from the sea. Most of these have been aimed at catching more fish by using better techniques and equipment, including powered fishing boats, and in perfecting means of detecting the whereabouts of the fish themselves.
18. Much attention has thus been devoted to building up a fuller understanding of the biology of the fish (their breeding, distribution and behaviour) which will provide reliable guide-lines for the world's fishermen as to the preservation of stocks for future harvesting. Eventually, perhaps, through increasing international enlightenment and co-operative action, both the seas and the inland waters will be able to supply human needs to a far greater extent than has been the case in the past. Indeed, there are encouraging signs that this is taking place already for, according to the latest statistics of the Food and Agriculture

Organization ${ }^{5}$, the world catch in 1963 was about 46 million tons, or twice the amount produced as recently as in 1951.
19. It is necessary, however, when considering the dietary significance of the increased amount of fish available, to take into account that consumption is not evenly distributed over the earth's surface. Large numbers of people rely on fish to supply more than half of their animal protein intake, and estimations of the additional arable land needed in these areas to match the protein now available from fish show that some countries could not maintain their nutritional standards, or even survive, without fish. ${ }^{6}$ But while the fishing fleets of some countries are being rapidly expanded, in others the off-shore fish populations are not being exploited, owing to the lack of technical knowledge, equipment and manpower.
20. Quite apart from the greatly improved nutritional standards which can be brought about as the result of an increase in the catch of fish, the diversion of fish and fish wastes to the production of fish-meal for export could be of significant benefit to countries in their balance of trade.

## Prevention of wastage of agricultural and fishery products

21. While the improved agricultural practices referred to above would lead to a substantial increase in the world's food resources, this is not, in itself, enough. Increased production must be supplemented by improvements in preservation, conservation and marketing, in order to reduce the spoilage and waste which now occur.
22. The development of scientific techniques of food processing and preservation was a key factor in the evolution of civilizations and urban settlements. Food technology is the link between production and consumption. It includes the processing and preservation of foods by such traditional methods as sun-drying, salting or fermentation, as well as by the modern methods of dehydration, canning and freezing, and by the ultramodern methods of freezedrying and the use of ionizing radiation. The major reasons for processing food-stuffs are to prevent spoilage and wastage, to permit yearround availability and to develop new products of good nutritive value at a cost which all can afford.

[^217]23. In the encouragement of the production of traditional protein foods and grain legumes, international efforts have been focused on the development and production of inexpensive protein concentrates from sources hitherto largely unused. For instance, protein-rich foods, of low cost, have been developed in a number of countries from such indigenous protein resources as oil-seed meals and presscakes; fish protein concentrate is another important potential source of high-grade protein.

## The contribution of atomic radiation

24. In each of the broad fields of increasing food production so far surveyed, the new science of atomic energy is playing an increasingly important part, above and beyond the provision of inexpensive power from nuclear reactors, which, in itself, will undoubtedly have a major impact on agriculture.
25. The plant breeder has now at his disposal a wider and infinitely more variable range of materials for his selection as the result of the hereditable mutations provided by sources of radiation. Tracer techniques offer a new means of obtaining a better understanding of animal and plant life, of soils and water, and of the complex relationships between them.
26. The heavy loss in field crops at all stages of production, distribution and storage already referred to can be considerably reduced by the application of radiation and radio-isotopes for the effective control of fungal and bacterial infection and of the ravages of insect pests. Tracer studies are helping investigations into some of the basic problems of livestock production, notably those concerning the efficiency of food utilization by the animal. The use of carbon-14 as a tool for estimating the productivity of ocean-water is probably the most important application of radio-isotopes in fisheries.

## Non-Conventional sources of food

27. Though the discoveries of the scientist and experimenter have added immeasurably to the world's knowledge of husbandry and have made possible substantial increases in the production of food from the existing resources of land and water, the lapse of time which frequently occurs between the availability of new knowledge and its translation into agricultural practice is a matter of great concern, for a decade may pass in the slow process of implementation. Thus, in considering means of increasing food production by 1980, serious efforts must be made to reduce this time lag, for many new discoveries show promise of
coming to fruition in the next ten to fifteen years.
28. One of the developments which would have the greatest impact on world food production would be the successful outcome of the work currently proceeding on the desalination of sea-water. This is neither a new idea nor is it impracticable, but the distillation processes currently used are still far too expensive to be economically practicable in the agricultural context, where many million gallons of water are needed for bringing the vast dry areas into cultivation, and for irrigation. A successful breakthrough in this single development would revolutionize current food production forecasts.
29. Considerable effort has been applied to research and developmental aspects of the supply of protein from less conventional sources, with highly promising restults. The carbohy-drate-rich by-products of certain industries, such as the sugar and the wood pulp and paper industries, could be used to produce sizable quantities of edible yeast. So far only minor quantities of food yeast are used as human food, mainly as a good source of certain vitamins (B-complex), rather than as a source of protein and energy.
30. A recent development is the production of proteins by yeasts growing on paraffinic hydrocarbons obtained by refining crude petroleum. Such products are currently being evaluated for wholesomeness and biological value. With the exception of food yeast, these "petroleum proteins" appear to give the best hope for a cheap good source of protein.
31. Algae are increasingly attracting the interest of research workers in various countries. Pilot mass-cultures of chlorella have provided extremely encouraging products in satisfactory yields.
32. Protein extracted from green leaves is a very promising potential source of protein food. A considerable amount of pioneering work has been done, but a number of problems, some common with algae, still remain to be solved before a low-cost product of good nutritional value, and also acceptable to the human palate, can be produced.
33. In general, technological feasibility in developing food products from unconventional sources is not a limiting factor, since modern food technology can cope easily with most such problems. The most critical and difficult aspect in introducing these products for large-scale use in the human diet is acceptability and marketing.

The prospects of increases in food production by 1980
34. There seems to be general agreement that the world population will be of the order of 4,000 million by 1980 . In order both to provide for the increase which will have taken place by then and to satisfy the need to improve the present low level of the diet in many of the developing countries, it will be necessary to increase total food production, in these areas in particular, by more than twice their existing level, and within this figure the current supply of food of animal origin will need to be increased three-fold. ${ }^{7}$
35. Can these large increases be achieved? There appears to be no doubt that the application of man's existing knowledge to farming practice, in all its aspects, would be adequate to take care of human food needs, possibly to the end of the century. But whether it will be so applied is another question which lies largely within the area of administration.
36. In some of the developing countries, there does not appear to be an awareness of the extent to which a progressive agricultural industry can contribute to the national economy. If there is such concern, it is usually limited to the production of cash crops which can be exported to earn foreign exchange. If agriculture is to be developed along lines which will improve the home production of food, a very much more progressive policy will be needed. If the farmer is to produce more, a good deal more money must flow from the exchequer for the provision of the necessary supporting services-research, extension, the provision of markets and storage accommodation, roads and such large-scale agricultural improvements as irrigation and drainage-and for systems of agricultural credit, the formation of co-operatives and so on.
37. Since the only practical medium-range solution to the hunger problem in the developing areas is to greatly increase food production within the country, the peasant farmer (numbered by the tens of thousands) is the key figure. Hence, those incentives which motivate him to improve the productivity of his holding must be provided. The first, and foremost, incentive would be to give him some security of tenure of the land he farms, for improvements to productivity come only slowly. He would then need friendly advice and guidance as to how to develop his skills and to improve his husbandry techniques, and in the

[^218]care and protection of his livestock. To hav any hope of achieving his task, he would need the ancillaries, the fertilizers, the equipment, the seed and the means of protecting his animals
and plants from pest and disease, at a price he could afford to pay. Only when these matters had been satisfactorily resolved would he be able to play his part.

## The relationship between the volume of agricultural investment and the rate of population increase

## Victor Herer

## Introduction

1. The rate of population increase determines to a large degree the necessary rate of growth of agricultural production. ${ }^{1}$
2. Let the rate of population increase be $p$ and the desirable rate of growth of food consumption per head of population $f$, then the necessary rate of growth of agricultural production, $r$, will roughly be:

$$
\begin{equation*}
r=f+p \tag{1}
\end{equation*}
$$

3. The volume of agricultural investment needed to obtain such an increase of agricultural production is defined by the following formula: ${ }^{2}$

$$
\begin{equation*}
r=\frac{I}{D} \cdot \frac{1}{m}+u-a \tag{2}
\end{equation*}
$$

where: $I=$ gross investment in agriculture;
$D=$ net product of agriculture increased by depreciation, or the gross product of agriculture;
$m=$ capital intensity of the increase in agricultural production in terms of the ratio of gross investment to the increase in net product;
$u=$ agricultural production increase owing to technological progress not related to investment, e.g., when new varieties of seed are used;
$a=$ losses in the products, owing to diminished productive capacity.

[^219]4. The values $u$ and $a$, denoting respectively, the growth of agricultural production owing to technological progress not related to investment and losses in the product owing to diminished productive capacity, can be assumed to be constant and independent of the rate of population increase. Hence, the relation between the rate of population increase and the necessary volume of agricultural investment will be:
\[

$$
\begin{equation*}
r=\frac{I}{D} \cdot \frac{1}{m} \tag{3}
\end{equation*}
$$

\]

It follows from equations (1) and (3) that:

$$
\begin{equation*}
p+f=\frac{I}{D} \cdot \frac{1}{m} \tag{4}
\end{equation*}
$$

Therefore:

$$
\begin{equation*}
\frac{I}{D}=m(p+f) \tag{5}
\end{equation*}
$$

5. Equation (5) shows that the rate of population increase and the capital intensity of the increase in agricultural production are among the factors determining the volume of necessary agricultural investment.
I. Interrelation between population inCREASE AND VOLUME OF AGRICULTURAL INVESTMENT
6. The interrelation between the population increase and the volume of agricultural investment, expressed in equation (5), can be examined in two variants.

## A. The first variant

7. In the first, it is assumed that the capital intensity of the growth of agricultural production is independent of the rate of population increase.
8. Under this assumption the volume of agricultural investment grows with the growing rate of population increase. Any change in the volume of necessary agricultural investment resulting from the change in the rate of population increase depends on the degree in which the increase in population participates in the growing demand for food in the country. In
the case of developed countries, where the population's average ${ }^{3}$ requirements for food are satisfied at a relatively high level, the needs of agricultural investment-assuming, in addition, unchanging capital intensity-are determined by population increase alone. In those countries, the needs of agricultural investment change in proportion to population increase. ${ }^{4}$
9. In those countries where the rate of population increase is low, the impact of the rate population increase upon the volume of agricultural investment is obviously less pronounced, although, in some cases, agricultural investments may increase considerably because the average standards of nutrition call for improvement.

## B. The second variant

10. In the second variant, it is assumed that the capital intensity of the growth of agricultural production changes with the changing rate of population increase. Under this assumption, which seems more realistic than the previous one, the problem may be examined in its two aspects.
11. The interrelation between the rate of population increase and the capital intensity of the growth of agricultural production. What is important here is perhaps not the volume, but the age structure of population increase, and also the distribution of this increase into food-producing and food-consuming population the latter covering non-farm population and those dependents of farmers who do not work on farms.
12. The larger the proportion of foodproducing population in the population increase, the lower the capital intensity of the growth of agricultural production can be. ${ }^{5}$ As the proportion of food-producing population rises, there is a growing possibility of increasing the contribution of live labour and, hence, of reducing the share of investment in producing the additional farm products needed to feed the the increased population.

[^220]13. If it so happened that the entire population increase in a given time and country comprised farmers' dependants or non-farm population alone, then any increase in the agricultural product would have to be obtained mainly by means of stepped-up investment and, therefore, at a higher capital intensity. The opposite situation would exist in a country where the entire population increase equalled the increase in active farm population; in this case, a growth of agricultural production might be obtained by means of additional contribution of live labour, with few, if any, investments outlays.
14. The capital intensity of the growth of agricultural production is determined to some extent by the relation between the agricultural manpower increase and the population increase. If the structure of the population increase, from the point of view of the ratio of foodproducing manpower to total population, remains stable, then it is possible to keep an unchanged level of food consumption without raising labour productivity in agriculture; as a result, the capital intensity of agricultural production can also remain unchanged. If, however, the structure of population increase changes in such a way that there is a growing proportion of food-producing labour, it may result in reducing the capital intensity of the growth of agricultural production.
15. Hence, every addition to agricultural manpower, given constant productivity of labour, reduces the number of food-consuming population per one person employed in agriculture. This may result in diminishing the capital intensity of the growth of agricultural production in so far as capital intensity is a function of the ratio of food-producing to foodconsuming population.
16. If, on the other hand, the structure of population increase leads to a decline in the proportion of food-producing population, this may result in an increase of capital intensity of the growth of agricultural production.
17. The prospects of increasing the agricultural product on the basis of population increase alone, without investment, vary from country to country. In the developing countries, where the reserves of untilled arable land are very large, and in the countries where yields are low because of deficient farming due to labour shortage, it may be possible to increase the agricultural product without investing too much capital. But in the European countries, where intensive agriculture is the rule, the prospects of increasing the agricultural product by relying only on population increase are rather limited.
18. In the over-populated countries of Asia, with their high ratio of agricultural population to total population increase, it is quite possible to use the increase in population for raising agricultural production; this can be done by resorting to special methods, which are described below.
19. The interrelation betzeeen the rate of agricultural production and capital intensity. In the long run, it is possible to raise the rate of agricultural production increase without adding to capital intensity of agriculture, provided that no labour substitution takes place.
20. As proved by the experience in many countries, technological progress can successfully counteract the effect of the biological law of diminishing returns from additional outlays in agriculture. ${ }^{6}$ If, however, the short-run problem is examined from the point of view of the growing rate of population increase and the rising rate of growth of agricultural production related to it, it is clear that technological progress, over a period of time, is completely independent of the rate of population increase. Accordingly, each addition of growth of agricultural production related to the additional increase in population must be considered in the aspect of relatively unchanging techniques. This means that the growth of agricultural production required to meet the demand of the increased population generally entails growing capital outlays; in other words, it implies an increase of the marginal and average capital intensity of agricultural production.
21. It is safe to say that a growing rate of population increase, since it adds to the food demand in the country, requires an increase in agricultural investment; any additional increase in the agricultural production can be obtained by increased capital intensity.
22. Under certain conditions, however, a rising rate of increase of active farm population may counteract the capital intensity of the growth of agricultural production and, hence, may restrain the growing need of investment in agriculture.
23. In an extreme case, it is conceivable that in a developing country, if the increase in the agricultural product is obtained without investment or with very little investment, the level of

[^221]per capita food consumption will remain unchanged. In this case-probably extremely rare in current times-essentially no additional investment would be needed because of population increase.
24. The volume of agricultural investment is the resultant of the described factors, which determine the relation between agricultural investment and population increase.
25. In the developed countries, the relatively high level of average food consumption and the low rate of population increase are factors restraining the volume of necessary agricultural investment. On the other hand, since there is no increase in farm population, the capital intensity of the growth of agricultural production in those countries is very high.
26. In the developing countries, the situation is reversed. The low level of average food consumption and the high rate of population create pressure for more investment in agriculture, while the increase in agricultural manpower tends to reduce capital intensity of the growth of agricultural production.
27. Between these two extremes, there is a whole range of intermediary situations which may prevail in various countries at various times.
28. Thus far, the problem of disguised unemployment in agriculture has not been considered. The existence of disguised unemployment in agriculture obviously reduces the possibility of using the increase in population for decreasing the capital intensity of growth of agricultural production. ${ }^{7}$
29. However, in considering the problem one must bear in mind the uneven distribution of manpower, its indivisibility and its immobility in small peasant farms. In small-scale peasant farming, disguised unemployment may exist in some regions, while, in others, the agricultural production may prove flexible and adjustable to the growing manpower. In the latter case, the increase in farm population may produce certain effects in reducing the capital intensity of the growth of agricultural production.

## II. Attempted estimation of the volume of agricultural investment in a deveLOPING COUNTRY

30. Statistics for the last ten years reveal that the average annual rate of population

[^222]increase in many developing countries is 2.5 per cent. Considering the low level of food consumption in those countries, an additional minimum increase of agricultural production, aiming at a realistic improvement in consumption standards, can be estimated at 2 per cent. Hence, the minimum rate of growth of agricultural production in most developing countries should be at least 4.5 per cent. However, this is so much above the actual rate of growth that the author is inclined to accept a more realistic estimate of the minimum rate of growth of agricultural production, namely, 3.5 per cent per annum, or a 1 per cent increase in annual consumption per capita.
31. The next step is to estimate the needed volume of agricultural investment related to an average annual growth of agricultural production amounting to 3.5-4.5 per cent. For this purpose, the author has used the data on capital intensity of the growth of agricultural production in Poland, ${ }^{8}$ where a small-scale peasant economy prevails and the level of agricultural employment of thirty-two productive persons per 100 hectares of arable land has been only slightly reduced during the last eight years.
32. The ratio of capital intensity to the growth of agricultural production in the last eight years has been five zlotys per one zloty of increase in the net product. ${ }^{9}$
33. Next to be examined is the relation between this volume of agricultural investment and the volume of the net product in agriculture. To attain a 3.5 per cent growth of agricultural production, agricultural investment would have to equal 22 per cent, and to attain a 4.5 per cent increase- 29 per cent of the net agricultural product. This means that a 3.5 per cent $=4.5$ per cent growth of agricultural production places a heavy burden upon the agricultural income of a developing country. The situation is further complicated in a country proceeding to industrialization while agriculture has a large share in the national income. (It is typical for the developing countries that some 70 to 80 per cent of the national income is produced by agriculture.) If agriculture has a large share in the national income, then 10 to 15 per cent average annual increase in industrial output (a rate necessary for industrializ-

[^223]ation) cannot be financed from non-agricultural sources since the latter are very small.
34. Agricultural income thus bears the burden of financing not only agricultural investment in industries producing goods for agriculture, but also most of the other industrial investments as well, plus the total costs of the cultural revolution in the country (development of education, medical care, etc).
35. In his Geography of Hunger Josué de Castro quite rightly points out that each continent still has vast areas of land which might provide food for the starving population. ${ }^{10}$ It seems, however, that the major problem in fighting hunger is not how to find land which might produce food. It is, rather, the question of finding investment funds to cultivate the land. The problem of freedom from hunger consists in the necessary means of investment to eliminate food shortages. It is also the problem of selecting such production techniques and such methods of raising the agricultural products as would be best adapted to the balance of manpower and to the structure of population increase in a given country. The proper economic policy to be pursued in the developing countries is to ensure the maximum use of the increase in farm population to obtain the growth of agricultural production with minimum investments.

## III. Financing of agricultural investment and population growth

36. The problem of financing agricultural investment in a developing country with a low level of labour productivity in agriculture has several aspects. Only two of them are dealt with in this paper. They are as follows:
(a) If the surplus produced by agriculture in a developing country is to be used to a maximum degree for investment purposes, any form of draining the agricultural income to cover the needs in consumption of the possessing classes must be radically eliminated;
(b) The choice of proper investment form is also very important. Considering the burden of agricultural investment on agricultural income, investment may be classified into two categories:
(i) Monetary investment, i.e., investment through the purchase of factory-made capital goods;
(ii) Self-help investment, i.e., investment executed mainly by non-mechanized peasant labour providing the means of

[^224]production for agriculture (land-betterment projects, peasant housing, roadbuilding in agricultural regions, increase of livestock etc.) with an insignificant addition of factory-made capital goods.
37. Each monetary investment in agriculture reduces the current consumption, but opens prospects of increased consumption in the future or results in a corresponding reduction of industrial investments. Self-help investment, on the other hand, takes away nothing from the consumption fund.
38. In the case of monetary investment, the controversy between investment and consumption, and between agricultural and industrial investment, is quite evident. It is all the more pronounced when problems of foreign trade are involved on a broad scale.
39. Self-help investment, on the other hand, opens the way to utilization of the manpower reserves and does not affect current consumption. An increase in self-help investment does not cut down constumption in the initial period and makes it possible to expand both consumption and investment at the same time.
40. Under a planned-economy system, a developing country with large reserves of agricultural manpower can, under certain circumstances, attain a much higher rate of growth of agricultural production than an industrialized country which has no such reserves. This is particularly true of those countries in which
irrigation projects, offering wide possibilities for self-help, play an especially important role.
41. Manpower reserves, if used in self-help investment, can be largely transformed from a hampering factor into a factor stimulating agricultural growth. ${ }^{11}$ In actual practice, of course, the entire investment process cannot be covered by self-help investment. Every increase in this type of investment requires a certain increase in monetary investment. But the developing countries might attain a very high proportion of self-help investment in total agricultural investment and its increase.
42. It seems, therefore, that self-help investment is of extremely great importance for agricultural growth in the developing countries. Such investment may include various projects stimulating agricultural growth, for example, forest clearing, tilling new lands without tractors, land reclamation and irrigation, and creation of farm buildings from clay or bricks fired on the spot. It is also self-help investment when the cattle livestock is increased through the use of non-commercialized fodder (hay, pastures).

[^225]
# The effect of population pressure and seasonal labour surplus on the pattern and intensity of agriculture in Taiwan 

S. C. Hsieh and T. H. Lee

1. There are two types of "farm labour surplus", namely, long-term, or structural, and seasonal. The structural farm labour surplus occurs in a country where the land is limited, there is over-population, and industry and commerce are just developing. The seasonal farm labour surplus, however, indicates a leisurely labour force resulting from the seasonal demand for labour in agricultural production.
2. In a country with a developing economy and low agricultural productivity, there exist at the same time the two types of farm labour surplus and, such being the case, the degree and extent of making possible use of the labour force are extremely low. Unless the farm organization and cropping system are greatly improved, the problem of farm labour surplus can never be solved in an area under severe population pressure. A possible way of utilizing the labour force is to increase rural employment opportunities so as to enhance agricultural productivity. The intensive farming system adopted in Japan and Taiwan serves as a good example.
3. In the case of Taiwan, where the atable land is restricted to 870,000 hectares, and the farm labour force is approximately 1.8 million with an annual increase rate of about 1.2 per cent, it is extremely difficult to raise the farm labour productivity to a higher level under the present circumstances. In spite of the financial support of the Government, the expandable arable land is somehow limited. In the past half century, there was some increase of arable land in the first thirty years. For the last twenty years, however, the acreage has remained at the level of 870,000 hectares without any visible change. On the other hand, the continuous increase of agricultural population and labour force has gradually lowered the ratio between population and land. It seems utterly impossible to raise the average labour productivity in Taiwan through the reduction of farm labour force or the increase of arable land. In order to promote employment opportunities and to increase agricultural production, the type of farming and
cropping system that can absorb a large capacity of labour input should be encouraged. Under such a situation, the increase of land productivity would likewise enhance the labour return. Therefore, the gross labour return is the direct result of intensive utilization of land and labour, as well as of the improvement of the type of farming and cropping system.
4. The farmers have adopted several cropping systems, which vary with the natural conditions, the marketing system and the supply of farm labour force. Generally, there are the multiple cropping system, the rotational cropping system, the crop and livestock integrated farming system, and the crop and farm products processing integrated system. This paper is confined to a discussion of the relationship between the various intensive cropping systems and the intensity of labour use. The capacity of labour input of each crop and the growing seasons are quite different, and various crops can be integrated to form a cropping system, in order to absorb the highest capacity of labour input. The fertility of the soil, the capacity of the labour input, as well as the gross labour return, are the determining factors for setting up the cropping systems. In Taiwan, the farmers ustually adopt two or three types of cropping systems in combination on a farm. The increase of the number of labour-intensive cropping systems is reflected in the increase of multiple-cropping indices, from 116 during the period 1911-1915, to 132 in 1931-1935 and 180 in 1956-1960.
5. In the past fifty years, the arable land in Taiwan has been increased by 26 per cent while the agricultural population has accelerated its growth by 125 per cent and farm labour force has increased by 50 per cent. With the rapid increase of agricultural population, there has followed the decline of the percentage of the farm labour force in total agricultural population, from 50 per cent to 30 per cent, and the decrease of the average cultivated area per agricultural population from 0.31 hectare to 0.18 hectare. Prior to 1935, the increase of cultivated land was made possible through the rapid
expansion of newly reclaimed land. However, since 1940, the population pressure has also been increasing rapidly and the only possible measure to meet the changing situation is to
make intensive use of the land, as well as to multiply crop planting in a given area. The changes made in the system of land utilization are shown in figure I:

## A. Paddy land


B. Single-cropping paddy land

C. Dry land


Figure I
System of land utilization, Taiwan, 1910-1960
6. The labour input for each hectare of cultivated land has been increased from 195 days in the period 1911-1915 to 220 days in 19311935, and further increased to 305 days in 19561960. The seasonal distribution of labour has become more even since the introduction of the labour-intensive cropping system. The impact of the intensive cropping system on seasonal distribution of labour can be seen from a crosssection comparison made of the intensities of labour in different areas.
7. Farmers in Taiwan have managed to adopt the labour-intensive cropping system with a view to absorbing more family labour through the planting of various crops that require different capacities of labour input. Such a system does not incur any waste of labour, but, rather, tends to increase simultaneously the average productivity of land and labour. Under this system, the demand for labour is high and the time for harvesting the previous crop, as well as for planting the following crop, is extremely short. Sometimes the farmers manage to plant the next crop between the rows of the previous crop, in order to avoid the concentration of labour demand in a given short period of time and to provide more time for the growth of the next crop.
8. Prerequisites to success of intensive cropping system. The intensive cropping system must bring sufficient social and economic benefits to justify its adoption. It should, first of all, increase the farmer's income, for without this, farmers would be reluctant to accept such a system. Therefore, an increase in the productivity of the land-including improvements of crop varieties, culture practices and cultivated land-and an increase in the demand for farm products are prerequisites to the success of this system.
9. Improvement of crop varieties and culture practices. There is a shortage of vegetables in Taiwan in summer-time. If vegetables could be planted in the months of May and June without affecting the second rice crop, the farmer's income would be increased. Technically, it is rather difficult to plant vegetables during the months of May and June. However, following the technical improvement of crop varieties and the culture practices of interplanting of vegetables and other crops, the farming system in central and southern Taiwan has been changed from three crops to four crops a year.
10. Improvement of cultivated land. The improvement of cultivated land includes irrigation, drainage, soil improvement and other investments. Its purpose is two-fold: first, in
time of drought or inadequate water supply, properly irrigated land can be planted with one or two kinds of crops. Secondly, after the improvement of cultivated land, the input of fertilizer and labour is considerably increased, and the farming is made more intensive and thus can absorb more inputs in production.
11. Changing the pattern of demand for farm products. The demand for farm products includes both food consumption and the use of such products for industrial and other purposes. Rice and sweet potato belong to the category of labour-extensive crops. If one wishes to substitute vegetables, citrus fruits, tobacco and rape-seed for grain crops, one must first determine the market demand for such intensive crops. Vegetables are a daily necessity in Taiwan, and as such, the increase of population, as well as the large consumption of summer vegetables, have helped to stabilize the farmer's profit by virtue of the introduction of interplanted vegetables. Another winter crop, tobacco, offers great profit because of the system adopted by the Taiwan Tobacco and Wine Monopoly Bureau in purchasing the tobacco leaves. Purchases are made through a signed contract which gives an attractive price to the farmers. In addition, it seems necessary that the labour-intensive cropping system should be further supported by the development of agricultural processing industries and the improvement of natural consumption.
12. Planning of labour-intensive cropping system by linear programming approach. In introducing the intensive cropping system, a certain type of cropping system should be planned in a given area to serve as blue print for individual farm planning. If the scale of operation and the pattern for operation of farms in a given area are widely different from each other, it may be appropriate to devise several model cropping systems for adoption by the farmers. The objective of the planning should include the maximum farm income to be derived from the family labour return, as well as from the rental of self-owned land. The means to attain this objective is to make full use of the available crop area and farm labour force within a given piece of land in order to select the most profitable cropping system.
13. An example is taken from Lung Tung Village of Lung Chin Township in central Taiwan, in which the cultivated land is only 81.33 hectares with an average of 0.44 hectare per family, of which 0.39 hectare is paddy land and 0.05 hectare is dry land. On the average, each family consists of 8.3 persons and has 3.1
A.

B. Labour use

|  | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. Oct. | Nov. | Dec. | Total |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Labour supply (days): | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 70 | 840 |
| Labour use: <br> Before programming: | 1.2 | 27.8 | 22.0 | 11.6 | 14.3 | 1.3 | 20.4 | 13.5 | 9.6 | 5.9 | 27.3 | 9.1 | 164 |
| After programming : | 12.2 | 55.1 | 22.4 | 12.1 | 14.6 | 41.5 | 59.5 | 13.4 | 9.5 | 5.9 | 58.7 | 24.8 | 329.7 |

Figure II
Cropping system and labour use before and after programming
persons in the labour force. The man-land ratio is very high.
14. The base programme is to consider the average cultivated land of each family, as well as the average labour force of each family. It is assumed that 0.5 hectare and three workers constitute an average farm.
15. The most important crops that can be planted in this village are as follows, by season:
(a) First crop season (March-June) : rice, vegetables, water-melon, peanuts, tomato and cucumber;
(b) Summer crop season (June-August): musk melon, water-melon and vegetables;
(c) Second crop season (August-November) : rice, sweet potato and vegetables;
(d) Winter crop season (NovemberMarch): wheat, vegetables, rape-seed, peas and flax.
16. The raising of livestock and poultry is restricted by the shortage of feed crops, with the result that each family only has, on the average, 1.2 hogs, 6.2 chickens and 0.8 cattle. In spite of this under-development of livestock and poultry, there are some pieces of land devoted to the planting of sweet potato with a view to supplying the necessary feed crop. However, the raising of livestock and poultry will not be considered in this programme.
17. The labour coefficient of crop planting is the number of days required for planting the crop in one hectare of land. The farm price is an average of three years' price.
18. Resource limitation. The standard cultivated area is 0.5 hectare, of which paddy land is 0.45 hectare and dry land is 0.05 hectare. Since the average number of hogs per family is one head, it is necessary that 0.03 hectare of dry land should be planted with sweet potato in order to meet the annual requirement of 400 kilogrammes of sweet potato. In each
of four crop seasons (first crop, summer crop, second crop and winter crop), 0.45 hectare of paddy land is cultivated. The cultivated area of dry land is 0.02 hectare in each of three crop seasons (first crop, second crop and winter crop).
19. Labour limitation. Working twenty-five days each month, the three workers in one family can contribute seventy-five days of labour. With five days being spent on hog raising and sweet potato planting, the net available labour supply is seventy days. The Taiwan Food Bureau extends loans to farmers for the purchase of fertilizers, and no special and additional farm implements and other capital goods are needed by the labour-intensive cropping system.
20. Based on the revenue coefficients, technical coefficients and resource limitation, a simplex table of the first stage could be prepared and computation of the most profitable cropping system could be worked out through a linear programming solution.
21. The farmers spend 330 days in planting the above-mentioned crops in an area of 0.47 hectare. If the required sixty days for annual feed production in 0.03 hectare of dry land and for livestock raising is added to the 330 days, it makes a total of 390 labour days. There is a yearly increase of 166 days when compared with the average labour of 224 days per family before the implementation of the intensive cropping system derived from linear programming. The farmer's income has increased from 12,186 new Taiwan yuan (before programming) to $\$$ NT 25,941 (after programming), an increase of \$NT 13,755. The ratio between man and land in Lung Tung Village is very high and there is no effective way for the labour-intensive cropping system to make full use of the labour force. The shadow price of labour as indicated in the linear programming solution is zero.

## Food resources of the earth

K. M. Malin

[Translated from Russian]

1. Some writers on population questions contend that in the not-too-distant future, if the present rate of population growth continues, there will not be enough room on earth to accommodate the human race. Others hold that the population of the earth is already too great for the available resources and that even the present population cannot be provided with, for example, sufficient food. According to United Nations estimates, the earth's population may be as large as $6,000-7,000$ million by the year 2000 . This figure should be verified in the light of the influence exerted on population growth by a number of factors (industrialization, the growth of the urban population, increased employment of women, raising of the level of education, etc.). The earth's population cannot, of course, be infinitely large if only because the earth's size is finite. Furthermore, it is not possible to make projections for some arbitrary future time on the basis of the present rate of population growth. There are other estimates which fix the earth's popu-
lation in the year 2000 at 4,600 million. However, that is a question which cannot be dealt with in detail in this paper.
2. The question of potential food resources has been extensively discussed in the world Press and at United Nations conferences. The data published in this connexion have been based either on the analysis of agricultural practices or on study of the resources of the world's cultivated areas and of solar energy. We shall, in addition, approach this important problem in terms of the resources to be obtained from various chemical elements.
3. Table 1 below is based on a daily diet providing 3,000 calories and 100 grammes of protein, including 60 grammes of animal protein.
4. As the above table shows, the world food deficit, as expressed in its grain equivalent, is 639 million tons, which amounts to approximately 613 million tons when corrected to allow for marine products. The grain equivalent

Table 1

| Product | Annual per capita requirement in kg. | Annual world <br> requirement <br> (for popula- <br> tion of 3,100 Annual world <br> million) in production <br> millions of in millions <br> tons of tons |  | $\begin{gathered} \text { Deficit }(-) \\ \text { or surplus }(+) \end{gathered}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | In mil. tions of tons | Grain cquivalent $\stackrel{i n}{n i l}$. ніом. of tons |
| Grain | 100 | 315 | 514. | $+199$ | $+199$ |
| Meat | 50 | 157 | 62.9 | -94 | -376b |
| Milk | 365 | 1,048 | 348.8 | -699 | $-175 b$ |
| Potatoes | 100 | 315 | 394 | $+79$ | $+20$ |
| Sugar | 30 | 94.5 | 51.6 | -43 | $-45{ }^{\text {b }}$ |
| Vegetables | 150 | 472.5 | 120 | $-352.5$ | -44b |
| Fruit | 150 | 472.5 | 120 | $-352.5$ | - 55 b |
| Eggs | 18 | 56.7 | 13.7 | $-43.7$ | $-175{ }^{\text {b }}$ |
| Vegetable oil. | 6 | 18.9 | 25 | $+6$ | $+12^{\text {b }}$ |
|  |  |  |  |  | -639 |

[^226]of the annual per capita food allowance indicated in the table amounts to 614 kilogrammes if utilization of the assimilable portion of secondary grain production is taken into account.
5. It follows from what we have said that agricultural production at the present level is sufficient to provide a standard diet for no more than 2,150 million people. If we assume that the earth's population will in fact reach $6,000-7,000$ million by the year 2000 , then annual food production will have to be in-
creased by a factor of 3 to 3.5 in order to provide a standard diet for everyone.
6. Potential food resources calculated on the basis of areas under cultivation and past agricultural experience. Even at the existing level of average crop yields, expansion of the areas under cultivation-partly with and partly without the need for capital investment (see table 2)-will make it possible to feed not only the earth's present population but even the population anticipated by the year 2000 .

Table 2

| Total land area |
| :---: | :---: | :---: | :---: | :---: | :---: |

Food resources will also increase as a result of higher crop yields. As can be seen from table 3 (which is based on figures for 1957), grain crop yields vary widely from country to country.

Table 3

| Crop | Yieldin centners per hectare |  |  |
| :---: | :---: | :---: | :---: |
|  | Average for all capitalist conntries | High | Lowe |
| Wheat | 10.7 | 42.7 (Denmark) | 3.2 (Burma) |
| Rye | 11.1 | 29.2 (Netherlands) | 3.1 (Australia) |
| Barley | 12.9 | 40.6 (Netherlands) | 2.3 (Tunisia) |
| Maize | 18.7 | 48.0 (Belgitm) | 4.3 (Burma) |
| Oats | 12.4 | 33.3 (Denmark) | 4.1 (Portugal) |
| Rice | 18.4 | 57.4 (Spain) | 6.3 (Puerto Rico) |

7. There is similar variation in the case of other crops.
8. If the necessary action is taken, particularly irrigation measures in areas of insufficient rainfall, crop yields in every part of the world can be raised to the levels attained for the various crops in the high-yield countries.
9. Our calculations show that, at these levels, one hectare will yield sufficient food to provide a standard diet for seven people. That means that the world's present cultivated area can be made to yield enough food to sustain 10,000 million people and that expansion of the cultivated area to 9.33 million hectares will ensure enough food for 65,300 million people.
10. However, the average yields attained in the advanced countries do not in any sense represent the practical limit of agricultural achievement. In the Union of Soviet Socialist Republics, for example, plots ranging in size from 15 to 100 hectares have, in a number of cases, yielded 100 or more centners of maize per hectare. In some instances, plots of various sizes have yielded considerably larger quantities of potatoes, sugar beets, wheat and other crops than the average for the advanced countries.
11. All these facts lead to the conclusion that, if proper use is made of the available scientific data and of modern technology, it will be possible to obtain average yields at least twice as high as those now achieved in the
various advanced countries. In that case, a cultivated area of 1,430 million hectares will provide sufficient food for 20,000 million people and an area of 9,330 million hectares will yield enough for 130,000 million.
12. Potential food resources calculated on the basis of power resources. Each year, $5.5 \cdot 10^{20}$ calories of solar energy reach the surface of the earth, i.e., an average of $1.08 \cdot 10^{12}$ calories per square kilometre.
13. Let us proceed on the following assumptions: (a) the average duration of the vegetative period on earth is six months; (b) of the total amount of solar energy to which crops are exposed, 50 per cent (the photosynthetically active part) is absorbed by plants; (c) 30 per cent of the energy absorbed (in terms of quanta) is utilized in the formation of organic matter; (d) 25 per cent of this matter is consumed in the plants' breathing. It follows from this that organic matter containing $6.05 \cdot 10^{10}$ calories can be obtained from the average square kilometre.
14. Let us make the following assumptions: (a) the standard daily diet is equal, in terms of units of energy, to 3,000 calories, of which 14 per cent is protein, 30 per cent is fat and 56 per cent is carbohydrates; (b) 40 per cent of the protein energy and 15 per cent of the fat energy is derived from vegetable matter; (c) when livestock is given vitamin-enriched fodder, the livestock products obtained have a content of one calorie for every six assimilated in the fodder; $(d)$ the assimilated portion of the energy contained in vegetable food or fodder represents not less than 50 per cent of the total energy retained by plants. We thus find that, in order to provide one person with a year's standard food allowance, plants must retain 5.9 million calories of energy. That means that solar energy can yield enough food per square kilometre for 10,000 people (enough per hectare for 100 people); thus, the earth's present cultivated area can feed a population of 143,000 million, while the potential cultivated area can feed a population of 933,000 million.
15. When we consider that the seas and oceans are exposed to approximately 2.4 times as much solar energy as the earth's land areas and that it is theoretically possible to modify the nature of plants so that they will utilize solar energy even more fully, it can be stated that potential food resources, as calculated on the basis of solar energy resources, are sufficient to sustain several million million people.
16. Of course, it should not be concluded from the above that the earth will necessarily have a population of let us say a million million.

These figures merely serve to show the huge food potential that exists in terms of solar energy resources. Moreover, it is known that not only solar energy but any type of energy which is transformed into light energy with photosynthetically active waves can be used for the production of food by biological means.
17. Potential food resources calculated on the basis of the existing resources of the chemical elements contained in food components. The main elements which enter into the organic structure of plants are carbon, oxygen, hydrogen, nitrogen, phosphorus, sulphur and magnesium. Other essential elements play an important part in regulating plant metabolism. These are, in particular, calcium, potassium and iron. The mass of a plant calculated in terms of dry substance is 90 per cent carbon, oxygen and hydrogen. Such elements as nitrogen, potassium, calcium, magnesium, sulphur and phosphorus occur in quantities amounting to a few per cent or tenths or hundredths of 1 per cent, while such elements as boron, copper, manganese, zinc, iodine, bromine and arsenic occur in the dry mass of plants in thousandths, ten-thousandths or even smaller parts of 1 per cent. We know today that many of even those elements which occur in thousandths or smaller parts of 1 per cent are essential to plants, chiefly because they ensure normal metabolism.
18. For our purposes, all elements consumed by plants can be divided into two groups, the first of which includes carbon, oxygen, hydrogen and nitrogen while the second includes all others.
19. The elements in the first group are characterized by the fact that they enter (in an elementary or combined state) into the following cycles: the element (or compounds of the element) living matter from the atmosphere or the hydrosphere, to which they return after the dissolution of the organic matter (see table 4).
20. It is clear from table 4 that it would take more than 100,000 years for all the water in the atmosphere and hydrosphere to be exhausted even if it was used only once and if the earth's population reach 1 million million. Since the period during which water is fixed by any organism is incomparably shorter than that and water readily returns to the hydrosphere after the destruction of organic matter, it can be stated that existing water resources are sufficient to sustain 1 million million or more people. This, of course, does not alter the fact that mankind faces the necessity (and, as time goes on, will increasingly face the necessity) of redistributing water resources on the

Table 4

|  | Elements and substances |  |  |
| :---: | :---: | :---: | :---: |
|  | Carbon | Nitrogen | Water |
| Reserves in the atmosphere or hydrosphere (in tons) | 6.4.1011 | $4.0 \cdot 10^{15}$ | 1.4.1018 |
| Consumed in providing an annual food allowance for one person (in kg.). . | 600 | 24 | 900 |
| Required annually (in tons) : <br> (a) For photosynthesis on the present scale | 1.71.1011 | $6.8 \cdot 10^{9}$ | $2.56 \cdot 10^{11}$ |
| (b) In order to provide food through photosynthesis: |  |  |  |
| For 5,000 million people. | 3.0.109 | $0.12 \cdot 109$ | 4.5.109 |
| For 100,000 million people | 6.0.1010 | $2.410^{9}$ | $9.0 \cdot 10^{10}$ |
| For 1 million million people... | 6.0.1011 | $2.410^{10}$ | 9.0.1011 |
| Length of full exchange cycle of atmosphere and hydrosphere (in years) : |  |  |  |
| (a) At the present rate of photosynthesis | 3.75 | 5.9.105 | 5.5.10 ${ }^{6}$ |
| (b) Assuming that food is provided through photosynthesis: |  |  |  |
| For 5,000 million people. | 210 | 3.3.107 | $3.3 .10^{8}$ |
| For 100,000 million people.... | 10.5 | $1.6-10^{6}$ | $1.65 \cdot 107$ |
| For 1 million million people. | 1.05 | $1.6 \cdot 10^{5}$ | $1.65 \cdot 10^{5}$ |

surface of the earth (particularly in view of the water requirements for transpiration and for industrial and everyday purposes).
21. Nitrogen, as we know, follows two interrelated cycles in nature : elementary nitrogen, combined nitrogen, living matter. The development of industrial methods of fixing nitrogen and the availability of adequate energy resources make it possible for man to obtain any desired quantities of nitrogen from the atmosphere in order to produce food. Hence, it can be concluded, for the same reasons as in the case of water, that the available reserves of nitrogen are not a limiting factor in the production of food.
22. The reserves of carbon in the atmosphere are considerably smaller than those of nitrogen and water in the hydrosphere. Moreover, carbon dioxide is extracted from the atmosphere not only in the formation of living matter but also in the carbonization of calcareous materials (products resulting from the weathering of rock). This is accompanied, however, by processes which replenish the reserves of carbon dioxide in the atmosphere: volcanic activity and the burning of products of past photosynthesis.
23. According to existing information, the carbon dioxide content of the air has increased
by 12 per cent since the industrial revolution, and it is expected to increase by an additional $70-80$ per cent in the next 100 years. Man is in a position to utilize the reserves of carbon ( $6.4 \cdot 10^{15}$ tons) contained in the products of past photosynthesis, the carbon contained in carbonates ( $1.3 \cdot 10^{16}$ tons), etc. It is clear from all of this that there should not, in principle, be any shortage of carbon for purposes of food production. Mankind may, however, find it necessary to regulate the carbon dioxide content of the atmosphere and to use carbon dioxide on a larger scale in agriculture, which, given adequate energy resources, will also be feasible.
24. Of course, photosynthesis ensures against any decrease in the oxygen resources of the atmosphere. However, if man should burn all the products of past photosynthesis without making certain that current photosynthesis continued at the necessary rate, the reserves of free oxygen would prove insufficient. It may be that at some point mankind will have to stop burning coal, oil and other fuels and use them exclusively for purposes of chemical synthesis without oxidation with oxygen.
25. The production of mineral fertilizers with nutrient elements of the second group calls for the exploitation of concentrated deposits of these elements which were formed
at a certain stage in the development of the earth's crust. Unlike those in the first group, the elements in question do not return to concentrated deposits following the dissolution of organic matter. The natural formation of new concentrated deposits of these elements is most unlikely to occur, and, even if it should occur, the process would require a geological span of time.
26. Most soils are deficient in phosphorus and potassium and sometimes in a number of other elements in this group. These elements do not follow the closed cycle: soil living matter, since first of all, many plant remains do not return to the soil; secondly, compounds of a number of elements which cannot be assimilated by plants are formed in the soil; and,
thirdly, nutrients are carried away into the seas and oceans. As a result, soil which has previously been worked requires, for purposes of further cultivation, the addition of fertilizers containing various nutrients.
27. The production of an annual food allowance for one person entails the removal from the soil by plants of approximately 6 kg . $\mathrm{P}_{2} \mathrm{O}_{5}$ and $13 \mathrm{~kg} . \mathrm{K}_{2} \mathrm{O}$, but, because of this loss, it is usually thought necessary to introduce $15 \mathrm{~kg} . \mathrm{P}_{2} \mathrm{O}_{5}$ and $22 \mathrm{~kg} . \mathrm{K}_{2} \mathrm{O}$ into the soil for the purpose of providing this allowance.
28. If this nutrient requirement was met solely through the use of mineral fertilizers, the reserves of, for example, phosphorus and potassium ore would be used up within the periods indicated in the following table:

Table 5

| $\begin{gathered} \text { Ore } \\ \text { reserves } \end{gathered}$ | $\begin{aligned} & 10^{10} \\ & \text { tons } \end{aligned}$ | Reserves are sufficient for the follozing number of years |  |
| :---: | :---: | :---: | :---: |
|  |  | For 10,000 million people | If the population of the earth increases at the 1951-1960 rate |
| $\mathrm{P}_{2} \mathrm{O}_{5}$ |  |  |  |
| Actual | 1.0 | 66 | 90 |
| Potential | 11.9 | - | - |
| Total | 12.9 | 860 | 220 |
| $\mathrm{K}_{2} \mathrm{O}$ |  |  |  |
| Actual | 1.8 | 82 | 100 |
| Potential | 6.0 | - | - |
| Total | 7.8 | 354 | 170 |

29. The present level of utilization of fertilizers is far below what is needed to cover the loss of nutrients by the soil. In 1961, for example, 10 million tons of $\mathrm{P}_{2} \mathrm{O}_{5}$ and 8.6 million tons of $\mathrm{K}_{2} \mathrm{O}$ were introduced into the world's soil, whereas the approximate annual loss through crops is 15 million tons of $\mathrm{P}_{2} \mathrm{O}_{5}$ and 30 million tons of $\mathrm{K}_{2} \mathrm{O}$. It is also believed that the quantities of nutrients carried away into the seas and oceans each year are several times as great as those introduced into the soil by means of fertilizers. Thus far, then, what man has done with regard to these elements has merely served to dissipate them to an ever greater extent.
30. Of course, the ore reserves of plantnutrient elements may prove larger than they now appear to be. The actual reserves of plant nutrients can also be increased by raising the cofficient of their extraction from ore, utilizing low-grade ores and utilizing compounds of phosphorus, potassium, etc., which are found mixed in with other ores.
31. However, the reserves of the chemical elements in the second group can be made truly inexhaustible only by creating a full artificial cycle for these elements. That can be done if a process is developed for extracting them from rock in which they occur in amounts which are close to the average content of these elements in the earth's crust. The complex processing of such rock may prove to be quite feasible, in which case any further dissipation of the elements will be prevented.
32. The creation of a cycle for these elements can be largely brought about by other means as well. Thus, if only one tenth of the ocean reserves of potassium ( $6.3 \cdot 10^{14}$ tons) is used, they will last for 560 years if the earth's population continues to grow at the 1950-1960 rate. Potassium will not only be extracted from sea water but also return to it to some extent. In other words, a cycle will be operating, although by no means a closed one as yet.
33. Something approaching an artificial cycle of agronomic elements can be brought about by means of measures designed to reduce the loss of nutrients from the soil (such measures as an intensified effort to prevent soil erosion and the washing away of nutrients and to speed the transformation of compounds which cannot be assimilated by plants into assimilable ones).
34. A much closer approach to the creation of an artificial nutrient cycle can be achieved through soilless agriculture (hydroponics) in
conjunction with the processing of plant remains and animal and human waste products so as to bring about the re-entry of nutrients into the plant-growing cycle. This process, in which electricity obtained from any source can be used, also helps to ease the problem of finding sufficient land for cultivation.
35. However, the main solution to the problem of creating a complete nutrient cycle will be achieved by perfecting the chemical synthesis of all food components. This will also facilitate the nutrient cycle itself, as can be clearly seen from the following table:

Table 6

|  | Car- <br> bon | Nitro. <br> gen | Phos- <br> phorus | Potas- <br> sium |
| :--- | :---: | :---: | :---: | :---: |
| Required in order to provide an an- <br> nual food allowance for one person <br> with modern food production meth- |  |  |  |  |
| ods (kg.) $\ldots \ldots \ldots \ldots \ldots \ldots .$. | 600 | $33 / 25 \mathrm{a}$ | $15 / 6^{\mathrm{a}}$ | $22 / 13 \mathrm{a}$ |
| Annual per capita requirement (kg.).. | 140 | 6 | 1 | 0.1 |

a The numerator indicates the quantity of nutrients introduced into the soil and the denominator the quantity removed.
36. Needless to say, the production of food through chemical synthesis also completely eliminates the problem of finding sufficient land for cultivation.
37. Chemists believe that theoretically it is perfectly possible to produce, by industrial means, food which is tasty, fully nutritious and free of all the harmful substances which are often found mixed in with natural food. The question is the extent to which such production will prove economical, but that is a matter for detailed study.
38. Thus, in terms also of the reserves of the chemical elements which go to make up food components, man's ability to produce food is virtually unlimited.
39. The problem of creating a closed cycle of nutrients in the production and consumption of food is, in our opinion, one of the basic problems facing mankind, and scientists of all countries should join efforts in attacking it.

These combined efforts should be directed, first, towards the construction of large, multistorey automated enterprises for growing plants by hydroponic methods with the fullest possible cycle of plant nutrients and, secondly, towards the chemical synthesis of all food components.
40. It is clear from what has been said above that the earth's natural resources are sufficient to provide food for a population of almost any conceivable size. Yet, roughly a third of the people on earth do not receive an adequate diet even though food is often destroyed because there is no market for it. This contradiction is attributable to the fact that the greater part of the world is still dominated by a social system under which all production, including food production, is designed to enrich a minority rather than to provide the greatest possible satisfaction of the people's needs. When all production throughout the world is carried on for the benefit of all people, hunger will disappear.

# Population growth and the food problem in Latin America 

Y. G. Mashbitz

[Translated from Russion]

1. Population and the consumption and production of food are among the most important problems in every country. They are directly connected with a highly complex combination of social, economic, natural and historical factors.
2. Because colonial rule has left the developing countries of Asia, Africa and Latin America backward, the high rates of natural population growth in most of them aggravate their social and economic problems and their food supply difficulties. According to a Food and Agriculture Organization publication, "More than half the world's population is undernourished or malnourished. Hunger, poverty and stagnation form a vicious circle. The situation is being aggravated by the acceleration of population growth which is in the nature of an explosion never before experienced in human history." ${ }^{1}$
3. According to the leading Brazilian scientist and public figure Josué de Castro, Latin America is one of the world's major hunger areas, with two thirds of the population suffering from malnutrition or an inadequate diet. ${ }^{2}$ According to calculations made by the well-known French demographer A. Sauvy, the standard of living in Latin America today is lower than in Western Europe in the 1870's and the average expectation of life in Latin American countries is not more than fifty to fifty-five years. ${ }^{3}$
4. Since the beginning of the twentieth century, Latin America has had the highest rate of population growth of any major region of the earth, its population reaching 218 million in 1962.
5. The population, which in 1900 had been 63 million, rose 57 per cent between 1900 and 1925 and nearly 65 per cent between 1925 and 1950 (the corresponding figures for Africa were

[^227]22.5 and 35.4 per cent and for Asia without the Soviet Union and Japan 18.2 and 35 per cent). In the 1960's the rate of population growth in Latin America has reached an average of about 3 per cent per year, which is considerably higher than in other regions.
6. Latin America's share of the total world population has been steadily rising. In 1900 it was 4.1 per cent, in 19506.5 per cent, and it will rise still further in the future.
7. The rapid growth of Latin America's population is not due to immigration, but mainly to the high rate of natural increase. In 1945-1960 the average birth-rate for the region as a whole was $42-43$ per thousand, while the death rate declined from 17-19 to 13-15 per thousand. By all appearances, the rate of population growth will remain high for the next few years. This is due in particular to the young age structure of the population of the region, where about 42 per cent of the inhabitants were under the age of fifteen in 1960. The population of the cities, and particularly the largest centres, is growing especially fast.
8. The relationship between the food supply and the rate of population growth in Latin America is unsatisfactory. Aacording to Food and Agriculture Organization data, the average population during the period 1958/59-1962/63 was 76 per cent higher than before the war, whereas food production was only 70 per cent higher. ${ }^{4}$ The food output index (1952/53$1956 / 57=100$ ) was. estimated at 124 in 1963/64 (the pre-war figure was 70). But the per capita food output index before the war was 104 , whereas in $1963 / 64$ it was $97 .{ }^{5}$ Latin America is the only region in the world where less food is produced per capita than before the war.
9. Since Latin America is a vast region with a great variety of social, economic and natural conditions, average figures for calorie

[^228]content and diet do not give an accurate picture of the food situation in the different countries. They do not take into account the extreme differences in the standard of living and diet of different groups of the population. According to information provided by United Nations experts, 50 per cent of the population of Latin America get only 16 per cent of the total quantity of consumer goods and services. ${ }^{6}$ The regional averages include Argentina and Uruguay, where stock-raising is well advanced and the diet is much better than in any other Latin American countries.
10. The calorie content of the daily ration of an "average" Latin American is about 2,500 calories. This is higher than the figure for Africa, but considerably lower than that for the United States and Canada (up to 3,300 calories). There are wide variations in the per capita calorie intake figures for different countries. In Argentina and Uruguay, the daily intake is about 3,100, in Bolivia, Ecuador and Central American countries (except Cost Rica) it is about 2,000 , while in the vast area of northeast Brazil it is less than 1,700 , which is among the lowest figures in the world.
11. The quality of the diet of the great majority of Latin Americans is even less satisfactory. Its main feature is the lack of protein, particularly rich protein of animal origin. In the Latin American countries, except for Argentina and Uruguay, the basis of the diet is vegetable (about three quarters of the average daily calorie intake). According to Food and Agriculture Organization data, 64 per cent of the average daily calorie intake is accounted for by grain, roots and sugar (the figure for Africa is 74 per cent and for North America 40 per cent). ${ }^{7}$ The great mass of Latin Americans consume little of the particularly rich and essential animal products. In Mexico, according to the 1960 census, nearly a quarter of the population do not eat meat, milk, eggs or fish. ${ }^{8}$ In the mid-fifties, the proportion of animal protein in the total protein diet in El Salvador was 8.1 per cent, in Guatemala 14.6 per cent, in the Dominican Republic 16.7 per cent and in Honduras, Peru and Mexico. 22 to 24 per cent. ${ }^{9}$

[^229]12. A similar diet is generally characteristic of most developing countries. "Projections indicate that hunger will persist as a major world problem at the end of the present decade.... Malnutrition will be even more difficult to eliminate. It is believed unlikely that livestock production in low-income countries can keep pace with rising potential demand, and the shortage of animal protein will therefore continue." ${ }^{10}$ According to Food and Agriculture Organization's latest estimates, per capita consumption of meat in the developing countries is 20 per cent of that in industrial countries, milk 14 per cent and eggs 12 per cent.
13. A country's diet greatly affects its level of economic development. In the United States and Canada the main bulk of protein (about 100 g per capita a day on the average) is provided by animal products. In the Latin American countries (except Argentina and Uruguay) per capita protein consumption is between two fifths and two thirds of that in the United States and Canada and animal produce provides only about a third or less of the protein consumed. ${ }^{11}$ According to material published by the Mexican Food Institute, in the rural areas of Mexico, maize, the basic product, accounts for 60 per cent of the daily calorie intake. Because of this diet, the health of 70 per cent of peasant children in Mexico is unsatisfactory. ${ }^{12}$ In Brazil vast stretches of the Amazon basin and the North East, where up to 80 per cent of the population have no chance to eat meat and dairy products, are areas of chronic hunger. The quality of the diet is particularly unsatisfactory in the mountain areas and tropical plains, where the great mass of the 30 to 40 million Indians, the most unfortunate part of the Latin American population, are to be found.
14. In Latin America, therefore, the low level of economic development means that the great mass of the population has a diet which is inadequate in calorie content and unsatisfactory in quality. This "physiological poverty", as it has been described by the well-known French geographer Pierre George, has a pernicious effect on the health of the masses, and particularly the young, who experience the un-

[^230]pleasant effects of the general prevalence of numerous diseases. ${ }^{13}$
15. Rural Latin America, where up to three fifths of the working population are employed in agriculture, is characterized by the low level of development of this important sector. It provides only 20 per cent of the gross output of the region. In 1945-1957 the value of output per worker in Latin America was $\$ 677$ (at 1950 prices), the figure for agriculture being only $\$ 325$ and that for the non-agricultural sectors $\$ 1,118$ ( $\$ 2,406$ in the extractive industries). ${ }^{14}$ In almost all Latin American countries agriculture is unable to meet the rapidly growing demand for food (due partly to the rapid growth of the urban population). In 19601963 agricultural imports into Latin America were approximately twice as high as pre-war.
16. The backwardness of agriculture in the Latin American countries is due to the narrowness of the domestic market which in turn is due to the anti-national, outward-looking nature of their agricultural and raw materials economies and their subordinate position in the world capitalist economy. Agriculture in Latin America is characterized by the predominance of large estates owned by local land-owners and foreign companies. The degree of concentration of land ownership in this region is considerably greater than in Africa and Asia. Together with these large estates, there is an exceptionally high degree of fragmentation of land ownership and tenure, resulting in a vast number of small and very small holdings, which suffer severely from their inadequate size. At the beginning of the 1960's the agriculture of Latin America comprised 7.5 million holdings, of which 1.5 per cent had 65 per cent of the agricultural land and 5.5 million had only 4 per cent. Of 32 million people employed in agriculture, 30 million either had no land or only the very smallest plot, 2 million were classified as small holders and 100,000 had almost two thirds of the agricultural land. ${ }^{15}$
17. The preliminary data from the most recent agricultural census in Peru (July 1961) are very indicative. A small number of very large estates, no more than 0.1 per cent of the total, have nearly two thirds of the agricultural land, while 35 per cent of all holdings, each less

[^231]than one hectare, have only 0.6 per cent of the agricultural land. In holdings of more than 1,000 hectares, which account for over a third of the total amount of cultivated land, pasture, forests and unused land occupy nearly thirteen times as much space as crops and plantations. In Peru, as in other Latin American countries, great stretches of land in the latifundia are not used. The small and very small holdings cannot develop commodity production on any considerable scale for lack of land. This not only aggravates the food problem, but holds back the development of all sectors of the economy in Latin American countries.
18. The anti-national pattern of land ownership and tenure and the tenacity with which feudalism has survived are the reason for the low technical level of agriculture in the Latin American countries. Erosion, particularly in mountainous areas and their foot-hills, has taken on national disaster proportions, particularly because of the spread of the cut-and-burn system of cultivation, the chopping-down of forests, uninterrupted cultivation of the same crops, sometimes over many centuries, inefficient use of pasture and primitive methods of cultivation. Fertilizers are little used in the Latin American countries. According to Food and Agriculture Organization data, in 1961 there were no more than 386,000 tractors in Latin America, or one fourteenth the number in the United States and Canada. Yields of maize, the chief crop in a number of countries in the region, are on the average three to three and a half times greater in the United States and Canada.
19. Output per worker in agriculture (in terms of grain) in Latin America fell from an average of 403 kg . in $1934-1938$ to 389 kg . in 1960/61 (the corresponding figures for North America are $3,303 \mathrm{~kg}$. and $9,909 \mathrm{~kg}$.). ${ }^{16}$
20. Latin America has vast areas of pastureland. Out of the region's total area of 2,054 million hectares, crops and plantations occupy 107 million hectares and pastureland 379 million hectares or three and a half times as much (the corresponding figures for North America are 227 million and 278 million hectares). ${ }^{17}$ The bulk of the pastureland, however, belongs to the latifundia. This is a great hindrance to the development of stock-raising and leads to a one-sided specialization in arable farming in most Latin American countries. Even in the most advanced stock-raising coun-

[^232]try in the region, Uruguay, where as much as 90 per cent of the land is pasture, the number of cattle has not risen since 1908. If stockraising were as productive in Uruguay as in New Zealand, the country could have exported seven times as much livestock products as it did in 1959. ${ }^{18}$ The average yield per head of cattle in Western Europe is seven times higher than in Africa and four times higher than in Latin America. ${ }^{19}$ Stock-raising in Latin America lags considerably behind crop growing. The livestock output index ( $1958=100$ ), which was 102 in 1950, went down to 86 in 1962, whereas the crop output index rose over the same period from 91 to 101. ${ }^{20}$
21. In Latin America only 5 per cent of the total agricultural land is cultivated (the figure for the world as a whole and for the United States is about 11 per cent.) Even in Argentina and Uruguay, the figure is only 12 per cent ( 2 per cent in Brazil). Between 1951 and 1959. the area of arable land per capita fell from 0.57 to 0.53 hectares.
22. In the literature on Latin America's problems, it is often categorically asserted that because of allegedly unfavourable topography, soil and climate, only about 5 per cent of the territory is suitable for agriculture. ${ }^{21}$ In actual fact the region has vast resources of land. In South America, the population density is only eight persons per square kilometre, which is one third of the world figure and one fourteenth of the figure for South East Asia. But nearly 40 per cent of the population of South America live on 5 per cent of the land and huge areas are almost unpopulated and undeveloped. Huge undeveloped territories are also to be found in Central America, Mexico and the West Indies.
23. The Pampas, Chaco, the Amazon basin and a number of other river basins offer considerable opportunities for agricultural development. The development of river basins in the tropics is no easy matter, but the experience of Mexico, which has been carrying out a "drive to the sea" ("marcha al mar") programme since 1947, with the aim of settling the tropical plains, shows what great possibil-

[^233]ities there are in this field. The construction of irrigation works is also very important and has great prospects in Latin America. Only about 6 per cent of the cultivated land in the region is irrigated (the figure for Asia is about 22 per cent and for Africa 11 per cent).
24. The development of sea fishing could considerably improve the food situation in the Latin American countries, which have a long coastline along the Pacific and Atlantic Oceans. But Latin America still, as it were, turns its back on the sea. In 1962 about 1 million tons of fish were caught in South America (excluding Peru), which is little more than a seventh of the catch in Japan. The emergence of Pera as one of the leading countries in the world sea-fishing industry has not led to any appreciable improvement in the country's food situation. Most of the catch goes to factories for the production of fish flour for export and only part is sold to the population of the towns in the coastal areas. In the biggest Latin American countries, Brazil, Argentina and Mexico, the per capita consumption of fish is only 2 or 3 kg . a year.
25. Can Latin America supply its rapidly growing population with food? This question is hotly disputed. According to experts' estimates, by the year 2000 the output of food in Latin America (excluding Argentina and Uruguay), with only a minimal improvement in the diet, will have to increase by nearly 240 per cent over the 1958 level in order to meet the growth in population. ${ }^{22}$ In the journal of the United States Population Reference Bureau, a Malthusian recipe is given for solving the highly complicated problems comnected with the high rate of population growth in Latin America, namely that "either the death rate must rise or the birth rate must be brought down." ${ }^{23}$ Progressive society in Latin America rejects these pseudo-scientific recommendations. It has been proved beyond doubt that even at the present level of science and technology the natural conditions in Latin America are such that the region's entire demand for food and agricultural raw materials could be fully met. Brazilian scientists have calculated that even at present Brazil and Argentina could feed 1,050 million people, or one third of the world's population. ${ }^{24}$
${ }^{22}$ Food and Agriculture Organization, Possibilities of Increasing World Food Production (Rome, 1963), p. 25 .
${ }_{23}$ Population Reference Bureau, Population Bulletin, No. 5 (Washington, 1958), p. 5.
24 Boletín geografico, No. 154 (Brazil, 1960), pp. 53-56.
26. The food problem in Latin America, like other problems common to the whole region, cannot be solved by partial measures of a scientific and technological nature. Raúl Prebisch, the well-known United Nations official and Argentinian economist, has said that in Latin America economic changes cannot be carried out effectively without fundamental changes in the social structure and that the present social structure in Latin America is a serious obstacle to technical progress, and hence to economic and social progress. ${ }^{25}$
27. Of great interest to Latin America is the way in which the food problem has been solved in Cuba, a country where the revolution inherited a backward single-crop economy. Despite the serious difficulties created by the United States blockade, the breaking of traditional economic ties, various natural disasters

[^234]and lack of experience, the whole population in Cuba has a regular diet. In daily calorie intake, Cuba is second only to Argentina in Latin America. Cubans are consuming more and more meat, dairy and fish products. The establishment of a diversified agriculture, thriving livestock industry and large-scale seafishing will make it possible within a few years to provide the Cuban people with a full diet in accordance with scientific standards, taking into account also the physical conditions of life in the tropics. The growth in the consumption of dairy products and the replacement of part of the animal fats consumed by vegetable fats represents a step forward in this connexion.
28. Latin America, like all. other regions of the world, can solve its vital problems only if there is peace, general and complete disarmament and effective international co-operation. These matters affect all countries and peoples, because the present and future of mankind depend on them.

# Urbanization, industrialization and food production in Brazil 

## Carlos Alberto de Medina


#### Abstract

Urbanizatron


1. According to the census of 1960 , the population of Brazil was $70,967,185$. When compared with the censuses of 1940 and 1950, this figure shows that the annual growth rate of the Brazilian population accelerated, increasing from 2.4 per cent to 3.6 per cent. Between 1950 and 1960, there was a population increase of 19,022,788.
2. The population growth, however, is clearly differentiated when urban and rural areas are confronted. While the average geometric rate of population increment was 54 per cent in the urban areas, in the rural areas it was 16 per cent. It must be added that the urban population grew from 39 per cent during the inter-censal period of $1940-1950$ to the above-mentioned rate of 54 per cent, while the growth rate of the rural population during the same period remained stable.
3. From 1950 to 1960 , the urban population was increased by $13,208,047$, while the rural population was increased by $5,814,741$. Notwithstanding this fact, the rural population prevails in the country, amounting to 54.92 per cent of the total population. The urbanization process, however, remains evident.
4. This process has been characterized by an intense rural-urban migration. Unfortunately, this process was not taken into account in collecting the data of 1960 and therefore only some indications about it are available. The Colonization and Immigration Department of the State of São Paulo, the most important State of the Union, and the only one with quite accurate statistics, published the number of the main population groups entering the state, coming from all over the country, which, according to their records, totalled $1,204,749$. In a recent survey, owing to insufficient information obtained, the author stated that "a third of the adult population of our selected cities would be rural migrants". ${ }^{1}$ Another survey held in a particular area of the State of São
[^235]Paulo indicates that twenty-four municipalities, out of a total of thirty-five, lost rural population in the period 1950-1960. The same process occurred in the State of Ceara in north-eastern Brazil, where fifty municipalities, out of 142 , lost rural population. In this state 30 per cent of the urban population in forty-five municipalities, out of the fifty-six surveyed, had lived in the cities for less than ten years. This trend is general in the country following an intense growth of the metropolitan areas: Rio de Janeiro, 39 per cent; São Paulo, 72 per cent; Recife, 50 per cent; Belo Horizonte, 93 per cent; and Salvador, 57 per cent. All of these cities have more than 500,000 inhabitants, and Rio de Janeiro and São Paulo have more than 3 million. A very significative case is that of the State of Rio de Janeiro, which had 62 per cent of its population living in the rural area in 1940 and which, in 1960, had only 39 per cent of its total population living there.
5. An article comparing industrial and agricultural centres in Brazil found a population increment of 63 per cent between 1950 and 1960 for the industrial ones and of 38 per cent for the agricultural ones.

## Industrialization

6. In 1907, there were in Brazil 3,250 industrial establishments employing 150,841 workers. During the First World War, 5,926 new establishments were installed in the country, bringing the total to 13,336 industrial units with 275,512 employees. In 1963, there were 198,000 industries with a total of 2.3 million workers. Brazil's industrial upswing came after the Second World War, amounting to 109,661 industrial establishments in 1960 and to an estimated total of 198,000 in 1963. Of this number, 162,000 employed ten or fewer workers. (The largest industrial establishments represented only 1.6 per cent of the total.) Thus, 98.4 per cent of the national industries were small enterprises absorbing reduced handwork, such as small factories or workmanship units scattered throughout the country. The large industrial establishments were centralized in the Guanabara-São Paulo-Minas Gerais
triangle, where the automobile, steel and ma-chine-tool industries, and part of the petroleum industry were located.
7. According to the industrial census of 1960, 54.6 per cent of all industrial establishments (all of them in the urban area) were located in four states: São Paulo, Minas Gerais, Guanabara and Rio Grande do Sul. In addition, 91,443 industrial establishments, or 83.3 per cent, were located in the southern and eastern physiographic areas. Only São Paulo, Guanabara and Minas Gerais can be regarded as areas of great industrialization. According to a survey on the thirty leading industrial municipalities of the country, only seven were not located in those areas.
8. This industrial growth has led to benefits for wider sections of the economy, through the development of new highways which link formerly isolated areas to the industrial and commercial heart of the country.
9. Another author declares that "the data on the most underdeveloped areas in Brazil, where the urban population continues to increase at a more accentuated rate than the total population and where there was not any industrial development", shows that the industrialization of the country is not a reason by itself to explain the process of intensive urbanization. ${ }^{2}$ The data of the census of 1960 , however, show that in the areas where industrial development is strong, population growth is also more outstanding.

## Agriculture

10. Although comprising 55 per cent of the total population of Brazil, the agricultural area of the country contributes only 28 per cent to the national revenue. During ten years (1950-1960), agriculture's contribution to the national revenue was stable. In 1960, that contribution dropped to 25 per cent, if the data are deflated Comparing the agricultural production of 1961 with that of 1962 (taking for granted that available statistics are accurate), based on the quantities of the principal foodstuffs and raw materials produced, the situation presented is very unsatisfactory. Excluding coffee, which is a fundamental product for the national economy ( 58 per cent of total exportation, 1957-1960), the production increment averages 2.3 per cent, which is insufficient, owing to the natural increase of the population and a greater demand for food, as a result of the individual's higher income.

[^236]11. The necessity of greater investments in agriculture, in order to supply urban residents properly with food and raw materials, has been emphasized by governmental projects in recent years.
12. Notwithstanding the fact that the main agricultural products show a continuous increase, a decrease in production volume is registered. Owing to deficient statistics, it is very difficult to analyse the problem. According to the available data, the chart for some essential products is given below:

|  | Production increment (percentage) |  |  |
| :--- | ---: | ---: | ---: | :---: |
| Products | 1960 | 1961 | $1963^{2}$ |
| Coin $\ldots \ldots \ldots \ldots$ | 9.8 | 3.2 | 5.3 |
| Rice $\ldots \ldots \ldots \ldots$ | 21.3 | 10.8 | 8.3 |
| Beans $\ldots \ldots \ldots$. | 6.5 | 5.3 | 2.1 |
| Potatoes $\ldots . . .$. | 7.6 | 2.9 | 2.3 |

Source: Brazil, Ministry of Agriculture, Production Statistics Service.
${ }^{a}$ Estimated.
13. This situation is caused by the low agricultural productivity. Brazilian agriculture has obsolete characteristics which lead to insufficient yields per hectare, as follows (in kilogrammes) : rice, 1,598; corn, 1,287; beans, 670 ; potatoes, 5,432 ; and manioc, 13,117 . The same situation prevails with regard to cattle raising: 200 litres per annum, or 0.5 livestock per hectare and 26 kilogrammes of meat per person.
14. Brazilian agriculture presents a great many problems, i.e., there is an insignificant use of fertilizers and mechanical equipment. As far as fertilizers are concerned, the utilization per cultivated hectare is as follows:

$$
\mathrm{N}=1.3 ; \quad \mathrm{P}_{2} \mathrm{O}_{5}=3.9 ; \quad \mathrm{K}_{2} \mathrm{O}=2.6
$$

15. Compared with the apparent utilization, the ideal use of fertilizers would be:

|  | Consumption (thousands of tows) |  |  |
| :---: | :---: | :---: | :---: |
|  | $N$ | $\mathrm{P}_{2} \mathrm{O}_{5}$ | $\mathrm{K}_{\varepsilon} \mathrm{O}$ |
| Ideal necessity | 987 | 1,181 | 961 |
| Apparent utilization | 40 | 120 | 40 |

[^237]16. One of the reasons for the insufficient use of fertilizers is the high price level. In the last ten years (1953-1962), the price of agricultural products was increased by 685 per cent and food by 662 per cent, against fertilizer price increases of 1,011 per cent.
17. As far as the scarcity of mechanical equipment is concerned, there were 4,181 hectares of land per tractor in agricultural areas; there were 469 hectares of crop land per tractor. In 1960, there were 63,493 tractors, compared with a total of $3,319,151$ agricultural establishments.
18. The total hectares in farm land was 265.4 million and the total hectares in crops was 29.7 million, i.e., only 11 per cent. However, between 1950 and 1960 there was a 56 per cent increase in crop land, owing to new settlements.
19. Thus, Brazilian agriculture is not producing adequate amounts and varieties of food for the population. Many explanations have been given, such as the one based on a study of the National Economics Council, which presents the Brazilian agricultural structure as having the following characteristics:
(a) Predominance of very large agricultural properties;
(b) Growing concentration of rural properties;
(c) Enormous proportion of farmers without land;
(d) Small parcel of cultivated areas;
(e) Harmful farming practices;
(f) Semi-feudal working conditions;
(g) Incipient mechanization, fertilization and plague eradication;
(h) Insignificant per capita income;
(i) Lack of security for the farm workers;
(j) Stimulation for new investments nonexistent;
(k) High percentage of the economically active population dedicated to agriculture;
(l) Total cultivated area very small, compared with Brazilian territorial extension;
(m) Poor sanitary conditions, resulting in a high rate of infantile mortality and reduced life expectancy;
(n) Low educational index, with a high percentage of analphabets in the rural area.

## Final remarks

20. Under the circumstances prevailing in Brazil, one may observe that, in its interrelation, the question tends to become aggravated. The Brazilian growth rate demands a larger volume of agricultural production. At the moment, "the various inquiries made throughout the country and the observations made on food
habits in the majority of the regions of Brazil, show that part of the population obtains an inadequate diet, but not so much from the quantitative, as from the qualitative, viewpoint". A specialized study that analysed the actual diet of Brazilians found it very deficient in fats, though carbohydrates are in great surplus. ${ }^{3}$ Proteins just about balance, although, with the actual supply of food, there is a significant lack of proteins from animal sources. The more abundant supply of proteins from vegetable sources, such as that from beans (a staple food in Brazil), offsets the lack of animal proteins. In all likehood, however, states the author, the actual calories consumed per capita did not exceed approximately 2,670 per day in 1960, an estimate which includes imported foods (almost entirely wheat) at the daily rate of 300 calories per capita, or about $10-11$ per cent of the total. The study presumes a high maldistribution of the national income and of food, which permits a small proportion of the population with the highest incomes to purchase, consume or waste large amounts of food. According to the author, a family of four to five people with a salary equivalent to the legal minimum in Rio de Janeiro, which spends 50 per cent of its income on food, would be supplied daily with an average of $1,200-1,500$ calories. This is the situation of the second most important city of the country, located in the area where there is the highest per capita income (equivalent to approximately 400 United States dollars). The city of Sáo Paulo is also in this area. These two Brazilian urban centres have the best living standard. Their death rates average 10.0 and 8.9 per 1,000 , respectively, while the over-all Brazilian rate is 15.0 . Their infant mortality rates are 67.7 and 60.0 , respectively, while the national rate was estimated at over 150 per 1,000 born alive in 1961. The progressive urbanization of the country is responsible for the raising of health standards, mainly in those heavily populated urban and industrial areas. An analysis of the centres of demographic pressure, i.e., of cities that, owing to their poptulation, show a greater demand for food and therefore receive priority attention from the Government, indicates that the inhabitants of the nine centres, corresponding to 22.6 per cent of the total population of Brazil, demand almost 25 per cent of the food production, not only with regard to quantity, but also to quality.

[^238]21. These urban-industrial centres serve as an attraction point for the rural areas, through the improvement of the ways of communication.
22. Two other factors contribute to intensity this relation, as well as to aggravate the problem of food demand. The first is caused by the process of replacing agriculture with cattle raising, thus resolving the landowner's human and economic problems by driving away the residents of his property. By so doing, he decreases their number and increases his profits, which are better assured with cattle raising. This phenomenon occurs throughout the country and is responsible for the intensification of the rural-urban migration. The second factor is the replacement of the worker by improved machines.
23. Jointly, these two factors are responsible for the acceleration of the urbanization process. Data about the eradication of old and unproductive coffee plantations show that 46.6 per cent of the total eradicated area in Brazil (237,032 hectares) was turned into pasturage. Only 33.6 per cent was turned into land producing food-stuffs for the internal market.
24. The process of urbanization thus brings to the city all the problems of the decadent areas of Brazil, aggravated by the fact that the former rural workers need food at once in order to survive in a country that in 1963 had an inflation rate of about 80 per cent. Moreover, those rural workers were not only consumers, but also producers, receiving from their employers land for their utilization in planting food. They also provided the hand labour which the landowner used for the same kind of cultivation. The Brazilian farmer is more interested in the products that are suitable for the international export market, putting aside temporary plantations, such as food, because the market is not stimulating for the producer. ${ }^{4}$

25 . If the industrialization process raises the income of the workers, an intense urbanization makes difficult the distribution and consumption of food, owing to the constant price increases and to its shortage in the market. The problem thus becomes a question of politics.

[^239]
## The population pressure and the development of new areas

E. N. Omaboe

1. One of the most widely discussed demographic phenomena in recent years is the tremendous annual increase in the world population. Quite naturally, projections based on past trends have been made, and in many quarters the resultant estimates have aroused considerable anxiety as to the world's ability to support these huge projected populations.
2. Available population statistics indicate, for instance, a threefold increase in the world population during the last 100 years. The world's population-supporting capacity has been made possible in the past by a number of factors, including technological inventions, investments in the improvement of productive equipment, increasing skills, use of natural resources and the opening up and development of new areas. Between 1950 and 1960 it is estimated that the world population showed an increase of about 470 million, a number which is nearly double the total population of Africa in 1960. It is estimated that the world population will total about 7,410 million in 2000 compared with 2,990 in 1960. Although this increase will be experienced by all continents the percentage contributions by the regions will vary. Generally, the developed countries of North America, Europe (including the Union of Soviet Socialist Republics) and Oceania will show lower population growth rates than the developing countries of Asia, Africa and Latin America. Whereas it is estimated that the average decennial increase between 1960 and 2000 for the developed countries will be about 13 per cent, estimate for the developing countries is more than twice as high, 30 per cent. It is in respect largely of the trends in population size in the poorer countries of the world that great concern has been expressed in various quarters.
3. In order to understand thoroughly the trends in the world population and the implications of these with respect to the development of new areas, it is appropriate not to confine oneself to numbers alone, but to take into account the qualitative changes which are involved. The quantitative aspects are those which are mentioned briefly above, namely, the increase in the number of human beings during
specified periods. The relationship between the quantitative increases in the human population and the opening up and development of new areas is not very difficult to comprehend. This, incidentally, is the aspect of the population pressure that has been widely discussed. On the other hand, the implications of the qualitative changes in the human population with respect to the development of new areas have received little treatment in the literature.
4. It is appropriate to explain first of all what is meant by the qualitative aspects of population pressure. This could be explained by changes in the standards of living of the population as measured simply by the real per capita gross national product. This is a very rough approximation indeed, because there are a number of factors which enter into the qualitative aspects of population, but which are not directly reflected in changes in the gross national product. An example will serve to illustrate this point. Knowledge of, or awareness of, the availability or existence of opportunities for the ready marketing of a given crop enhances the quality of a population, but this knowledge, by itself, will not increase the gross national product unless it is followed up by production to take full advantage of the existing favourable market conditions. It is therefore dangerous to equate the quality of a given population to the level of per capita national income alone without taking into account such important, but sometimes immeasurable, attributes of the population as education, attitude of mind, human response, etc., which may ultimately be reffected in the gross national product in an indirect manner only.
5. It is a well-known fact that the large increases in the world population have been made possible partly by the opening up and development of new areas. This phenomenon is by no means of recent origin. The world has seen the large-scale development of entire continents in the past. Mention could be made of the development of North America, Australia and New Zealand. Within countries also, more and more areas have been developed and brought under cultivation and, as a result, the
population-supporting capacity of the countries has increased. The development of new areas within "known" national boundaries is in many respects as exciting as that of the development of the "new world". In Ghana, for instance, it is estimated that more than half of the existing land under cultivation has been developed within the last fifty years.
6. There is no doubt about the impact of the increase in a country's population on the development of new areas within it, although this factor does not operate in isolation but in combination with other economic, sociological and even political factors. It is difficult to isolate and evaluate the direct impact of increases in population on the development of new areas. The system of land tenure existing in the country is an important factor which may combine with the quantitative population pressure to influence the development of new areas. If the prevailing land-tenure system were unsatisfactory, a mere increase in the population would not be immediately reflected in the opening up of new areas. In the extreme case, however, the population increase would result in considerable social and political pressure on the land tenure and ultimately lead to an agrarian revolution, which would sweep aside the land tenure and make possible the redistribution of land with a consequent opening up of new areas. Where, however, the system of land tenure was satisfactory, the increases in population would be reflected in the cultivation of more and more land, leading to the development of new areas. One example of what may be described as a satisfactory land-tenure system in this sense is that which existed in large areas in Ghana prior to the commercialization of land. Large tracts of land were held collectively and vested in the "stool" or "skin", and all bona fide subjects of the stool could obtain the use of the land by providing the chief and elders with a small "drink". ${ }^{1}$ With the rising commercial value of land, the system has been considerably modified and, in some cases, subjects of the stool have to compete with "outsiders" for stool land on strictly commercial terms. ${ }^{2}$

[^240]7. Available statistics in Ghana and other West African countries are not sufficient to permit an objective appraisal of the real impact of the increasing populations on the development of new areas. It is, however, possible to draw some general inferences from the available information. It is known that vast areas have been brought under cultivation during the last half-century and that during this same period the populations of the countries and the entire sub-region have increased considerably. What is not known, however, is the extent to which the development of these new areas has been brought about by the population increases. It is undoubtedly true that the population growth has had some effect on the cultivation of new areas.
8. In her study of the migrant cocoa farmers of southern Ghana, Polly Hill accepts the impact of the increases in the population of Akwapim State as being one of the major factors in the "migratory process" which led to the opening up of the forest areas of Akim Abuakwa. On this subject, she writes as follows, "The population of Akwapim, one of the healthiest districts of Ghana, was presumably increasing-though population statistics are no guide. While there was in general no shortage of agricultural land, the inhabitants of some towns found it necessary to go further afield and future land scarcity could have been foreseen." ${ }^{3}$
9. To illustrate the effect of the qualitative aspects of the population pressure on the development of new areas, the spread of the cultivation of cocoa in Ghana is examined below. The growth of the cocoa industry in Ghana has been spectacular and illustrates quite vividly what considerable pull the qualitative aspects of population pressure can exert in the cultivation of new areas. The cocoa industry is also important because its cultivation has been closely associated with the production of such food crops as plantain, cocoyam, etc., which are not cash crops, but which provide the greater part of the population with its staple food requirements.
10. Cocoa is believed to have been introduced into Ghana in 1879. The initial cocoa plantings were made in the vicinity of Mam-

[^241]pong, Akwapim, and from this area cocoa cultivation spread very rapidly, first, along the Akwapim ridge; and later in the eastern region, the western and Volta regions, and the Brong-Ahafo region. The first plantings in Ashanti, for instance, were believed to have been made in 1901 in Ashanti Akim.
11. The point that is of interest to the subject under discussion is the way in which cocoa cultivation spread to these areas, thus opening up the forest areas and helping in the general economic and social development of the country. The Akwapim farmers, who were the first to be brought into direct contact with cocoa cultivation, began to open up the forest areas of Akwapim State until they found their own state land inadequate to satisfy their aspirations, whereupon they began to "emigrate" to other forest areas, notably, in Akim. They did this through a system of group-land purchase by forming themselves into "companies" and acquiring large tracts of forest areas in other states for distribution among the members forming these companies. Another system, which is also similar to that of the Akwapims, is the "hura" system practised mainly by the Krobos (Yilo Krobo). It is sometimes claimed that the earlier migration by the Krobos into what is now called Krobo State, for the cultivation of food and oil-palm, was based on the huza system of group purchase of a tract of land and that the Akwapims imitated the huza system when they adopted the company system. ${ }^{4}$ The point that is of interest is that the development of these areas, whether in Ashanti and Akim for cocoa cultivation or in Krobo for food and oil-palm cultivation, was made possible largely through the migration of farmers from areas where economic and social factors were exerting pressure on the population.
12. Although the density of population was a factor in the opening up of the new areas, the qualitative aspects of population pressure were by far the more important factors. The introduction of cocoa, a new cash crop, with a guaranteed favourable market, provided the farmers with a strong incentive, which was sufficient to induce the farmers to suffer a number of hardships, abandon temporarily their traditional practices within their tribes and emigrate to take full advantage of the oppor-

[^242]tunities offered by the new crop. Knowledge of the opportunities offered by the new crop was therefore very important in influencing the farmers to migrate. Without this incentive, the population would have grown without the farmers emigrating to seek new areas for cultivation, for the available land in Akwapim would have been sufficient to support an increasing population indulging in traditional farming techniques based mainly on subsistence production.
13. It is of considerable interest to note that before the introduction of cocoa the Akwapim farmers had been brought into contact with a cash economy largely through the sale of palm-oil and the purchase with the proceeds therefrom of basic necessities of life. There was therefore a major incentive for the Akwapim farmers to spread out into forest zones belonging to other states.
14. To illustrate the full force of the operation of this incentive, one could contrast the activities of the Akwapim farmers with the Akims whose forest areas were "invaded" by the Akwapim farmers. The Akims were also farmers, but their chiefs were content at the time to collect a few pounds from the Akwapim chiefs as proceeds from the sale of valuable forest lands, and the Akim farmers were also satisfied for some time to limit their farming activities to the production of food crops on lands within walking distance of the towns. ${ }^{\text {s }}$
15. The development of new areas is still currently continuing. All the new cocoa areas come into this category. Farmers leave their normal places of living to open up the forest areas in order to take full advantage of the economic and social opportunities offered by the cocoa industry. This migratory process was helped in the past and is still being helped by the development of transport and communication, the improvements in the marketing and distributive systems, and direct and indirect government services. These are all factors which enter into the qualitative aspects of the population pressure and help to make it a very forceful element in the development of new areas.
16. Thus far, the discussion has been confined to the development of the virgin forest areas of Ghana, mainly because that has been the outstanding feature of the country's agricultural expansion during the past fifty

[^243]years. However, there are other aspects of the developmental process which must be mentioned because of the increasing importance they are assuming. These are the development and expansion of new townships and the opening up of the previously largely ignored savannah areas.
17. The primary impetus for both of these phenomena has been the rapid population growth in Ghana during the past fifty years. African cities and towns, in general, hold a relatively small segment of the total population, and in this, Ghana is no exception, but all the available evidence seems to indicate that the proportion has been rising very rapidly during the past few years. The reasons for this are primarily economic. Most African Governments have not been satisfied with their traditional role of merely being suppliers of raw materials to the advanced countries, and there have been increasing attempts to diversify the economy by establishing manufacturing industries and developing mineral resources. The needs of industrialization-such as availability of raw materials, easy access to ports and markets, labour, power, etc.-have resulted in the growth of towns and cities at an increasingly rapid rate. In Ghana, for example, the annual rate of growth for Accra and Kumasi (the two cities of over 100,000 population) was 8 per cent between 1948 and 1960. The comparable figure for the period 1931 to 1948 was 5.2 per cent). Towns with a population of 10,000 and over had an annual rate of growth of only 2.9 per cent between 1931 and 1948, but between 1948 and 1960, the annual rate of growth rose to 6.4 per cent.
18. It is not only industrialization which has led to this rapid development of towns. Rather, industrialization may be better described as the "pulling" factor which causes the inflow of migrants into the towns, but there are also powerful "pushing" factors which send people away from the agricultural or rural areas. Even though it was stated above that the development of the forest areas is still going on, it is obvious that there is a limit to this expansion and in certain areas at least, the exhaustion point is being approached; this means that new areas must be sought for development. Moreover Ghanaian cocoa is no longer fetching the high price which it formerly commanded on the world market. The current low return the average farmer gets for his investment means that the principal motive for the development of the cocoa areas is weakening, and more and more farmers, especially the younger educated
generation of farmers' sons, will turn to new areas. This pressure on the young generation to move out of the farming areas into new areas is now evident, and there is a continuous drift of people from the rural areas into the towns and cities.
19. Obviously, this movement has some very far-reaching implications which no Government can ignore. There are bound to be acute social and economic problems, and the Government will have to cope with some very serious. administrative problems, i.e., the provision and maintenance of adequate services in such basic areas as housing, medical facilities and employment.
20. Another aspect of the developmental process which must be briefly mentioned is the opening up of savannah areas in response tothe country's increasing agricultural requirements. The Ghanaian population is credited with a very high rate of increase and if the present rate continues, it may well double by 1985 or 1990 . How will this increasing population be settled and fed? It is now apparent that the current agriculture of Ghana, which still consists largely of subsistence farming, is inadequate to meet the food requirements. While more and more people are leaving thefarms for the towns, methods of farming have not changed significantly. One way of meeting this problem is to open up the flat savannah areas, which have so far been ignored because the inadequacy of rainfall makes them largely unsuitable for peasant settlement. On the other hand, because of their relative flatness and the absence of large trees, they are much more amenable to the use of such modern farming techniques as mechanization and irrigation.
21. The savannah areas are thus potentially areas of great agricultural expansion, and the possibilities in this field have been amply demonstrated by the increasing number of state and co-operative farms which are springing up. all over the country. This type of development undoubtedly requires considerable human and financial resources, and the limiting factor in the development of these areas will be the ability of the Government to provide the necessary resources.
22. Although examples have been drawn from only Ghana to illustrate the pull which population pressure can exert on the development of new areas, the general line of argument is applicable to many developing countries. To conclude, it may be said that under certain conditions the population pressure could result. in general economic development.

# The future of the population and the food supply of India 

V. G. Panse and V. N. Amble

1. With the second largest population in the world (439 million in 1961), India faces the twin problems characteristic of developing countries, viz., a high rate of population growth and a slow development of agriculture. A third problem peculiar to India is its large and uncontrolled bovine population. An attempt is made in this paper to discuss briefly the prospects for the human population and its nutrition in the foreseeable future, i.e., for a period of fifty years from 1961 to 2011, as a result of the interaction of these three factors. For obvious economic reasons and a widely prevalent religious sentiment against meat, especially beef, Indian agriculture must continue to be crop-oriented. Milk is the only source of animal protein essential for human nutrition which is universally acceptable in the country. Additions to this source will have to come from fish and from small animals-pigs and poultry, which can feed on crop residues. Any substantial increase in these sources is also a distant prospect.
2. The land resources of India and their current uses are given below (in millions of hectares) for the triennium around 1960/61: (a) total geographical area, 326; (b) forests, 56; (c) barren and unculturable land, 34 ; (d) land put to non-agricultural use, 14; (e) culturable waste land, 19; (f) permanent pastures and grazing, 14; (g) tree crops and groves, 6; (h) old fallow, 11; (i) current fallow, 11; (j) net area sown, 133; ( $k$ ) gross area sown, 153; and ( $l$ ) area sown more than once, 20.
3. While the bulk of additional production in future must come through increased productivity of land, there is some scope for expanding the area under cultivation, partly by breaking waste land and partly by cropping land more than once (double cropping). That this scope is real is seen from the experience of the first two Five-Year Plans (1951 to 1960), during which the greater portion of increased agricultural production resulted from the latter source than from increased productivity of land. New land must not, however, be brought under cultivation indiscriminately, since along with agricultural crops, there must also be increased
production of timber and other forest products, and of livestock products like milk and wool. Careful ground surveys need to be made to allocate land for optimum use. With regard to bringing new areas under cultivation, this paper is concerned only with the waste land listed above in (e), ( $h$ ) and (i), which total 41 million hectares. Grouping the 320 districts into which the country is divided, into five main agro-climatic regions, viz., Himalayan region, northern plains, coastal region, peninsular region (black soil) and peninsular region (red soil), the authors have examined the normal annual rainfall and the current extension of irrigation in the individual districts comprising each region. It has thus been estimated that out of the waste land available, 15 million hectares can be brought under the plough, leaving up to 10 per cent of the waste land for other uses. A similar examination of the extent of double cropping in the various districts of each region has led to the estimation that the area under double cropping could be increased by 18 million hectares through the adoption of suitable measures. Assuming, generally speaking, that the extension of cropped area under these two categories is distributed among the various crops in their current proportions, 17 million tons would be contributed to the production of food-grains, i.e., cereals and pulses.
4. Water is an agricultural resource as essential as land and India is fortunately well supplied with it through rainfall. Only 7 per cent of the districts have an annual rainfall of less than 51 centimetres. About 20 per cent of the districts have a rainfall between 51 and 76 centimetres, while 42 per cent have a rainfall of 76 to 127 centimetres and the remaining 31 per cent over 127 centimetres. Thus, rainfall is plentiful for nearly three fourths of the land area. Today most of the rain, which comes down in a comparatively short rainy season, flows off to sea, causing, in its way, damaging floods in several areas. A most essential requirement for increasing agricultural production in India, whether by extension of area under crops, by irrigation or by the use of
fertilizers, is to control this vast bulk of watersupply by suitable conservation measures, such as dams across streams, contour terraces and bunds, proper drainage, etc., and thus make it available directly or indirectly for growing crops in different seasons. A gross area of only 32 million hectares was irrigated at the end of the Second Five-Year Plan, but the potential for irrigation is estimated at 76 million hectares. Detailed surveys would undoubtedly show that this potential could be raised and the authors are assuming a potential of 81 million hectares gross, which they believe to be conservative. When this potential is achieved, one may expect an additional production of 21 million tons of food-grains, apart from the proportionate increase in other crops. The potential for contour bunding and terracing is put down as 49 million hectares, out of which only a little over 1 million hectares was covered by the end of the second Plan. The additional production of food-grains expected from this programme, together with associated farming practices, is about 7 million tons. Direct irrigation or indirect measures for conserving soil moisture would not only give an increased crop yield, but would also increase the efficiency of fertilizer use. In fact, water-supply and the use of fertilizers have to be treated as complementary measures. The widest possible use of fertilizers is, in the author's view, the most important single contributory factor for raising the agricultural production in India. Data are being collected on the responses of various crops to fertilizers, with and without irrigation, under actual farming conditions in a countrywide programme. With the help of the results already available, it is possible to project with some confidence the maximum increase in production that can be secured from nitrogen and phosphate with the current agricultural practices. For food-grains, this figure is about 75 million tons, which is of the same order as the actual production of these crops ( 80 million tons) at the end of the Second Five-Year Plan. Requirements of abotit 8 million tons of nitrogen and 6.5 million tons of phosphorus $\left(\mathrm{P}_{2} \mathrm{O}_{5}\right)$ are calculated for all agricultural crops. When crop varieties which are especially responsive to fertilizers are developed, the increase in production can be stepped up further. Currently, however, maize is the only crop for which such seed appears likely to become available, and this has been taken into account by adding about 2 million tons to increased production. An important recent introduction in Indian agriculture is the chemical control of pests and diseases of crops. This programme is in its infancy, but an
increase in crop yield by 10 to 15 per cent from this source is not an unrealistic estimate. Chemical protection of crops will be accelerated as the use of fertilizers increases, but the expected gain in production from this source has not been calculated, as it can be offset against unavailability of an estimated 12.5 per cent of food-grain production for human consumption through use as seed, cattle feed and losses in storage, transport, etc. Thus, there is a reasonable potential, as far as current technological knowledge goes in the context of Indian conditions, of an additional availability of 122 million tons of food-grains for human consumption, over the corresponding figure at the end of the Second Five-Year Plan, or a total availability of 192 million tons. With improvement in agricultural technology, this figure is likely to be raised further by some margin. The authors believe that the necessary effort for achieving this availability will be made both through conscious planning and through increasing pressure of population. Both factors are already significant in contributing to greater agricultural production.
5. On the question of population growth in India, the authors agree generally with the position taken by Coale and Hoover in regard to the likely course of mortality and fertility rates in developing countries with low income. ${ }^{1}$ They show that even under these conditions, mortality can decline relatively rapidly and at a low cost, with the help of antibiotics, public health services and sanitation. Fertility, however, takes longer, is more difficult to control and is related to the standard of living. There is consequently a considerable time lag between the decline of mortality and fertility. With the current low level of availability of public health services, the extremely poor state of sanitation in rural India (where the bulk of the population resides), the incidence of malnutrition in an appreciable fraction of the population and the lower limit to mortality imposed by the subtropical conditions, it is difficult to imagine that mortality rates as small as those prevalent in western Europe or North America will be attained in India during a foreseeable future. Considering the prevalent mortality rate in India of 19.4 and examining this figure in countries similarly situated, the authors believe that a reduction in mortality rate to a level below ten would be unrealistic and would rather place it between eleven and twelve. With a high infant mortality, the economic necessity of bearing many children so that some may

[^244]survive, and of having large families to provide the much-needed manual labour for a peasant agriculture has turned into a traditional belief against any kind of birth control. For every girl, the chief aim is to marry and raise a family, and social prestige is attached to women with several children. In this situation, much sustained effort on the part of the public authorities by way of propaganda, education and action in the rural areas must be forthcoming before any sensible impact can be made on the current fertility level. This activity is now confined mainly to some urban areas and has influenced only the educated urban population to some extent, but this population is practically an insignificant fraction of the total Indian population. Therefore, the authors of this paper agree with Coale and Hoover that there is no possibility of any downward change in fertility for at least a couple of decades, i.e., up to 1981. The census results for 1961 strengthen this view, as the actual population in 1961 surpassed all earlier projections, including that of Coale and Hoover. In the hope
that public action for family planning and other contributory economic factors will develop sufficiently to begin influencing fertility towards the end of this period, it has been assumed that from 1981 onwards, fertility will decline linearly over the following thirty years to half its current level. With these two assumptions concerning mortality and fertility rates, the Indian population has been projected over five decades, beginning from 1961.
6. Details of these calculations will be published elsewhere. Beginning with the Indian life tables for 1951 to 1960 (based on the 1951 and 1961 censuses), an annual increase of 0.5 year in the expectation of life at birth was assumed until this expectation reached about fifty-five years. By utilizing United Nations model life tables (1956) for interpolating agespecific mortality levels and corresponding survival ratios, the expected quinquennial population was estimated. The projected values for population and its more important features are shown below:

|  | 1961 | 1966 | 1971 | 1976 | 1981 | 1986 | 1991 | 1996 | 2001 | 2006 | 2011 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Population (millions) | 439 | 490 | 551 | 625 | 713 | 811 | 910 | 1010 | 1107 | 1197 | 1275 |
| Growth rate (per cent). | 1.98 | 2.20 | 2.39 | 2.55 | 2.67 | 2.62 | 2.33 | 2.09 | 1.85 | 1.58 | 1.28 |
| Fertility | 195 | 195 | 195 | 195 | 187 | 171 | 154 | 138 | 122 | 106 | 98 |
| Death rate | 19.4 | 19.1 | 16.9 | 15.3 | 13.8 | 12.4 | 12.2 | 12.1 | 12.0 | 11.9 | 11.8 |

In the course of fifty years, the population would be nearly trebled. The growth rate of population, high as it is already, will rise still further to a peak value of 2.67 by 1981, in spite of a steadily declining mortality, and will start going down when fertility begins to decline.
7. According to the livestock census in 1961, the total number of bovines in the country was 227 million, comprising 176 million cattle and 51 million buffaloes. Among the three categories of animals, viz., adult males, adult females and young stock, cattle included the largest number of adult males, viz., 73 million, while among buffaloes, adult females formed the largest number, 25 million. In the absence of any kind of vital statistics for livestock, as well as for any reliable long-term trend in their numbers, it is extremely difficult to project with confidence the number of bovines over five decades. However, this has been done by taking into account the growth rates of different categories of animals among cattle and buffaloes between the latest two quinquennial livestock censuses for 1956 and 1961. These two censuses were both accurately
done and had a nearly complete coverage. The calculated growth rates ranged from 17.0 for adult females to 22.4 for adult males among cattle, and from 22.8 to 33.8 for these two categories of animals among buffaloes. If these growth rates persisted in the future, the livestock population in the year 2011 would be 766 million, comprising 552 million cattle and 214 million buffaloes. Taking into account all animal feeds, crop residues, grains and other concentrates, fodder and grazing that are estimated to become available by that time, it would appear impossible to feed this vast number of livestock at the current levels of feeding, inadequate as they are, and the result would be that the current per capita availability of milk, about 120 grammes per day, would be reduced to 86 grammes. The alternative of growing sufficient fodder to maintain even the current level of feeding for these numbers also appears an impossible proposition, as it would mean diverting a prohibitively large proportion of irrigated land to fodder production. The only feasible solution would be to control the number of livestock in such a manner that they are put to efficient use and can be fed
adequately with available resources. Male livestock currently is used for draft in cultivation and transport, and there is, on an average, one pair of adult bovine males to every 3.4 hectares of cultivated area in the country. According to the numbers projected for the year 2011, there would be a pair for every 1.1 hectare of the cultivated area. Considered against the reasonable requirement of a pair of male animals for 4.05 hectares of land, the number of males in the livestock population by 2011 would be enormously in excess of the requirement. If a pair were maintained for 4.05 hectares, the number of adult males could be reduced from 248 million to 65 million in cattle and from 43 million to 11 million in buffaloes. The corresponding saving in livestock feed would enable cows and buffaloes to produce enough milk to make 240 grammes per capita available per day. The modest nutritional standards aimed at for the Indian population include an availability of 200 grammes of milk per capita per day. The necessity of maintaining a large number of male livestock can be further reduced by gradually introducing mechanization in Indian agriculture and, to the extent that mechanization made progress, the available feed could be diverted to the improvement of milk yield, thereby raising the available quantity to a still higher level.
8. The food supply available for human consumption at the end of the Second FiveYear Plan was not adequate to meet the modest nutritional requirements of the Indian population, as recommended by the Indian Nutrition Advisory Committee. ${ }^{2}$ For the population of 439 million in 1961, the per capita availability was calculated at 2,033 calories and 51.8 grammes of protein per day, against a physiological requirement of 2,128 calories and 61 grammes of protein. ${ }^{3}$ Allowing for wastage of food and uneven distribution among the different economic groups of population, the retail requirement was 2,370 calories and 67 grammes of protein, according to Sukhatme. ${ }^{4}$ The available supply thus represented a shortage of 14 per cent of calories and 22 per cent of protein. In the course of fifty years it is estimated that the population will increase 2.90 times, while the available food supply can be raised 2.74 times, if the full potential of increased agricul-

[^245]tural production, as it is currently seen, can be realized. The population structure will also alter, so that there would be a somewhat larger proportion of adults as compared with 1961 ; the nutritional needs of this population would also be slightly greater. Thus, the gap between availability and requirement of food would widen further. The retail availability for the population of 1,275 million in the year 2011 was calculated at 1956 calories and 50.4 grammes of protein per capita per day, which would fall short of the retail requirement of 2,425 calories and 66 grammes of protein by 19 per cent and 23 per cent, respectively. A particularly serious aspect of this deficiency is that the supply of milk, which is an essential source of protein, would be depleted to three fourths of its current availability (which is itself subnormal), if the cattle population continued to grow unchecked. The Indian population thus faces the grim prospect of being condemned to a permanent state of undernutrition and malnutrition, with the attendant deterioration of labour productivity and of the entire national economy.
9. To avert this catastrophe, vigorous action must be taken along three broad lines. The first and foremost is to increase agricultural production speedily with the help of programmes concentrated basically on the extension of irrigation and other moisture conservation measures, the maximum use of fertilizer and the provision of incentives to farmers to produce more. Such incentives would include guaranteed prices for agricultural commodities, reduced cost of fertilizers and other inputs, and the elimination of share-cropping and other harsh tenancy conditions. If the potential for production of food-grains (and other items of food) that have been visualized were to be fully attained in the next twenty-five or thirty years, the available food supply would provide a modest standard of nutrition to the population of 980 to 1,000 million that would exist at that time. This would help to increase labour productivity in various fields, create a more hopeful outlook on life in the population and make it receptive to ideas and programmes for raising the standard of living, including the limitation of family size. If, on the other hand, hunger were to persist and possibly to be aggravated, all other programmes will be of no avail. The second line of advance must be progressive mechanization of all agricultural processes. Male livestock, which is practically the only source of power for agriculture today, forms the largest proportion of the total bovine population and consumes a substantial proportion
of the livestock feed. By first rationalizing the numbers of male livestock required for agriculture and transport and then replacing them gradually by mechanical and electrical power, a large stock of livestock feed could be diverted for conversion into milk, thereby significantly increasing the availability of a vital ingredient in the diet of the Indian population. Mechanization would have another equally important effect. By replacing the large amount of manual labour required for current agriculture by machines, the incentive to raise large families to supply this labour would weaken and thus help population control. The third line to be adopted is direct propaganda and action for control of population through family planning in rural areas. The magnitude of this task
needs to be comprehended, since family planning will make an impact on population growth only when the idea and the means reach the vast rural population scattered in more than half a million villages. Maternity and child care must be the spearhead of this programme, because only when women see that the children they produce can be raised as healthy individuals without the frequent risk of their dying in infancy, will the urge for procreating too many children cease. The authors believe that action along these lines will be accelerated and, with further advances in technology and their application, it is not yet too late to hope that the population of India can look forward to a fuller and richer life in the foreseeable future.

# Population, land resources and agricultural growth 

S. R. Sen

1. The relationship that exists between population, land resources and agricultural growth (which is a large contributor to economic growth, especially in developing countries) has been a subject of sharp controversy ever since Giovanni Botero posed the problem towards the end of the sixteenth century. Two centuries later Malthus thought that he had found a "scientific" answer to the problem. Another century-and-a-half have passed since then and it is now generally admitted that Malthus was not so scientific after all. But the end of the controversy is not yet in sight. While there are still strong adherents of the view that in the final analysis, the increase of population in relation to land resources leads to diminishing returns and hence slows down agricultural growth, there are equally strong proponents of the opposite view that pressure of population induces innovations and better and more intensive use of land resources, thus helping to promote agricultural growth,
2. The rate of economic growth (including agricultural growth) depends on the rate of development of the human as well as the material factors and this in its turn is largely dependent on the rate of saving and investment in the economy. Other things remaining the same, if population grows at a fast rate, consumption increases correspondingly. Therefore, saving and investment are adversely affected and this tends to slow down economic growth. This has happened in certain of the developing areas of the world where the rate of growth of population has been high and technological progress slow. On the other hand, there have been other developing areas with relatively sparse and stagnant population, and ample land resources where the rate of agricultural growth (and of economic growth) has been very slow because the manpower was not adequate, either in number or in efficiency, to exploit appropriately the land resources available and produce the saving needed. But there also have been areas where the fact that the rate of population growth was relatively high and the density of population per hectare heavy prompted the people to strive for a high rate of
economic growth. The challenge posed by population pressure led them to exercise all their ingenuity to develop the available land and other resources. The spread of education and the development of science and technology helped the development of the human factor by improving technical knowledge and skill and by controlling disease. In particular, where the higher rate of population growth was brought about through a relatively lower death rate (as compared with the birth rate), improved health standards and a longer expectation of life (especially for those who comprised the working force), it meant that a larger fraction of the life span of the average individual could be devoted to productive activity. Not only were the workers healthier and therefore more efficient, but also the investment made to build them up yielded results over a longer period.
3. The development of science and technology also made it possible to step up considerably the productive potential of the limited land resources available to mankind. In the past, land had to provide both standing-room and nutrients to plants. Now factories are producing an increasing proportion of the nutrients so that land is being called upon more to provide standing-room for plants and less to provide nutrients. This means that much higher production from a limited area of land is now technically feasible. In the last century, population pressure was much less than what it currently is and yet famine was quite common in most of the countries. In spite of the large increase in population, there is considerable surplus of food today in America and Oceania, while Europe is fast approaching a stage of surplus in spite of its dense population. The problem of food shortage is faced today primarily by the developing countries, especially those of the Far East and the Near East. The difficulties posed by low productivity of land and shortage of food seem to be faced more by the developing countries which have failed to respond adequately to the challenge of development, than by the developed countries where the density of population is high. Although there has been a sharp increase in population
in recent years and there is today less than half a hectare of cultivated land per capita in the world, science and technology have already made it possible to step up food production from this limited area several times more than what was considered feasible earlier. Boyd-Orr estimates that an eight-fold increase in food production is possible on the basis of existing technical knowledge; Colin Clark's estimate is even higher, viz., ten-fold. Science is opening up new vistas every day and there are hopeful predictions of further technological breakthroughs. However, if there is to be no serious fear of food shortage for some time to come, as a result of population growth, the developing regions must apply currently known techniques to achieve the level of productivity reached in such countries as Japan through such applications. It is interesting to note that in Japan the improvement in agricultural productivity has been brought about more through improvement of technology than through the increase in inputs. Between 1880 and 1938, agricultural production in Japan rose by 150 per cent while inputs rose by only 30 per cent. This trend has not only been maintained, but even improved upon in recent years.
4. The reason for the slow rate of agricultural growth (and for that matter of economic growth), which is currently being faced by most of the developing countries, is then to be sought less in the high rate of growth of population or in the limited availability of land resources, and more in the fact that because of various constraints these countries have not been able to make effective use of science and technology for the development of their population, as well as their land resources. These constraints apply at different levels-family, village, district and state-and are of various kinds-operational, sociological, economic and political. The key to development lies in identifying these constraints
at different levels and taking appropriate measures for removing or reducing them. The bulk of the effort has no doubt to be at the local and national levels, but international action can be also of considerable help. At least until these countries reach the so-called take-off stage, international action for the transfer both of technical knowledge and capital from the developed to the developing countries and of food-stuff from surplus to deficit areas, can help in overcoming or reducing many of these constraints.
5. Although, from a purely technological standpoint, there may be considerable prospects for agricultural development in most of the developing countries and increasing efforts may be made both at the national and at the international level for removing some of the constraints referred to above and to step up the rate of investment for the development of the human as well as the material factors, there is likely to be wide disparity in the rate of agricultural growth and level of economic development in different developing countries for a long time to come. Even with the same population situation or land situation, or both, different areas may achieve quite different rates of growth under the same kind of development effort. And where the development effort itself is of a different kind, the disparity is likely to be much greater. The passibility of widely disparate rates of growth and the serious stresses and strains which may result therefrom require special study by all those who are interested in the problem of economic development.
6. Some of the problems posed above may be illustrated from the experience of India with which the author is familiar. The population situation in the republic of India since the beginning of this century may be seen from table 1:

Table 1. Total population and birth, death and growth rates, 1901-1961

| Year | Population (millions) | Estimated tates in the following decennium |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Birth rate (per thousand) | Death rate (per thousand) | Compousd rate of growth per annum (percentage) |
| 1901. | 238.4 | 52.4 | 46.8 | 0.52 |
| 1911. | 252.1 | 48.1 | 47.2 | (-) 0.03 |
| 1921. | 251.3 | 50.8 | 40.4 | 1.05 |
| 1931. | 279.0 | 46.2 | 33.5 | 1.28 |
| 1941. | 316.7 | 43.1 | 30.0 | 1.32 |
| 1951. | 361.1 | 40.4 | 20.9 | 1.98 |
| 1961. | 439.2 | - | - | $\cdots$ |

7. The rate of growth of population was relatively low, the mortality rate relatively high and the average expectation of life relatively short until 1951, when India launched its First Five-Year Plan for economic development. During the pre-plan period, the rate of saving in India was of the order of 5 per cent and the rate of increase in national income was ustally less than 1 per cent. Since the annual growth of population during the period hap-
pened to be no smaller, pre-plan India had an essentially stagnant economy, if not worse. Before 1920, both population and agricultural production were growing at a very slow rate, as may be seen from table 2. During the next thirty years, while population growth was considerably accelerated, agricultural growth tended to lag behind, largely because no special effort was made to remove the constraints which were inhibiting agricultural production.

Table 2. All-India annual compound rates of growth of agricultural production and population, 1900/01 to $1960 / 61$
(Percentage)

| Period | Increase in agricultural production | Increase in cultivated area | Increase in productivity | Increase in population |
| :---: | :---: | :---: | :---: | :---: |
| 1900/01 to $1919 / 20$ a | 0.53 | 0.29 | 0.24 | 0.25 |
| 1920/21 to 1939/40 ${ }^{\text {a }}$ | 0.20 | 0.24 | (-) 0.44 | 0.83 |
| 1940/41 to 1949/50 ${ }^{\text {b }}$ | (-) 0.97 | 0.66 | $(-) 1.63$ | 1.32 |
| 1950/51 to $1960 / 61$ b | 3.52 | 1.18 | 2.34 | 1.98 |

a Data for undivided India.
${ }^{6}$ Data for the republic of India.
8. As a result, however, of the programme of economic development which India initiated in 1951, its net national income increased at a compound rate of 3.56 per cent per annum and agricultural production at a compound rate of 3.52 per cent per annum between 1950/51 and $1960 / 61$. The consequent improvement in health facilities and in standard of living led to an annual growth of population by 1.98 per cent during this decade, compared with 1.32 per cent in the previous decade. This sharp increase in the growth of population no doubt meant that the increase in per capita income was less than it might otherwise have been. Nevertheless, per capita income (at 1948/49 prices) went up from Rs. 247.5 in 1950/51 to Rs.293.7 in 1960/61, i.e., by an annual compound rate of 1.74 per cent. Instead of having a stagnant economy, where the rate of economic growth is about the same as that of population growth, India has now reached a situation when the former is nearly twice the latter. The rate of growth of agricultural production is well ahead of that of population. The daily foodgrains supply per capita has increased from 13.5 ounces in 1951 to 16.2 ounces in 1961. The expectation of life at birth has gone up from thirty-two to forty-one years and this has been both a result and a contributory factor of economic growth. The rate of saving, another indicator of economic growth, has gone up from 5 per cent in $1950 / 51$ to 8 per cent in 1960/61.
9. The plan of economic development in India included a massive programme for agricultural as well as industrial development. The programme for agriculture comprised, inter alia, irrigation, soil conservation, land reclamation, increased use of improved seeds, plant protection materials and chemical fertilizers, and a number of ancillary measures like extension, education and research. The total outlay on the agricultural and irrigation programmes amounted to about Rs. 10,000 million during the first two plans. As a result, during the ten-year period ending 1961/62, agricultural production increased at a compound rate of 2.94 per cent per annum at the all-India level. The area under crops increased at the rate of about 1.25 per cent per annum, while agricultural productivity per hectare increased at the rate of 1.67 per cent per annum.
10. Within this over-all picture, however, there is considerable disparity from area to area, and this has taken place in spite of the fact that the nature and magnitude of the development effort, including the policies and programmes, have been more or less similar throughout the country.
11. The point may be illustrated by table 3, which summarizes the experience of fourteen major states of the country for which comparable data are readily available. At the two extremes are Rajasthan and Kerala. In Rajasthan, the pressure of population is the

Table 3. Annual compound rates of growth of agricultural production, cultivated area, productivity and population, 1952/53 to 1961/62
(Average $1952 / 53$ to $1954 / 55=100$ )


[^246]lowest; and in Kerala, it is the highest. In both states, production has just been able to keep pace with population. But in Rajasthan, there has been an actual fall in productivity and the increase in production is entirely due to increase in area. In Kerala, the increase in production is shared almost equally by increase in area and increase in productivity. In Punjab, where the rate of growth of agricultural production is the highest, it is more than double that of population. Here area and productivity are almost equally responsible for the increase in production. On the other hand, in Madras, where the rate of growth of productivity is the highest, the density of population is over double that of Punjab and the rate of growth of population is less than half that of the latter; the rate of growth of production is four times as high as that of population. Although these two states are at two extreme ends of the country and have the highest rates of agricultural growth, in one case the rate of growth of population is very high, while in the other the density of population is very heavy. Yet both have done well in their own ways under the stimulus provided by the national plan of economic development. Maharashtra, Gujarat and Madhya Pradesh have the same density of population and yet, in the first, which is more industrialized, the rate of growth of produc-
tivity has been substantially higher. In the three states of Bihar, West Bengal and Assam, which are in the Ganges-Brahmaputra basin and for which region a four-fold increase in agricultural production was considered quite feasible in a detailed study made by an expert team appointed by the Food and Agriculture Organization, the rate of growth has been rather low. Of these three states, the performance of Bihar and West Bengal has been relatively better than that of less-industrialized Assam, in spite of the fact that the latter has many modern, large-scale plantations. In Uttar Pradesh, Andhra Pradesh and Orissa, which are predominantly agricultural, growth of agricultural production has been very slow.
12. The main point that emerges from this rather superficial comparison of the relationship between population, land resources and agricultural growth in different states of India is that there is no unique relationship between the three, even when the policies are the same and the effort for development is more or less uniform. In some cases, the land area may appear to be sufficient; and yet, if it is subjected to severe physical and socio-economic constraints, it may not easily respond to efforts for development. In certain areas where land area is very limited, if the situation is such that
more input and better human skill could be applied, it could yield much better results. The main point here is to what extent the physical and socio-economic constraints may be removed and the productivity of soil improved through the application of science and technology. Similarly, the absolute number or density or rate of growth of population may not, in itself. influence production in the same way. Even if the poptulation pressure is small and the rate of growth slow, if the people lack necessary skill, education, tools and incentive, they may not succeed in improving the rate of growth. On the other hand, a population with high density, as well as high rate of growth, may
react to the challenge of development in a positive manner, so as to make full use of the results of science and technology, and wrest substantially larger yields from the limited land resource available to it. It is, therefore, important that the problems of each area should be studied carefully and specific measures taken to improve the quality of the land or the quality of the workers, so that the rate of growth could be optimized. No general pattern of development can be prescribed for all areas nor any general hypothesis formulated in regard to whether population growth, in itself, is a limiting or stimulating factor for agricultural and economic growth.

# Prospects of agricultural development in connexion with population growth 

M. M. Sokolov

[Translated from Russian]

## I

1. In mid-1962, the earth's population was 3,150 million, having increased by a million in the course of a year. According to United Nations estimates, the total will be 5,000-7,000 million by the year 2000. Will agriculture on earth be able to produce enough food for the inhabitants of our planet?
2. Two opposing answers to this question are offered in the literature on the subject. One group of ideologists is made up of the neoMalthusians, who hold that the earth's population is increasing too rapidly and has already reached a level at which it cannot feed itself. This group includes such people as W. Vogt and E. Pendell in the United States, C. Darwin and C . Darlington in the United Kingdom, A. Vogel in the Federal Republic of Germany, and P. Reboud in France. The second group consists of humanistic, progressive scientists who are fighting to preserve and enrich life on earth. It includes such figures as J. D. Bernal, L. Prasolov, D. Pryanishnikov, W. Williams, F. Baade and J. de Castro.
3. After the Second World War and the crushing of fascism, an intensified effort was made in many countries to propagate Malthusianism. In the United States, the United Kingdom, France, the Federal Republic of Germany, Japan and elsewhere, there have recently appeared a great many books and articles which refer to the danger of population growth and the crisis in vital resources. Not only economists and philosophers but also representatives of many of the natural sciences are active in propagating Malthusianism.
4. All Malthusians pursue the same aim. They are alike in acting as apologists for the capitalist system and in attempting to show that that particular social order is the most viable one. They are all bent on proving that there are chosen races which form a "creative minority" in contrast to the grey majority. The "creative minority," they believe, has been summoned by fate to rule over the majority. They openly take an arrogant, contemptuous
attitude towards the majority of the people who produce all material values on earth.
5. All Malthusians accept the law of diminishing soil fertility. They attribute the world's food shortage to two fatal causes: the law of diminishing fertility and the shortage of land suitable for cultivation. Hence, they contend, agricultural production cannot be increased either by raising yields or by bringing new land under cultivation. The Malthusians did not, of course, discover the law of diminishing soil fertility. It was first formulated in the eighteenth century by the physiocrat Turgot and was later put to extensive use by David Riccardo in his theory of differential rent. Malthus seized upon the law and made wide use of it as the basis for all the theories he developed in defence of capitalism.
6. Progressive scientists have exposed the anti-scientific nature of Malthusianism; they have shown that there is no absolute law of population and that the difficult position of the working masses under capitalism is the result of exploitation. Contemporary reactionary scientists and apologists for capitalism are again attempting to revive Malthusianism as a political theory and an ideological weapon in the struggle against the working class. Classconscious workers firmly repudiate Malthusianism. Far from perishing, the working class is growing and becoming stronger; it is being drawn closer together and tempered by battle. V. I. Lenin, the founder of the world's first socialist State, wrote that class-conscious workers will always wage a merciless struggle against attempts to impose this reactionary, cowardly theory on the most advanced, most powerful contemporary social class-the class which is most ready to initiate great changes.
7. Kar Marx, the brilliant thinker and founder of scientific communism, gave a great deal of attention to the problems of soil productivity. He pointed out that contemporary advances in chemistry and their application in agriculture invalidated the old notions about soil fertility. Fertility was not a natural
property of the soil, as was customarily thought, but was wholly dependent on social relationships. Armed with modern technology, man was increasingly taking a hand in the biological processes of the soil; by introducing larger and larger quantities of mineral and organic fertilizers into the soil, he was increasing its productivity and making it possible for soil nutrients to be assimilated by plants to the greatest possible extent.
8. Many prominent scientists currently active in biology, agriculture and other fields in various countries reject the anti-scientific fabrications of the Malthusians and their misanthropic ideology. On the basis of estimates of soil resources in various countries, L. I. Prasolov, the noted Soviet soil scientist and member of the Academy of Sciences, found that a great deal of land was still unused. According to his estimates, the total land area of the earth is 149 million square kilometres. Of this total, 12.5 per cent comprises the most fertile plain areas, 36.4 per cent intermediate plain areas (forest and dry steppe areas), 11.8 per cent mountain pastureland and forest areas, and 8 per cent desert areas, southern steppes and tundras in which agricultural activity is possible. A total of 10,000 million hectares, or 70 per cent of the earth's land surface, is suitable for agriculture. At present, only 1,000 million hectares, or even somewhat less, is being used for agriculture and horticulture.
9. In modern times, the brown forest land of North America and Australia, the red soil of Central and South America, and the black and dark chestnut-colored soil of the Russian and Ukrainian steppes, Siberia, Kazakhstan, the United States, Canada and Argentina are being brought under cultivation. This general process of expansion and redistribution of agriculture has been accompanied by the development of new crops and new forms of agriculture which are the result of socio-economic change and technological progress. On the basis of extensive practical studies, L. I. Prasolov believes that the total area now under cultivation can be increased sevenfold over an extended period. This view is shared by two Soviet soil scientists, A. Sokolovsky, a member of the Academy of Sciences, and Professor V. Kovda. Professor J. D. Bernal, whose book World Without War contains a table showing existing and potential land utilization on the various continents, also believes that the cultivated area can be increased sevenfold over a period of time.
10. Irrigation holds a huge potential for the further expansion of agricultural produc-
tion. At the present time, the earth's total irrigated area amounts to slightiy more than 100 million hectares, or 2.5 per cent of the total desert and semi-desert area. An additional 113 million hectares of desert and 286 million hectares of chestnut-colored semi-desert can be brought under crops through the use of irrigation. It is a well-known fact that the yields obtained from irrigated land are several times as large as those obtained from non-irrigated land in the same area. Existing irrigated land represents approximately 13 per cent of all land under cultivation, but its total yield is 87 per cent of that obtained from all non-irrigated land. Irrigation of the non-irrigated areas would increase the productive potential of world agriculture by a factor of 6 to 6.5 . Great gains can also be made by draining swamps and jungles, which are used for agricultural purposes to a very limited extent.
11. Expansion of the area under cultivation is not the only means of increasing agricultural production. In most countries, this is accomplished mainly by raising crop yields. Boundless opportunities exist for agriculture in this regard. The highest grain yields have been achieved in Denmark and the Netherlands, where the average yield over a period of years has been between 35 and 45 centners per hectare. The long-term yield for wheat in the United Kingdom and the Federal Republic of Germany is 34 centners per hectare, while an average of between 21 and 23 centners for raw cotton is achieved in the Union of Soviet Socialist Republics. These high yields are obtained through the use of large quantities of mineral fertilizers. Egypt, southern Italy and Japan have recorded the highest rice yields, amounting to approximately 50 centners per hectare; the best Italian farms produce as much as 80 centners per hectare. Farmers in the United States corn belt average 35 centners of maize per hectare; outstanding farms achieve yields of between 60 and 80 centners, and record maize crops in the United States have gone as high as 120 . Leading Soviet maizegrowers have achieved very high yields; in 1959, E. Dolinyuk averaged 223 centners of maize per hectare in an area of 105 hectares. An unprecedentedly high rice yield, amounting to 225 centners per hectare in some areas, was achieved in the People's Republic of China in 1958. High crop yields depend primarily on the general level of agriculture, on improved utilization of land and on proper rotation of crops. If these requirements are met, yields can be doubled or tripled over a period of years. That means that under proper conditions mankind will be able in the future to raise agricul-
tural production to levels roughly twenty times as high as those now achieved. That is the reply of world science to the neo-Malthusians' dark prophecies of approaching disaster for mankind.
12. However, agriculture is not the only means by which man's food resources can be increased. The sea is a valuable and inexhaustible source, and only a tiny portion of what it has to offer is now being taken from it. If all these sources are exploited, it will be possible to solve the problem of feeding all the peoples of the world and sustaining not only the earth's present population but a far larger one.

## II

13. During the past decade (1954-1963), the population of the Union of Soviet Socialist Republics rose by 35 million, representing an average annual increase of 3.5 million. As at 1 January 1964, the country's population was 226 million; it will reach approximately 250 million by the end of 1970 and 280 million by the end of 1980.
14. Between 1954 and 1962, while the population was increasing by a factor of 1.2 (by 17 per cent), total agricultural production in the Union of Soviet Socialist Republics rose by a factor of 1.6 (by 61 per cent), with crop output increasing by a factor of more than 1.5 (by 56 per cent) and the output of livestock products by a factor of almost 1.7 (by 67 per cent). With a view to fully meeting the population's requirements for agricultural products, the general long-range plan for developing the national economy of the Union of Soviet Socialist Republics called for increasing total agricultural production by a factor of approximately 3.5 over the next twenty years (the period 1960-1980).
15. Fulfilment of the tasks set for agriculture during the next twenty years will call for tremendous efforts by the entire Soviet people, particularly since agriculture in the Union of Soviet Socialist Republics is carried on under complex, difficult natural and climatic conditions which at the present time must still be taken into consideration. The Soviet Union is, for example, situated in more northerly latitudes than the United States, and some 40 per cent of its territory is within the permafrost area. A large part of the land under cultivation is in areas with a low average annual temperature. Less than 10 per cent of agricultural land in the Union of Soviet Socialist Republics, as compared with more than half of such land in the United States, is situated in areas with an average annual temperature of more than 10 degrees centigrade. Because of
the long winter, the period of vegetation of agricultural crops is shorter in most of the Union of Soviet Socialist Republics than it is in the United States. The autumn and spring frosts which occur throughout our country limit the period of vegetation and the duration of spring sowing and autumn harvest operations. Nearly one fifth of all land under cultivation in the Union of Soviet Socialist Republics is situated in areas in which the frost-free period lasts less than 120 days. Soviet agricultural production suffers substantial losses as a result of frequent droughts; most of the main agricultural areas of the United States are unaffected by droughts. Nearly 40 per cent of our agricultural land has an annual precipitation of no more than 400 millimetres, whereas only an insignificant percentage of all agricultural land in the United States is situated in areas with this level of precipitation. Only 1 per cent of Soviet agricultural land, as compared with more than half of such land in the United States, is in areas with an annual precipitation of more than 700 millimetres. The main grain areas of the Union of Soviet Socialist Republics, especially the southern part of the Ukrainian Soviet Socialist Republic, the Volga region, western Siberia and the Kazakh Soviet Socialist Republic, are subject to frequent droughts. On the other hand, throughout most of the extensive older areas of the United States in the north and south-which, according to the 1954 census figures, account for 80 per cent of all marketable agricultural pro-duction-droughts are unknown. The cold winters experienced throughout most of the Union of Soviet Socialist Republics create problems in animal-breeding. Except in some southern areas, livestock cannot be left in the open during the winter. In the United States, the mild climate simplifies the problem of taking care of livestock in wintertime, and a good deal of pastureland can be used the year round.
16. Of course, advances in science and technology make it increasingly possible to influence natural processes so as to increase agricultural production. However, overcoming these adverse natural and climatic conditions calls for a tremendous added outlay of labour and money.
17. In many parts of the Union of Soviet Socialist Republics, climatic factors sometimes manifest themselves in combinations which are difficult to deal with. In 1963, for example, weather conditions were unusually bad. The winter of 1962-1963 was an extremely cold one in the Union of Soviet Socialist Republics and many European countries. In many parts of
the Union of Soviet Socialist Republics, there were severe prolonged frosts during which the earth was not covered by snow. As a result, large areas sown to winter crops, particularly wheat, suffered total or partial crop failures and had to be resown to spring crops. Moreover, the summer of 1963 proved to be a hot, dry one, particularly during the period of plant vegetation and of the ripening of grain crops. The unfavourable weather conditions extended over a huge expanse of the European part of the Union of Soviet Socialist Republics and
sections of Siberia and the Kazakh Soviet Socialist Republic. As a result, the 1963 harvest was below normal, especially in grain crops. At the same time, record harvests of cotton and other crops were achieved in parts of Central Asia and other southern areas where irrigation farming was practised.
18. The following table shows the present level of production of grain crops and of the principal livestock products as well as the volume of production planned for the next twenty years (1960-1980):

Table 1. Production of grain and of the principal livestock products

|  | Total (in millions of tons) |  |  | Per capita average (in kilogrammes) |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1962 | 1970 | 1980 | 1962 | 1970 | 1980 |
| Grain crops | 148.2 | 230-260 | 290-310 | 669 | 933-1,055 | 1,040-1,110 |
| Meat (carcass weight) | 9.5 | 20-25 | 30-32 | 43 | 82-101 | 109-115 |
| Milk | 63.9 | 115-135 | 170-180 | 289 | 466-548 | 611-648 |
| Eggs (figures for total production stand for thousands of millions; per capita figures are the actual number) | 30.1 | 68 | 110-116 | 136 | 278 | 396-417 |

The implementation of this programme for increasing agricultural production during the next twenty years will call for a further expansion of productive resources in agriculture through the use of intensified methods, the comprehensive application of chemical processes and mechanization as well as a sharp rise in crop yields and animal-breeding productivity.
19. At the present time, the main task facing the Soviet economy is to concentrate resources and efforts on the creation of a highly developed chemical industry so that it will be possible during the next seven years (1964-
1970) to achieve a sharp increase in the production of mineral fertilizers, chemical plantprotection agents and other chemical products for use in plant-growing and animal-breeding. The extensive use of mineral fertilizers opens the way to expanded agricultural production, higher crop yields and increased soil productivity.

The following table shows the output of mineral fertilizers and chemical plant-protection agents provided for under the plan adopted in the Union of Soviet Socialist Republics for the next seven years (1964-1970) :

Table 2

|  | 1963 | 1964 | 1965 | 1970 | $\begin{gathered} \text { Increase for } \\ \text { period } \\ 1083-1970 \\ (\text { per cent) } \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| All mineral fertilizers | 19.9 | 25.5 | 35.0 | 80.0 | 300 |
| (standard types in millions of tons). . |  |  |  |  |  |
| Nitrogenous fertilizers | 8.6 | 10.2 | 15.0 | 30.2 | 250 |
| Chemical plant-protection agents and pesticides (figures stand for thousands of tons |  |  |  |  |  |
| of the active ingredient) | 63 | 79 | 126 | 450 | 610 |

The production of mineral fertilizers is expected to reach $150-170$ million tons by 1980 . More than 42,000 million roubles is to be spent on development of the chemical industry and the comprehensive chemification of agriculture during the seven-year period (1964-1970); of this total, approximately 10,500 million roubles is to be invested in the chemification of agriculture.
20. The Union of Soviet Socialist Republics lags far behind the Western countries in the production of mineral fertilizers and chemical plant-production agents. It is planned to eliminate this gap by the end of the next sevenyear period (i.e., by 1970). Side by side with the increasing application of technology in agriculture, the production of mineral fertilizers is becoming a decisive factor in continued agricultural growth.
21. Mineral fertilizers have heretofore been used primarily for industrial crops (e.g., cotton) ; only on some individual farms and in certain parts of the country have they been used in limited quantities for grain crops. By 1970, roughly half of all mineral fertilizers produced ( $30-35$ million tons) will be earmarked for grain crops. It will be used most extensively on farms in the main grainproducing areas (the southern part of the Ukramian Soviet Socialist Republic, sections of the northern Caucases, the central black earth regions and the Virgin Lands Territory), where it can be employed to the greatest advantage. Gross grain output in the Union of Soviet Socialist Republics rose from 82.5 million tons in 1953 to 148.2 million tons in 1962, for an increase of 80 per cent. This was accomplished both by expanding the area under grain crops (through the opening up of virgin lands) and by raising crop yields. It is planned to increase gross grain output to 230 260 million tons by 1970 by raising crop yields. The use of mineral fertilizers will be combined with the widest possible utilization of all types of local fertilizers, especially manure.
22. In addition, an extension programme for the development of irrigation farming is being prepared at present with a view to increasing the production of grain, cotton and other agricultural products on irrigated land. In 1962, the Union of Soviet Socialist Republics had a total of 9.5 million hectares of irrigated land. According to preliminary estimates, an additional 2.8 million hectares can be brought under irrigation in the next few years in the Central Asian republics, Kazakhstan, the Russian Soviet Federative Socialist Republic
and the Ukrainian Soviet Socialist Republic. By using part of the irrigated land for grain cultivation, it will be possible to achieve an annual increase of some 35 million tons ( 2,000 million poods) in the production of grain crops, especially rice, winter wheat and maize. This will permit the creation of a reserve stock so that a certain quantity of grain will always be available, regardless of nature's whims. Implementation of the grain production programme is considered to be of the utmost importance, since grain production is the essential requirement for the further development of animal-breeding and for attainment of the production goals for livestock products.
23. Action of this kind to increase agricultural production is made easier by the fact that in the Union of Soviet Socialist Republics this production is concentrated in large socialist agricultural enterprises-state and collective farms. History has shown that the position of small peasant farms is a hopeless one, and they are doomed to disappear. In France and the Federal Republic of Germany, the liquidation of these small farms is encouraged by the State.
24. The development of socialist agricultural production in the Union of Soviet Socialist Republics is governed by a unified state plan. Means are available for improving the utilization of land, technology and manpower, which are concentrated in large agricultural enterprises. Objective conditions have been created for the scientific organization of agricultural production not only on each individual farm but on a nationwide scale. Socialist agriculture in the Union of Soviet Socialist Republics makes use of modern technology, a vast army of specialists and an extensive network of scientific research institutions, experimental stations and laboratories. Each passing year witnesses an increase in the number of advanced state and collective farms which attain a high level of quality in their work, and the experience of these farms in organizing production is passed on to the rest of the country's state and collective farms.
25. In the next twenty years ( $1960-1980$ ), by making extensive use of mineral and organic fertilizers and chemical plant-protection agents and by raising over-all agricultural standards, the Union of Soviet Socialist Republics will be able to increase total agricultural production by 250 per cent and that of the principal agricultural products by $100-300$ per cent, while population growth during the same period will amount to 30 per cent.

# Forecasts of nutritional requirements and the expected levels of demand for food 

P. V. Sukhatme and W. Schulte

1. The expected course of population growth over the remainder of this century suggests extremely large increases in food supplies even to maintain current consumption levels over the world as a whole. According to the United Nations medium projections, world population is expected to increase by 19 per cent from 1960 to 1970 , and by 45 and 115 per cent, respectively, by 1980 and 2000. Applied to the current average world diet, these increases in population would call for corresponding increases in food production.
2. In a purely academic sense, these food supplies might be considered adequate if food were distributed according to need-the global average calorie requirement is roughly equal to the average supply, and the present global protein supply is sixty-eight grams per capita per day and that of animal protein, twenty grams which must be considered reasonable by any standard. Distribution has, however, always been a major factor, with the gulf between developing and developed countries widening. In fact, findings of the Food and Agriculture Organization (FAO) show that up to one half of the world population, residing mostly in the developing countries, is underor mal-nourished, while over-nutrition is an accepted fact in the developed countries where surpluses are accumulating. There seems no shortcut remedy to the situation. The only effective solution is to improve the purchasing power of the peoples in the developing countries.
3. Bearing in mind the immediate need to increase the average per capita food supply in the regions now suffering from hunger and malnutrition, food-supply targets have been formulated by FAO as a spur to action and in order that nations may have a measure of the task confronting them. These are shown on a regional basis in table 1 . They are described as short-term, medium-term and long-term targets. They are not sufficient in themselves to overcome the problems of hunger and malnutrition, which, in addition, require appropriate measures to improve the distribution of food
and education in nutritional requirements. The short-term target aims at eliminating undernutrition and at meeting some of the most urgent problems of malnutrition among vulnerable groups of the population. The mediumand long-term targets aim at a progressive elimination of malnutrition, so that by the end of the century only an insignificant proportion of the population will be affected. The longterm target also reflects the additional needs arising from improvements in health and physique which are likely to take place with the attainment of the medium-term target. The short-term target is expected to be achieved by 1970; the medium-term target goes one step further in what must be a continuous effort to achieve improvement in health and physique through better nutrition, looking as far ahead as 1980. The long-term target does not provide any final answer to the problem of hunger and malnutrition, but it gives some idea of the scope for improvement in diet as the problems of poverty and scarcity become less acute; it is relevant for planning purposes, looking as far ahead as the year 2000 .
4. In formulating these targets, the technique of linear programming has been applied in translating nutritional targets (for calories and nutrients) in terms of foods, and care has been taken to ensure feasibility from the technical, as well as the economic and nutritional, points of view. On a per capita level, the recommended increases under the short-term target are 17 per cent for the over-all value of food supplies and 36 per cent in animal products in the developing countries. Under the medium-term target, increases of 32 per cent in the over-all value of per capita food supplies and 78 per cent in animal food supplies are suggested, the corresponding figures for the long-term target being 49 and 120 per cent.
5. If consumption levels in the developed countries were to decrease to the level implied under nutritional requirements, the targets for the developing countries would imply relatively modest increases in the global per capita food supply, on the basis of the existing population.

Table 1. Per capita quantities of major food groups available and required under nutritional targets, together with the calorie and protein levels (retail level)
(Grammes per day)


The depressing effect of the increasing concentration of the world's population in the developing countries on the global per capita food supply, in relation to requirements, would also become more modest. But it is extremely difficult to envisage a net fall in the per capita food supply in the developed countries. Assuming then that the level does not rise, overall increases in per capita food needs for the world as a whole work out at 8,16 and 24 per cent, respectively, under the three targets; and 12, 25 and 39 per cent, respectively, in per capita animal food supplies.
6. Tables 2 a and 2 b show the total increases in regional food supplies suggested by 1970, 1980 and 2000, calculated on the basis of the suggested increases in per capita food supplies and the expected increase in the population. For the developing countries as a whole, these figures imply that to remove hunger and to attempt a modest improvement in the quality of diet to meet progressively the needs of the vulnerable groups, the total food supplies will have to be increased by 43 per cent by 1970, 103 per cent by 1980 and 261 per cent by 2000.

The corresponding increases for the animal food supplies are 66, 174 and 432 per cent. These are minimum increases calling for such special distribution measures as school feeding programmes. In actual fact, however, the usual economic factors may largely continue to determine the distribution of available supplies, and this would call for much larger supplies of food than those set out under the targets. With this in mind, FAO has reached the conclusion that world food supplies will need to be doubled by 1980 and trebled by the turn of the century, in order to provide a reasonably adequate level of nutrition to the peoples of the world.
7. If the increase in national incomes of the developing countries is to be anything like the rate of 5 per cent compound per annum suggested in the current United Nations Development Decade, the demand created for food will be extremely large. Income elasticities for the various food groups which are considered typical of the various regions have been estimated by FAO. These show a general tendency to decline as the general level of income

Table 2a. Index of needs in total and animal food supplies for the developing regions, for the developing countries and for the world as a whole
$(1960=100)$

| Region | Total food |  |  | Animal food |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1970 | 1980 | 2000 | 1970 | 1980 | 2000 |
| Far East | 143 | 210 | 386 | 163 | 296 | 621 |
| Near East | 146 | 185 | 295 | 184 | 232 | 370 |
| Latin America ${ }^{\text {a }}$ | 145 | 195 | 345 | 169 | 225 | 396 |
| Africa | 133 | 163 | 272 | 166 | 203 | 398 |
| Developing countries. | 143 | 202 | 361 | 166 | 274 | 532 |
| World | 129 | 168 | 267 | 133 | 181 | 299 |

${ }^{\text {a }}$ Excluding the River Plate countries.
Table 2 b . Index of needs in supplies of major food groups for the developing countries and for the world as a whole
$(1960=100)$

| Food group | Developing countries |  |  | World |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1970 | 1980 | 2000 | 1970 | 1980 | 2000 |
| Cereals | 127 | 146 | 223 | 123 | 139 | 202 |
| Starchy roots | 117 | 142 | 223 | 117 | 138 | 204 |
| Sugar | 115 | 163 | 281 | 114 | 148 | 228 |
| Pulses and nuts | 153 | 213 | 365 | 144 | 193 | 312 |
| Vegetables and fruits | 132 | 202 | 363 | 124 | 171 | 275 |
| Meat | 168 | 265 | 535 | 134 | 178 | 299 |
| Eggs | 171 | 270 | 545 | 129 | 170 | 269 |
| Fish | 173 | -290 | 624 | 156 | 135 | 447 |
| Milk and milk products. | 163 | 280 | 482 | 130 | 177 | 271 |
| Fats and oils (incl. butter) | 153 | 219 | 382 | 130 | 171 | 264 |

improves. Bearing these tendencies in mind (which are more or less marked for different kinds of food), and assuming a sustained growth of Gross National Product of around 5 per cent compound per annum, the expected levels of food consumption in the various regions, based on income and population
growth, are projected for 1970 and 1980 in tables 3 a and 3b. Suitable downward adjustments are made to the total consumer expenditure for 1970 in countries in which the overall income growth and the percentage of investment are now short of the level at which such a growth is considered possible.

Table 3a. Projected level of demand for total and animal food at constant prices (at the farm level) by 1970 and 1980 , for the developing regions, for the developing countries and for the world as a whole

$$
(1960=100)
$$

| Region | Total food |  | Animal food |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 1970 | 1980 | 1970 | 1980 |
| Far East | 149 | 223 | 167 | 271 |
| Near East and Africa. | 144 | 210 | 160 | 252 |
| Latin America ${ }^{\text {a }}$ | 145 | 213 | 149 | 225 |
| Developing countries. | 147 | 219 | 163 | 260 |
| World | 134 | 179 | 139 | 190 |

* Excluding River Plate countries.

Table 3b. Projected level of demand for major food groups for the developing countries and for the world as a whole
$(1960=100)$

| Food group | Developed countries |  | World |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 1970 | 1980 | 1970 | 1980 |
| Cereals | 135 | 188 | 126 | 164 |
| Starchy roots | 126 | 164 | 119 | 144 |
| Sugar | 157 | 244 | 140 | 196 |
| Pulses and nuts. | 131 | 176 | 129 | 171 |
| Vegetables and fruits. | 148 | 221 | 140 | 196 |
| Meat . ............. | 164 | 263 | 144 | 202 |
| Eggs | 175 | 292 | 141 | 196 |
| Fish | 155 | 238 | 143 | 205 |
| Milk and milk products. | 167 | 271 | 136 | 185 |
| Fats and oil (incl. butter). | 155 | 240 | 134 | 180 |

8. It may be seen that sustained economic growth over the next two decades would lead to increases in food demand that might well overtake the nutritional targets. Where they are considerably above the nutritional targets, the forecasts of demand at constant prices may be regarded as flexible to some extent without prejudice to the general rate of economic growth. A substantial rise in food prices in relation to other prices could adjust demand towards supply. There is, however, a limit to this downward flexibility because of the undesirability of excessive rises in the relative price of food at the farm.
9. It should be noted that the balance of composition among the various food groups is quite different between the nutritional targets and the demand projections; sugar, fats and
cereals tend to rise more sharply under the demand projections. Economic and nutritional policies will be required to adjust demand in accordance with nutritional considerations.
10. The total demand for food at the farm level should rise somewhat faster than the increases suggested, since differentials in the quality of food-stuffs within food groups do not enter explicitly into calculating the totals in table 3b. The demand for the marketing services associated with food products is expected to rise even more substantially, partly because of the more exacting nature of demand as incomes rise and the decline in self-sufficiency among farmers, but mainly (in the developing countries) as a result of urbanization and the associated shift in the occupational structure of the population that is expected.
11. In estimating future food needs and demand, in the foregoing sections only the increase in the size of the population has been taken into account, as changes in the rural/ urban and age/sex structure are known to have a relatively small effect on over-all needs and demand. Rapid urbanization, which is to be expected for many of the developing countries, will, however, lead to a very large increase in the quantity of food marketed, the increase being several times greater than that in the total food supplies. This may present critical problems with regard to the transportation, processing and marketing of food supplies, even if the total food supply increases in line with total demand. Urbanization is also likely to affect relative food prices, as the prices in urban areas are expected to increase, owing to increased marketing costs. At the same time, there is a change in the consumption pattern away from staple foods; consumption other than food may become relatively more important. This might well depress food-demand projections by a few per cent in the developing areas. In the absence of detailed information, it is, however, difficult to estimate by exactly how much. The effect on individual food groups may be even greater.
12. Regarding changes in the age/sex structure of the population, the effect on the total calorie requirement, in the context of the existing population trends, can generally be expected to be less than 10 per cent and the effect on total protein requirement still smaller. The effect of the age/sex structure on demand for food may be somewhat more steeply graded in practice, partly owing to concentration of earning power within the family, partly to inadequate nutritional education and partly to taboos against using certain kinds of food. The effect on over-all consumption can reasonably be expected to be small, but it may be of interest for some food groups, as quantitative information becomes available. Without this information it is practically impossible to tell even the direction of expected effects on the average consumption level in developing countries.
13. There is little doubt that the potential for expanding food output to the extent implied under the targets set out in this paper exists. To look at the physical potential alone is, however, to ignore the economic, technological and institutional wherewithal required to realize the potential. The increases in food production called for in the developing countries are very large and will demand a drastic change in the techniques, major intensification and reor-
ganization of agriculture. No generally accepted answer has thus far been provided to the question, "What are the prospects for increasing food output?". In order to provide some broad conclusions at the regional level, the authors have made plausibility assumptions about the effect of technical progress on crop and livestock yields, the effect of the rising population on the intensity of cultivation (which in turn affects yields) and the possibility of increasing production through the development of new land resources.
14. As regards technical progress, the advantage seems to lie mainly with the densely settled areas, which generally offer more favourable conditions for the application of many of the new techniques suitable for increasing production. It may not be unreasonable to expect a simple annual rate of increase in production of 1.75 per cent in the densely populated areas of the Far East through the application of improved techniques on the existing agricultural land. Relatively smaller increases may be expected in the less densely populated areas. The authors have assumed rates of 1.25 per cent in the Near East, 1 per cent in Latin America and 0.75 per cent in Africa.
15. More problematical is the assessment of the likely effect of rising population on food production in areas where a large proportion of the population lives on and by the land. With rising populations, in these circumstances, even with no increase in cultivated area and no technical progress, production tends to increase with the natural evolution of a more intensive use of available agricultural resources, resulting in increasing yields. There is clearly more room for this intensification without technical progress in the emptier regions of Latin America and Africa than in the Far East, where land resources are already being used more intensively, or in the Near East, where the lack of water is a severely limiting factor. From the limited information available, it has been assumed that there are "elasticities" of 0.7 for Africa and Latin America, and 0.3 for the Far East and Near East, for the proportionate effect of rising population on production. The effects of technical progress and rising population on production are not independent. The joint effect of the two is also taken into account in these calculations.
16. As regards the third factor, the scope for extending the agricultural land is naturally largest in the least densely populated areas. It should be possible to achieve simple annual rates of increase in production as a result of
developing new land resources of 1.5 per cent in Africa and Latin America, against only 0.25 per cent in the Far East and the Near East.
17. For the developed regions, the authors have assumed in their calculations straight rates of increase on the basis of past trends.
18. On the basis of the assumptions noted above, production in the developed countries will rise by 65 per cent by 1980 and thus exceed food needs which, on the basis of trends in population and income, will not rise by more than 25 per cent. For the developing countries, taken as a group, the reverse picture obtains. With considerable effort, production might increase 70 per cent by 1980, though food needs-so defined as to take into account population increase and modest quantitative and qualitative improvements in diets-will have risen by around 100 per cent. These broad figures conceal a wide variety of conditions. Thus, in the Far East, where the heart of the world food problem lies, and in the Near East, production will fail to meet needs. Production
and needs are expected to be more or less the same in Africa, and there is an expected excess of production over need in Latin America. On a world-wide level, production will be more or less equal to needs. If food deficiencies and surpluses are to be levelled out, food trade (or aid) from the developed to the developing countries should amount to some 10 per cent of the world food production in 1980, compared with the current rate of less than 5 per cent.

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# Historical evidence concerning the effect of population pressure and growth on technical progress in agriculture 

E. de Vries

## I. The beginnings of agriculture

1. There has always been a very close relationship between the productivity of land and the density of population. In the hunting period densities were exceedingly low. According to Grahame Clark, neolithic Britain had a population of 20,000 (twelve square kilometres per capita) and in the Middle Bronze Age double that number. ${ }^{1}$ Colin Clark states that most of these were in England, where they had less than five square kilometres of hunting ground per capita and really had to begin to think about agriculture. ${ }^{2}$

## Shifting cultivation

2. It seems that, regardless of distance from the equator, the main form of agriculture was "shifting cultivation", the slash-and-burn method. The (stone) axe and fire were the main agricultural tools. The system invariably requires short periods of cultivation, interrupted by long periods of fallow.
3. In Indonesia (mainly Borneo and New Guinea), it was found that this method could sustain densities of forty persons per square kilometre. ${ }^{3}$ Where densities of population become too large, regressive ecological conditions set in and movements of people over larger distances become necessary. Generally, not all land is involved in a cyclical utilization, and one should distinguish between populationdensity and occupation-density, for example, the number of people per square kilometre of land included in the rotation. As in earlier times, fishing added to agriculture can sustain a much greater density of population, but good fishing grounds close to settlements are relatively scarce. This would, in small pockets, increase the occupation greatly. Colin Clark

[^247]enumerates many cases of measurements of "occupation-density", of yields per hectare, per man-year or per man-hour. ${ }^{4}$
4. Of course, wide variations are found, depending upon local conditions. However, on the basis of observations, annual production (and consumption) in kilogramme grain equivalents per capita varies least of all. It ranges from 250-300 kilogrammes per capita, the biological requirements for man to survive on a sustained basis.
5. The assumption of 250 kilogrammes seems to be quite reasonable. ${ }^{5}$ Based upon a family of five, and a productivity of $1,000-1,500$ kilogrammes per hectare, one family needs about one hectare of harvested cereals as its nutritional basis. It then depends upon the length of the cycle and how great the "occupa-tion-density" can be without disturbing the ecological equilibrium. Colin Clark on the basis of a private communication by Pierre Gourou, estimates that in the whole of "Black Africa", the amount of land cultivated is about one thirtieth of the potential cultivable land. ${ }^{6}$ This then would mean that one family needs about thirty hectares of cultivable land, for example, an occupation-density of six hectares per person or seventeen per square kilometre. It should be kept in mind that large parts of the main continents are beyond the occupational cycle.

## II. Introduction of new methods in agriCULTURE

6. Productivity of land is a function of soil and climate, but also of the technical level of agriculture. In the pre-scientific period (for example, the conscious search for improvements through the application of biological and technical sciences), the possibilities of changes in technology were scarce. It would be wrong to

[^248]underestimate the impact of these changes, however.
7. The first one, the transition from gathering to harvesting, for example, from collecting products of nature to products of culture, was revolutionary. It is a fascinating subject of further research in the prehistory of man, but somewhat beyond the scope of this conference and certainly beyond the scope of this paper. These remarks on shifting cultivation relate to a period of local adaptation over some thousands of years.

## Irrigation

8. Irrigation was a second revolutionary step, which, of course, came after shifting cultivation. Irrigation, generally speaking, marks the transition into permanent cultivation. It adds water as a main agricultural implement to fire and, in the long run (but very late), replaces the fire. Even in densely populated Java, at the moment, straw is burnt on the sazvahs before ploughing. Irrigation greatly increases the carrying capacity of the land. Maintaining the primary base of one hectare of harvested cereals per family, occupa-tion-density would rise to 500 people per square kilometre.
9. It should be noted that, generally speaking, irrigation is possible only on a small fraction of the territory of a nation or area and that, therefore, population density would remain at a low figure. The figure given above also disregards the likelihood of higher yields per hectare and the (limited) possibility of double cropping. Taking into account these factors, a full hectare of irrigated land leaves a margin above "subsistence-level". The traditional unit of cultivation then may well be reduced, e.g., on Java, in the Hindu period, the unit (Bahu, meaning cultivation-family unit) was 0.7 hectare. If one assumes doubling yields through irrigation, a payment of tithes or taxes of 20 per cent would still leave the family slightly better off than shifting cultivation. But if the levies became too oppressive an escape into dry-land shifting cultivation of rice would remain an effective line of defence of the cultivator. Until very recently, this was shown clearly on Java, through the establishment of new villages in the hills or in newly reclaimed forests.
10. Administrative or political pressure often operates with an explosion of evasion; population pressure would have the same impact on peasants' income, but this would be more of a creeping nature. On Java, it often means opening up dry fields on the mountain-
side, while retaining the home base in the village.

## New cultivated plants-domestic animals

11. It should be noted that population pressure-by inducing people to use marginal land in a new sense of margin under the impact of the new technique-can cause the reintroduction of older techniques. Some of the most spectacular of these shifts are linked with the introduction of another element-new cultivated plants and domestic animals. Next to irrigation, this has been the most revolutionary factor in improving agriculture. The interchange between the eastern and western hemispheres since 1500 A.D. constitutes the greatest revolution in agriculture in historic times. Maize, the potato, cassava and the peanut have saved Europe, Asia and Africa from starvation. Without wheat, sheep, cattle and horses, the western hemisphere could not have been developed at all. Coffee and cocoa were exchanged across the South Atlantic.
12. If, after 1650, a noticeable increase in population occurred, new crops and the accompanying intercontinental trade were its main source. The application of science (notably medical science), in the author's opinion, came later.
13. In the Danube basin, the rural population doubled in a very short time after the introduction of maize. In south China, the sweet potato, in combination with maize, had a similar effect. Without the potato, Europe would have been a dramatically over-populated country, as shown by the famine in Ireland. Similarly the Indians of North America could not have put up any resistance against the settlers without the horse and cattle, brought by the Europeans. And Africa responded immediately to the introduction of cassava, in 1861, by a missionary who was attempting to stave off famine in Rhodesia.
14. The conclusion may be that population increase has responded to a variety of innovations in agricultural techniques.

## III. Effect of population pressure on agriculture

15. However, the organizers of this conference ask the most difficult question of the inverse relationship. To what extent has population pressure forced or induced people, groups or nations to change the pattern of their agriculture? This is a challenging question which has, so far, no conclusive answer. Much basic research, country by country, would be needed and might be very worth while. In this
paper, only a few answers to the challenge of population pressure are indicated.
16. On the island of Java, population pressure became felt after 1880 as an aftermath of crippling loss of income from cash crops (diseases in sugar cane and coffee, elimination of indigo by synthetics and low prices of rice). The Government answered with the palliative of reduced taxes on labour. Then the peasant answered by a dramatic increase in double cropping (polowidjo) on irrigated rice fields in the dry season, which in turn, caused the Government of Indonesia to make irrigation more dependable, around the seasons. Corn, peanuts, cassava and, at a later date, soya beans became the most important "second crops". Soon (there is little indication of the precise sequence) these same crops also reduced the area under dry or highland rice and, in that respect, were even more successful than on irrigated land, where rice remains the only crop in the rainy season.
17. In the plains of western Java, where both the dry season and irrigation are less dependable, one-crop one-season rice has persisted. Atempts to introduce polowidjo were frustrated by roaming water buffaloes. Currently, however, under the pressure of population, the introduction, between two rice crops, of soya beans, followed by maize, is aimed at as a governmental policy.
18. In a sense, wherever improvement of irrigation or drainage becomes considered necessary and profitable, the demand can be seen as being induced by population pressure. Heavy investments (also if mainly in labour) are rational only in view of rapidly expanding demand. If demand is not rapidly expanding smaller improvements will be more profitable.
19. It remains to be decided whether a change in demand directly influences agricultural practice. In a theoretical concept of subsistence agriculture, this would seem logical, but it may well be that the indirect influence through (relative) price levels operates much more effectively. The book by Slicher van Bath, although not written with this agro-economic focus, illustrates amply the thesis that throughout the Middle Ages, in most of Europe, relative prices had a profound effect on agricultural methods, choice of crops, etc. ${ }^{7}$
20. Population pressure through natural increase of slackening of pressure, as a result of epidemics or war, repeatedly caused shifts from crops to pasture, from cereals to vineyards

[^249]and vice versa. It is the reversibility of these processes which is most astounding. The real income of the non-farmer seems to have been even more affected by the adaptation of cropping patterns to price levels than the real income of the farmer (largely determined by physical outputs of agriculture). Thus, there are clearly distinguishable periods of agricultural decline and prosperity. The former results in deserted land and villages, the latter in wellbuilt farm-houses and precious metals flowing to the villages (largely for conspicuous costume decoration). In the remarkable volume by Slicher van Bath, evidence is given repeatedly of the effect of less population, as epidemics or wars operate on short terms. The reverse effect of population increase works more slowly and seems often to have been overshadowed by events operating on price levels through marketing forces (improved transportation). In contrast to other historical works, Slicher van Bath begins his analysis from demographic-socio-economic forces and fits, as a result, the political-socio-economic changes into his pattern.
21. In many historical studies of Europe, power structures are the point of departure. The interrelations with demographic-socio-economic forces then are often blurred. As an illustration, rather than as a generalization, one may mention the outstanding Shorter Cambridge Medieval History, where the index does not contain the words "agriculture" or "population", but where it is stated, "In like manner-the new (Anglo-Saxon) colonistsbegan the felling of the vast primeval forests for fresh settlements, where Roman clearances had but feebly preceded them. The process was to continue for centuries as the population grew, and to change the face of Britain". ${ }^{8}$ This may mean shifting cultivation in earlier periods (but even then the forests would not be primæval) ; it certainly means that in the early Feudal period the heavier (Saxon) plough enabled people to cultivate longer strips of heavier soil. These fields yielded more easily a surplus for sale (or taxation) and contributed to the commercialization of agriculture. But it should be kept in mind that during the Roman period, Britain was already exporting grain for the garrisons along the Rhine, via the Lowlands.
22. With regard to Europe in general, Slicher van Bath states that during the period under consideration, the possibilities of ex-

[^250]panding the area were very limited and the relation between numbers of consumers and agriculture was precarious. ${ }^{\circ}$ Small changes in the number of people could upset the balance and a shortage of food, drink and clothing was the result-farmers are a well-known historical phenomenon-but an even worse effect came from chronic malnutrition. If this became the case, the poor shifted from expensive towards cheap food, away from animal protein and fats towards cheaper starch products. Rightly, Slicher van Bath draws a comparison with many developing countries in current times. Perhaps significantly, he attributes improvements in the first place to the development of trade and industry, hence to improved marketing outlets and sale of products as a way out for stagnant over-populated rural areas. It seems that in medirval Europe the technological improvements in agriculture were achieved through the circuitous way of increasing demand from the non-agricultural population leading to increase in prices for food and fibres. These prices activated farmers into diversification, intensification and land reclamation (including the construction of polders). Population increase in the rural areas alone

[^251]would have induced malnutrition and apathy.
23. It might be noted that the wholesale inexpensive importation of grain (from the Baltic, then from the Black Sea, then from North America and, finally, from Argentina) into the main consumption centres of western Europe brought about a reversal of agriculture into a stagnant, backward industry.
24. The question arises, whether it may be expected that increase in rural population per se will induce farmers to intensify and produce more. Apart from the pure subsistence agriculture (and most peasants are at least in a transitory stage), the author cannot be confident. It may well be that a reduction of fallow, over-grazing and erosion will set in, leading to a reduction of productivity into a Malthusian equilibrium in poverty and misery. It may well be that promotion of the sale of products (not for taxation, tithes or rent) for feeding the non-agricultural population is a better road towards technical and economic improvement. Population pressure, then, operating through urbanization and industrialization, would have a beneficial effect on agricultural techniqueswithout the development of the non-agricultural sector it would work to the detriment of agriculture.

# The effect of population pressure and seasonal labour surplus on the pattern and intensity of agriculture 

T. Yajima

## How the pattern was determined

1. It is almost taken for granted that the population pressure in Japan has made the population density become so high in the rural areas and, accordingly, the individual farm become so tiny. It is believed also that rice was chosen as the main crop in compliance with the population pressure, as well as with the monsoon-type climate, because rice can be cultivated with very high labour intensity in that climate.
2. This is true to some extent, but it is also true that the tiny farm itself is a cause of over-population and it, with the one-sided rice cultivation, is a cause of seasonal labour surplus in the farm. It is affirmed by the statistical survey that the smaller the farm size is, the higher the rate of natural increase of population, as well as the birth rate, and that the area where the percentage of very small farms is predominantly high in proportion to other sizes shows more rural exodus than other areas. ${ }^{1}$
3. Generally speaking, the population increase takes place mainly in the rural area, while the rate of increase of farm income cannot keep pace with that of population.
[^252]Therefore, increased population is absorbed by non-agricultural sectors. In other words, the non-agricultural industries are supported by the population discharged from the farming area.
4. In Japan, the development of industry began about a century ago with light industries like cotton and silk fibre and textile manufacture. With the development of this industry. the population, mostly female, who were discharged from the farm, have been indispensable. In that way, the small farm with a onesided single enterprise was necessary.
5. The basic agricultural policy also has been to keep and maintain such small family farms as much as possible and to produce as many food crops, especially rice, per hectare as possible. Thus, agriculture was shaped and promoted by the Government rather than by the farmers' own initiative. The government subsidy plays an important role for this purpose.
6. On the other hand, that the farm is of a tiny size is a traditional remnant from the feudal age. It is by no means a creation of the capitalistic economy, which only took advantage of this legacy. In regard to the population pressure from outside upon agriculture, it must have been reduced as economic development, as a whole, progressed.
7. However, the industrial structure has remarkably changed, especially since the Second World War, as shown in the following table:

Table 1. Gross value of industrial products

|  |  | 1930 |  | 1956 |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | (million yen) | (percentage) | million yen) | (percentage) |
| Textile |  | 2,174 | 36.6 | 1,420 | 16.8 |
| Metal |  | 501 | 8.4 | 1,666 | 19.7 |
| Machine |  | 695 | 11.7 | 1,540 | 18.2 |
| Chemicals |  | 902 | 15.2 | 1,560 | 18.4 |
|  | Total | 5,937 | 100.0 | 8,474 | 100.0 |

8. The weight has shifted from the light industries to the heavy and chemical industries, which do not depend so much on a part-time surplus labour force released from the farm as the former did. Furthermore, the problem does not lie only in the quantity of labour-power in demand, but also in its quality. They do not need so much unskilled labour as before. They are short of necessary labour supply, but the labour demand does not agree with the labour supply released from the farm because of the difference of labour quality demanded and supplied.
9. Most economists, in their current theories of economic development, do not consider it
either necessary or fitting for industry, after it has reached an advanced stage, to live on cheap labour, immobilized by land property.

The decrease of farming population and ris background
10. It is a well-known fact that the average and marginal productivity of labour is much lower in agriculture than in industry. It is also true that the difference in productivity and efficiency between industry and agriculture is greater in Japan than in other highly developed countries. For example, note the difference in daily wages:

Table 2. Difference in average daily wages
(Yen)

|  |  |  |  |  |  |
| :--- | ---: | ---: | ---: | ---: | ---: |
|  | 1957 | 1958 | 1959 | 1960 | 1961 |
| Mining $\ldots \ldots \ldots \ldots$ | 1,024 | 1,043 | 1,073 | 1,141 | 1,258 |
| Industry $\ldots \ldots \ldots \ldots$ | 806 | 799 | 863 | 935 | 1,041 |
| Commerce $\ldots \ldots \ldots$ | 797 | 802 | 862 | 926 | 970 |
| Agriculture : |  |  |  |  |  |
| Male $\ldots \ldots \ldots$. | 327 | 343 | 351 | 382 |  |
| Female $\ldots \ldots \ldots$. | 261 | 273 | 288 | 314 | 385 |

11. This phenomenon should be interpreted as that, in Japan, the population pressure is much stronger in agriculture than industry, while mobility of agricultural resources, including family labour-power, is greatly limited, and that the capital formation in agriculture is much less and slower in tempo than in nonagricultural sectors, as shown in the following table:

Table 3. Capital formation
(Thousand million yen)

|  | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| Capital formation in agri- |  |  |  |  |  |  |
| culture $\ldots \ldots . . . . . .$. | 201 | 204 | 226 | 279 | 345 | 349 |
| Total capital formation..... | 2,731 | 2,800 | 3,523 | 4,720 | 6,240 | 6,354 |

12. However, the population engaged in farming began to decrease in these years at the annual rate of 3 per cent. This should be called a new trend in Japanese agriculture, because Japan has never experienced such a decrease of farming population in the past. It is expected that this population decrease should have an important influence upon the future pattern of agriculture in Japan.
13. The decrease of farming population is, of course, primarily caused by the rapid economic growth in non-agricultural sectors, but it is also because of the changed character of the farming family itself. As is well known,

Japanese agriculture consists of family farms based on intensive work done by family members. Such a family farm is, so to speak, covered with a semi-permeable membrane through which out-flow of family members is not easy. The stronger the family tie is, the more difficult it becomes to release a family member, as an individual, from the farm. Such a situation has been found to be more or less prevalent among the family farms in Japan. However, once the family tie slackens, the permeability of labourpower through the family farm barrier becomes apparent. It is true that a traditional institution like the family system is not easy to break and
slow to be dissolved, but such a dissolution has begun.
14. It must be admitted that the background of this social change is not so simple, but the following points should be considered essential, in so far as the family farm is concerned. First, it must be pointed out that the constitutional law and the civil law, both basically revised after the Second World War, no longer accept the family as a judicial unit and, thus, the superiority of the family over a family member was denied. In addition, education, based on the new educational basic law following the same line, has brought up the young generation to be more individuality minded.
15. Secondly, the division of labour in the farm among the family members has been gradually formed as the agricultural technology has advanced. In that way, the basic or essential family worker began to be set up as separated from the assisting family worker or help-hand. The farm family now consists of three different groups-basic workers, assisting help-hands, and dependants-more clearly than in the past. At the same time, seasonal dilution of labour among family members is becoming more and more difficult.
16. The basic family workers are more stable than the assisting ones in population movement, while the latter have higher mobility and permeate more easily through the institutional membrane. ${ }^{2}$
17. On the other hand, the farm land law helps to hold the basic family worker on the farm, because the farmer is the only one who is entitled to maintain and purchase the farm land, according to the law. Therefore, once he loses the farmer's status, he loses it permanently. This is one of the reasons why the number of farms does not decrease as greatly as the farming population. The former is decreasing at an annual rate of less than 1 per cent, while the latter is decreasing at the rate of 3 per cent.
18. Thirdly, the impact from outside must be pointed out. While the impact is not strong, over-saturation of labour-power occurs inside the farm. However, as economic development, as a whole, proceeds, such an impact becomes strong. Farmers are increasingly obliged to depend on the market, for instance. Once

| 2 |  | $\begin{aligned} & \text { Basic } \\ & \text { family } \\ & \text { workers } \\ & (1,000) \end{aligned}$ | $\begin{gathered} \text { Assisting } \\ \text { family } \\ \text { wookers } \\ (1,000) \end{gathered}$ |
| :---: | :---: | :---: | :---: |
| February | 1960. | 11,687 | 5,856 |
| December | 1961. | 11,126 | 5,555 |
| December | 1962. | 11,251 | 5,290 |

shaken, they can no longer hold the oversaturation status.
19. Finally, it must be mentioned that compulsory education was extended from six to nine years after the Second World War and almost 100 per cent of the people complete elementary and junior high school. The population entering senior high school has also increased tremendously in number since the war. This is a general tendency both in urban and in rural areas.
20. It is also a well-known fact that the longer the education period is, the farther and wider one's moving distance and area becomes. ${ }^{3}$ An educated son or daughter of the farmer has more chances to earn higher wages in other businesses than does a less-educated one. For the former, the difference of marginal productivity in and out of the farm is greater than for the latter.
21. The population pressure will increase almost in proportion to the number of part-time assisting family workers and the length of their education period, set other things being equal. This relationship may be summarized as follows:

$$
P=r E \cdot A
$$

Where $P=$ population pressure $E=$ length of education; $A=$ number of family members assisting in farm work.

## An expected pattern of agriculture

22. The farmers are currently confronted with the problem of how to adjust the traditional type of farming to the new circumstances. The seasonal surplus labour should be minimized as far as possible through an appropriate combination of farm enterprises. In this context, the dairy enterprise, especially winter dairying, shall be recommended.
23. One may consider an average farm with 2.5 working units of family members in Tokachi, Hokkaido, which is a representative up-land crop area in Japan. The major crop in this area is currently beans, which occupy about 50 per cent of the total acreage under cultivation. Here an average farm has about ten hectares of cultivated land. Having such a farm in mind, the following simplex table was set up:
[^253]Table 4

| Net income per 10 ares and head. | 7,528 | 6,945 | 11,448 | 5,928 | 52,344 |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\underset{(b e a n s)}{p_{1}}$ | $\underset{\text { (potatoes) }}{P_{3}}$ | $\begin{gathered} P_{3} \\ \text { (sugar-beets) } \end{gathered}$ | $\underset{(w h e a t)}{P_{f}}$ | $\underset{(m i l h}{P_{5}} \text { cows) }$ |
| Land | 1 | 1 | 1 | 1 | 6.8 |
| May (675) | 3.2 | 10.3 | 17.5 | 0.9 | 27.0 |
| June (675) | 4.7 | 1.0 | 16.6 | - | 38.4 |
| July (675). | 6.3 | 5.8 | 1.6 | 13.0 | 26.2 |
| September (607.5). | 2.9 | 17.0 | 22.0 | 13.0 | 53.2 |
| October (540) | 5.9 | - | - | - | 17.1 |

It should be noted that 2.5 labour units with a ten-hour workday and twenty-seven working days per month makes 675 hours, and that the labour hours in September and October are shortened to nine and eight, respectively, in
consideration of shorter daytime in these months.
24. The results of the linear programming with variable total acreage are shown in the following table:

Table 5

|  | Step |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1 | 2 | 3 | 4 | 5 |
| Beans | - | - | - | 36.03 | 69.34 |
| Potatoes | - | - | 4.48 | - | - |
| Sugar-beets | 24.55 | 17.15 | 17.27 | 7.76 | - |
| Wheat | - | - | - | - | - |
| Milk cows | - | 9.51 | 9.34 | 9.16 | 7.64 |
| Total acreage. | 24.6 | 81.8 | 85.3 | 106.1 | 121.3 |
| Marginal income | - | - | - | - | - |
| Productivity of land. | 11,448 | 7,214 | 6,862 | 5,851 | 5,413 |
| Net income. | 280,996 | 694,285 | 717,780 | 839,700 | 922,030 |

This table shows that beans and milk cows make the best combination for a 12.13 hectare farm which promises 922,030 yen in net income with a better distribution of labour.
25. However, now that an increased yield is in good prospect through improved technology, the net income per ten ares and head can be set with safety as follows for the near fature:

Table 6. Simplex table (with variable total acreage)

26. The linear programming with the simplex table shown above leads to the following results:

## Table 7

|  | Step |  |  |
| :---: | :---: | :---: | :---: |
|  | 1 | ? | 3 |
| Beans | - | - | 61.75 |
| Potatoes | - | - | - |
| Sugar-beets | 24.55 | 13.73 | - |
| Wheat | - | - |  |
| Milk cows | - | 13.91 | 10.28 |
| Total acreage | 24.55 | 86.06 | 115.17 |
| Marginal income |  | - | - |
| Productivity of land | 13,572 | 9,819 | 9,183 |
| Net income | 333,130 | 937,210 | 1,204,470 |

In this case, one may expect $1,204,470$ yen in net income from beans and milk cows on 11.5 hectares, with much less seasonal labour surplus.

## SUMMARIES OF PAPERS

# The interrelation between population trends and agricultural methods 

Ester Boserup

When population growth increases the ratio of population to land, it becomes necessary to shorten the recovery periods for the land, i.e., to let one crop follow more closely upon the previous one on any given plot of land. Such intensification of land use must result in a deterioration of the soil unless the shortening of recovery periods is offset by additional agricultural operations designed to protect the land and preserve its fertility. Therefore, a cultivator family in a densely populated region, which must use the land intensively (for instance, by taking more than one crop from the same plots each year), must spend far more hours per year in agricultural work than a cultivator family in a sparsely populated region, which can make use of long fallow periods. With increasing population density, there is thus a tendency not to increasing underemployment in agriculture, but to a fuller employment, with voluntary underemployment gradually disappearing and seasonal underemployment becoming much reduced, if not eliminated completely.

Since the extensive systems of agriculture are so easy and leisurely, the cultivators are likely to continue to use them in communities with sparse and stagnant population. Such communities are unlikely to develop economically, because the need for very large fallow areas forces the cultivator families to live in small, widely scattered groups.

The change of fallow system that must occur under the pressure of population growth has far-reaching repercussions on the way of life of the rural population because land tenure, social organization and many other factors are interconnected with the system of land use. Moreover, some of the changes caused by the shortening of fallow affect death rates and birth rates, and there is thus a two-way connexion between agricultural methods and demographic trends.

## Role of peasant-workers in economic development under conditions of population pressure

Stane I. Krasovec

Peasant-workers (also called workers-peasants, semi-proletarians, part-time farmers) are farming people whose holdings are too small, owing to population pressure and lack of land and who supplement their farm income by taking local non-agricultural jobs at low wages. They were an almost negligible proportion of the rural population at the time of classical industrialization, tending to disappear in the high stage of development. Today, however, in developing countries, they are substantially increasing in number and proportion (from one fourth to one half and more of total agricultural holdings).

Having been the poorest segment of the papulation in previous times, they are today wealthier than marginal farmers and unskilled factory workers (owing to shorter working days, modern transport and farm mechanization), and constitute a considerable accelerating factor in economic development by making possible greater national savings in social investments (housing, etc.), thus, relieving the pressure on the food market, and by increasing effective demand on consumer goods of higher elasticity. This is even more the case when they are better protected against excessive exploitation and their agricultural production is encouraged. Their alleged weaker productivity, both in agriculture and urban industries, is outweighed by the above advantages.

This paper refers to the cases of Yugoslavia and Poland, and makes reference to some suggestions on how the contribution of this stratum could be greatly increased if their development and activity were planned, guided and encouraged. Some reference is also made to conditions of pressure of the population in towns and to the abundant supply of land in rural areas (as in the countries of Africa, south of the Sahara). The role of the peasantworkers is, however, considered a temporary one which exists only during the take-off stage, and for some time after, until a higher stage of economic development is reached.

## Interrelationships among population trends, land availabilities and food supplies

Ralph W. Phillips

The nature of the interrelationships among land available for food production, population numbers and food supplies depends upon many factors, as they interact in any local or national situation.

Land is limited; the amount available per capita is being rapidly reduced as population increases. In 1960 there were 1.2 acres of arable land per capita in the world. Keeping the amount of arable land constant, there were 1.92 acres per capita in 1920; in 2000, the amount will be 0.6 , assuming the United Nations medium projection of population is correct. Even if all the some 3,000 million acres of potentially arable land could conceivably be brought under cultivation by 2000 , the amount per capita would be less than in 1960; the amounts of grass and forest lands would be substantially less.

Per capita calorie supplies vary from 3,510 per day in New Zealand to 1,800 in the Philippines; total protein from 112 grammes in New Zealand to 42 in Ceylon and the Philippines; animal protein from 77 grammes in New Zealand to 6 in India. Even to maintain the current unsatisfactory dietary levels, the Food and Agricultural Organization estimates that world food production must be increased by 123 per cent in 2000; if there is to be reasonable improvement, food production must be increased by 174 per cent. In countries where population is rising most rapidly, and to reach a more modest dietary target, an increase of 293 per cent would be required, involving increases of 130 per cent in cereals, 275 per cent in pulses and 485 per cent in animal products.

In view of the many technical, economic and organizational problems to be overcome if such
increases are to be achieved, national leaders must recognize the nature and magnitude of the task, and initiate much more substantial action than is now taking place, in order to develop agricultural resources and to bring agriculture into its essential place in economic development.

## The influence of population trend in the plans of developing countries

N. K. Sarkar

An aspect of population movement that has been paid relatively less attention in the development plans of developing countries is the rural to urban migration. As industrialization progresses, this type of population movement gathers momentum and creates significant differential in the rural and urban population growth rates. The areas where the impact of these differential growth rates are felt most acutely are food supply, housing and employment. Among these three, the food shortage in the urban areas has the most explosive consequences. The urban food-supply mechanism is put under a severe strain as consequence of such developments.

The economic plans generally have not taken note of the possibility of a supply gap in food for the urban areas. It is possible, however, to obtain a rough estimate, under certain simplifying assumptions, of the growth rates in the demand for food of the urban and rural sectors, as implied in the various growth targets of the plans. These estimates suggest that in a number of countries a serious shortfall in urban food supply may appear if the plan targets, as set forth in their plans, are indeed successfully implemented. If this inconsistency is to be avoided, what is called for is either a reconsideration of the plan targets or policy measures aimed at increasing the urban food supply and achieving a more rational distribution.

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    ${ }^{3}$ W. Brass, "Uses of census or survey data for the estimation of vital rates", African Seminar on Vital Statistics, Economic Commission for Africa (United Nations document E/CN.14/CAS.4/VS/7).
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    ${ }_{5}$ Ansley J. Coale and Paul Demeny, Regional Model Life Tables and Stable Populations (Princeton, Princeton University Press, 1966).

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[^9]:    2 Bjornulf Bendiksen, "Bosettingen i Norge 19601980", Sosial申konomen, 5-6 (1963), pp. 10-14, 21.

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    3 John Hajnal, "The prospects for population forecasts", Procedings of the World Population Conference, 1954 (United Nations publication, Sales No.: 55.XIIL.8), pp. 43-53.

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    b The projection mentioned here assumes an infant mortality rate of 250 in 1951 . On an alternative assumption of infant mortality rate of 225 , an upper limit of 424 million was estimated by the authors.
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    b Based on a plausible draft of an economic plan.
    ${ }^{\circ}$ Assuming continuation of recent demographic trends irrespective of economic growth until 1970's when a hypothetical economic crisis would repel more in-migration.
     since the 1961 census.
    e The difference between the 1950 and 1961 censuses, allowing for 10 per cent underenumeration at the former and 5 per cent at the latter, implied 23 per cent growth per annum.

    IThe total population estimated from the 1962 labour force implied an annual increment of 5,200 since the last census.
    ${ }_{5}$ Beginning at 23 per cent, growth decelerates toward the 10 per cent peak of the country's only other industrializing boom town by the time 173,000 inhabitants are reached, whereupon a steady 10 per cent increase is maintained.

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    5 Pascal K. Whelpton, "An empirical method of calculating future population', Journal of American Statistical Association, vol. XXXI (1936), cited by R. J. Myers in "Comparison of population projections with actual data", Procecdings of the World Population Conference, 1954, vol. III (United Nations publication, Sales No.: 55.XIII.8), p. 102. Precursors of this general method were Edwin Cannan (making projections of the population of England and Wales in 1895), and A. L. Bowey (making projections of various countries for the League of Nations in 1926). See John Hajnal, "The prospect for population forecasts", Proceedings of the World Population Conference, 1954 , vol. III (United Nations publication, Sales No.: 55.XIII.8), p. 46 ; and Hugh Wolfenden, Population statistics and their compilation, revised edition (Chicago, University of Chicago Press, 1954), p. 93.

[^64]:    ${ }^{6}$ For citation of the published projections see John V. Grauman, "Success and failure in population forecasts of the 1950's: a general appraisal"; Proceedings, vol. III.
    ${ }^{7}$ Grauman (ibid.) has discussed these. Among other advances he cites the improved methods of population projections utilizing stable-population analysis and cohort fertility analysis pioneered by Whelpton. (Incidentally, cohort analysis also gave insight into why earlier methods had failed.) Also see the various papers on population projections in vol. III of the Proceedings of the World Population Conference, 1954, op. cit.; and John G. C. Blacker, "The use of stable population models for the construction of population projections," International Population Conference, Ottawa, 1963 (Liège, International Union for the Scientific Study of Population, 1964).
    8 United Nations, Meihods for Population Projections by Sex and Age (United Nations publication, Sales No.: 56XIII.3), p. 1.
    ${ }^{9}$ See Robert J. Myers, "Comparison of population projections with actual data", Proceedings of the World Population Conference, 1954 and Jacob S . Siegel, "Some aspects of the methodology of population forecasts for geographic subdivisions of countries", in Proccedings of the World Population Conference, 1954 , vol. III (United Nations publication, Sales No. : 55.XII.8), pp. 113-132.

    10 John V. Grauman, "Success and failure in population forecasts of the 1950's: a general appraisal", Proceedings, vol. III.

    11 Blacker, op. cit., p. 75. Blacker cites H. Gille, Accélération démographique en Extrême-Orient: quelques résultats des recensements de 1960-1961, Population, No. 4 (1961), pp. 637-648.

    12 I would like to point out that this paper is concerned throughout with school-age population projections and not with projections of school enrolment figures. Planners and policy makers would require both types of projection for the purpose of plaming for education. For some projections of en-

[^65]:    rolment and other educational statistics see U.S. Dept. of Commerce, Bureau of the Census, "Illustrative projections to 1980 of school and college, enrollment in the United States", Current Population Reports, Population Estimates, series P-25, No. 232 (Washington, D.C., 22 June, 1961), and U.S. Dept. of Health, Education, and Welfare, Projections of Educational Statistics to 1973-74, 1964 edition (Washington, D.C., 1964).
    ${ }_{1 s}$ Fortunately, various techniques for appraising the quality of a country's vital and population statistics for population projections are available. See, for example, United Nations, Methods of Appraisal of Quality of Basic Data for Population Estimates (United Nations publication, Sales No.: 56.XIII.2).
    14 The necessity of the breakdown by sex is clear. Even countries that have only subtle aspects of the double standard must plan for the differential educational needs of the two sexes.

[^66]:    15 Of course, estimates of the number of primary school graduates are in turn necessary so that plans for secondary level education can be made.

    16 Local sample surveys may be employed as one method, among others, of obtaining relatively adequate vital statistics data. See M. A. El-Badry and C. Chandrasekaran, "Some methods for obtaining vital statistics in India", International Population Conference, New York 1961, vol. II (London, John Wright and Sons, 1963), pp. 377-386. Also see other papers in part 10 of this volume.

[^67]:    ${ }^{17}$ Local epidemics, floods, famines and location of new industries are some of the occurrences I have in mind.

    18 For a brief discussion of these methods, see footnote 8, op. cit., chapter I. Also see Van Beuren Stanbery, Better Population Forecasting for Areas and Communities (United States Department of Commerce, Washington D.C., September 1952). Siegel believes that "the methods which attempt to assess the economic prospects of an area represent the most logical and promising approach to the problem of forecasting local populations", op. cit., p. 119. It should be noted that where the economy is planned the extent of internal migration for local areas may be easier to predict.
    ${ }^{19}$ For an excellent discussion and extensive evidence in support of this statement, see Siegel, op. cit., pp. 122-126.

[^68]:    1H. V. Muhsam, "Population data and analyses needed in assessing present and future housing requirements" (E/CN.9/CONF.2/L.10), paper prepared for the United Nations Seminar on Evaluation and Utilisation of Population Census Data in Asia and the Far East (Bombay, 1960). See also Estadistica (June, 1963), pp. 301-322.

    2 United Nations, Economic Commission for Europe, Techniques of Surveying a Country's Housing Situation, including Estimating of Current and Future Housing Requirements (United Nations publication, Sales No.: 62.II.E/Mim.33).

    3 United Nations, Statistical Office, Methods of Estimating Housing Needs (E/CN.11/ASTAT/ HSP/L.4) (1963).

[^69]:    ${ }^{4}$ Louis Henry, "Structure de la population et besoins de logements," Populations No. 3 (Paris, 1949), pp. 433-466; and "Perspectives relatives aux besoins de logements", Population, No. 3 (Paris, 1950), pp. 493-512.
    5 United Nations, Committee on Housing, Building, and Planning, World Housing Conditions and Estimated Housing Requirements (E/C.6/13) (1963).
    ${ }^{6}$ U.S. Bureau of the Census, "Marital status and family status: March 1962", Current Population Reports, series P-20, No. 122 (Washington, D.C. 1963).
    7 See United Nations, Economic Commission for Europe, Techniques of Surveying a Country's Housing Sitiuation, including Estimating of Current and Future Housity, Requirements. (United Nations publication, Sales No.: 62.II.E/Mim.33).

[^70]:    ${ }^{8}$ Roland Pressat, "Un essai de perspectives des ménages", International Population Conference, Vienna, 1959 (Vienna, International Union for the Scientific Study of Population, 1959), pp. 112-121.

    9 U.S. Bureau of the Census, "Illustrative projections of the number of households and families, 1960 to 1980", Current Population Reports, series P-20,

[^71]:    10 U.S. Bureau of the Census, "Illustrative projections of the number of households and families, 1960 to 1980", Current Population Reports, series P-20, No. 90 (Washington, D.C., 1958).

    11 United Nations, Economic Commission for Europe, Tectniques of strveying a country's housing situation, including estimating of current and future housing requirements (United Nations publication, Sales No.: 62.II.E/Mim.33).

    12 S. P. Brown, "Analysis of a hypothetical stationary population by family units: a note on some experimental calculations", Population Studies, vol. IV, No. 4 (London, March 1951), pp. 380-394.
    13 A. R. Hall and M. R. Hill, "Housing demand in Australia, 1959-1974", Economic Record, vol. XXXVI, No. 76 (Melbourne, December 1960), pp. 550-567.

    14 United Nations, Economic Commission for Europe, Techniques of surveying a country's housing situation, inchuding estimating of current and future housing requirements (United Nations publication, Sales No.: 62.ILE/Mim.33).

    15 Willem Steigenga, "Family structure, age composition and housing needs", International Population Conference, Newe York, 1961 (London, Inter. national Union for the Scientific Study of Population, 1963), vol. I, pp. 243-250.

    16 A . H. Walkden, "The estimation of future numbers of private households in England and Wales", Popnlation Studies, vol. XV, No. 2 (London, 1961), pp. 174-186.

[^72]:    17 Gérard Calot, "Perspectives du nombre des ménages de 1954 à $1976^{\prime \prime}$, Etudes Statistiques, Nouvelle série, no 2 (France, Institut national de la statistique et des études économiques, April-June 1961), pp. 149-159.
    is Shigemi Kono, "Household projections for Japan, 1960 to 1975", Jinko Mondai Kenkyu, No. 83 (Tokyo, July 1961), pp. 1-13.

    19 U.S. Bureau of the Census, "Illustrative projections of the number of households and families, 1960 to $1980^{\prime \prime}$, Current Population Reports, series P-20, No. 90 (Washington, D.C., 1958).

    20 Gérard Calot, op. cit.
    21 U.S. Bureau of the Census, "Illusrative projections of the number of households and families, 1960 to $1980^{\prime \prime}$, Current Population Reports, series P-20, No. 90 (Washington, D.C., 1958).

[^73]:    22 United Nations, "Demographic and social characteristics of the population," Handbook of Population Census Methods, vol. III (United Nations publication, Sales No: : 58.XVII.6).

[^74]:    ${ }^{23}$ S. P. Brown, op. cit.
    ${ }^{24}$ Ruth Glass and F. G. Davidson, "Household structure and housing needs," Population Studies, vol. IV, No. 4, London (March, 1951), pp. 395-420.
    ${ }^{25}$ H. V. Muhsam, "Population data and analyses needed in assessing present and future housing requirements", United Nations Seminar on Evaluation and Utilization of Population Census Data in Asia and the Far East (E/CN.9/CONF.2/L.10) (Bombay, 1960) ; Estadistica (June 1963), Dp. 301-322.
    ${ }^{26}$ In the U.S.A., the number of family members is the total population less inmates of institutions, primary individuals, and secondary individuals. Projections of the number of persons in these categories are prepared as part of the general scheme for projecting households and families U.S. Bureau of the Census, "Illustrative projections of the number of households and families, 1960 to $1980^{\prime \prime}$, Current Population Reports, series P-20, No. 90 (Washington, D.C., 1958).

[^75]:    ${ }^{27}$ J. Dousa, "Problemy zjistovani perspektivni skladby domacnosti," Statisticlky Obzor, No. 12 (Prague, 1959), pp. 536-544.

[^76]:    28 U.S. Bureau of the Census, "Projections of the population of the United States, by age and sex: 1964 to 1985" Current Population Reports, series P-25, No. 286 (Washington, D.C., 1964), pp. 35-37.

    29 Guy HL. Orcutt et al., "A demographic model of the U.S. household sector," Microanalysis of Socioaconomic Systems: A Simulation Study, part II (New York, Harper and Brothers, 1961),

[^77]:    ${ }^{1}$ See the paper entitled "Calculation of population projections with the aid of electronic computers", presented at meeting B. 4 by A. F. Pobedina, Chief Specialist of the Computing Centre of the State Planning Commission of the Union of Soviet Socialist Republics.

[^78]:    ${ }^{1}$ The composition of the family in our country was first studied on a large scale when the 1926 population census data were processed. Cf. "Structure of the urban family (results of special processing)", The AllUnion Population Census of 1926, vol. LVI, part I (Moscow, 1931).
    ${ }^{2}$ Comparison with other data, however, in particular material from a sample survey in the Moscow region, has shown that the composition of families here has no marked peculiarities.

[^79]:    ${ }^{3}$ A. G. Kharchev, Marriage and the family in the Union of Soviet Socialist Republics (Moscow, Mysl Editions, 1964), p. 231.

[^80]:    ${ }^{4}$ For simplicity we are assuming that those members of the family who leave it after marriage do not return to it.

[^81]:    ${ }^{5}$ A. G. Kharchev, op. cit., p. 180.

[^82]:    ${ }^{1} \mathrm{P}$. de Wolft, "Employment forecasting techniques in the Netherlands", Enployment forecasting (Organization for Economic Co-operation and Development 1962), chap. V.

[^83]:    - J. Tinbergen, "Employment forecasting and planning", Employment forecasting (Organization for Economic Co-operation and Development 1962), chap. I.

[^84]:    3 W. H. Dawson, The avolution of modern Germany (New York, 1916), pp. 98-101.
    4F. Harbison and C. A. Myers, Education, manpower and economic growth (New York, 1964), pp. $84-85$ and p. 118.
    $\$ \mathrm{~J}$. Tinbergen, op. cit., p. 18.

[^85]:    ${ }^{6}$ Ibid., p. 14.
    ${ }^{7}$ H. B. Chenery, "The application of investment criteria", Quarterly Journal of Economics, vol. LXVII (1 February, 1953).
    8 P. J. Verdoorn, "Complementarity and long-range projections", Econometrica, vol. XXIV (1956), p. 429.

[^86]:    - International Labour Organisation, International standard classification of occupations (Geneva, 1958).

    10 S. O. Doos, "Forecasting manpower requirements by occupational categories," Planning education for economic and social development (Organization for Economic Co-operation and Development 1964), chap. XIII.

[^87]:    11 Harbison and Myers, op. cit., pp. 86, 122.
    12 S . Moberg, "Methods and techniques for forecasting specialized manpower requirements," Forecosting manpower needs for the age of science (Organization for European Economic Co-operation 1960), chap. VIIL.

[^88]:    18 Harbison and Myers, op. cit., p. 56.

[^89]:    ${ }^{14} \mathrm{P}$. de Wolff, "Intellectual resources and the growth of higher education", Forecasting. Manpower Needs for the Age of Science (Organization for European Economic Co-operation 1960), chap. XII.
    ${ }^{15} \mathrm{~J}$. Tinbergen, "Quantitative adaptation of education to accelerated growth", Planning Education for Economic and Social Development (Organization for Economic Co-operation and Development, 1964), chap. XVI.
    ${ }^{16}$ Arbetsmarknadsstyrelsen, Some recent manpower forecasts in Sweden (Stockholm, 1961).

[^90]:    ${ }^{17}$ D. M. Blank and G. J. Stigler, The Demand and Supply of Scientific Personnel (New York, National Bureau of Economic Research, 1959).

    18 State Planning Organization, Manpower Requirements and Educational Planning in Turkey (Ankara, 1962).
    ${ }^{19} \mathrm{~N}$. Erder, "Forecasting occupational structure of the Turkish labour force", Planning Education for Economic and Social Development (Organization for Economic Co-operation and Development 1964), chap. XIV.
    ${ }^{20}$ Commissariat général au plan, Rapport général de la Commission de la main-d'cutore (Paris, 1961).

[^91]:    21 H. Vermot Ganchy, "Nos besoins en ingénieurs", I et II, Bulletin SEDEIS, Nos. 663 (1 November 1956) and 665 (1 December 1956).

[^92]:    1E. G. Jacoby, "Methods of school enrollment projections", Educational Studies and Documents No. 32 (UṄESCO, August, 1959).

    2 United Nations, "Selected bibliography on methods of projecting the school-age population, the economically active population, the urban and rural population, and the number and size of households", United Nations Seminar on Evaluation and Uivilzation of Census Data in Asia and Far East (Bombay, India, 20 June-8 July 1960) (E/CN.9/CONF.2/1-ST/ TAO/SER.C/47).

[^93]:    3 U.S. Bureau of the Census, "Illustrative projections to 1980 of school and college enrolment in the United States", Current Population Reports, Population Estimates, Series P-25, No. 232 (June, 1961); U.S. Bureau of the Census, "Forecast of population and school enrolment in the United States, 1948 to 1960", Current Population Reports, Population Estimates, Series P-25, No. 18 (February, 1949) ; U.S. Bureau of the Census, "Projections of school enrolment in the United States, 1953 to 1965", Current Reports, Population Estimates, Series P-25, No. 85 (December, 1953); and Current Population Reports, Population Characteristics, Series P-25, annual issues on school enrolment.

[^94]:    ${ }^{4}$ Louis H. Conger, "College and university enrollment projections", Economics of Higher Education (U.S. Office of Education, Department of Health, Education, and Welfare, 1962).
    ${ }^{5}$ U.S. Bureau of the Census, "School enrolment and education of young adults and their fathers: October, 1960", Current Population Reports, Population Characteristics, Series P-20, No. 110 ( 24 July, 1961) ; and U.S. Bureau of the Census, "Educational changes in a generation: March 1962", Current Population Reports, Population Characteristics, Series P-20, No. 132 (22 September, 1964).

[^95]:    6 U.S. Department of Commerce and U.S. Department of Agriculture, "Educational status, callege plans, and occupational status of farm and nonfarm youths, October, 1959", Farm Population, Series Census - ERS (P-27), No. 30; and U.S. Department of Commerce and U.S. Department of Agriculture, "Factors related to college attendance of farm and non-farm high school, graduates", Farm Population, Series Census-ERS (P-27), No. 32 (1960).

    7 Edward G. Stockwell and Charles B. Nam, "Illustrative tables of school life", Journal of the American Statistical Association, vol. LVIII (December, 1963), pp. 1,113-1,124.

[^96]:    ${ }^{8}$ Meyer Zitter, "Forecasting school enrollment for the United States and local areas," The Journal of Teacher Education, vol. 5, No. 1 (March, 1954), pp. 53-63.
    ${ }^{9}$ United Nations, Population Growth and Manpower in the Philippines (a joint study by the United Nations and the Government of the Philippines, chapters VI and VII) (United Nations publication, Sales No. : 61.XIII.2).

[^97]:    1 United Nations, Guanabara Demographic Pilot Survey (United Nations publication, Sales No.: 64.XIII.3).
    ${ }^{2}$ United Nations, Multilingual Demographic Dichionary (United Nations publication, Sales No.: 58.XIII.4).

[^98]:    ${ }^{1}$ For example, the Chinese method of age reckoning, and its relationship to the western method, is described by You Poh Seng, "Errors in age reporting in statistically under-developed countries", Population Studies, vol. XII, No. 2 (Nov. 1959), pp. 164-182.

[^99]:    2 Jomo Kenyatta, Facing Mount Kenya (London 1953), p. 106. See also H. E. Lambert, Kikuyu Social and Political Institutions (London, 1956).

[^100]:    3 For a general description of the surveys, see the writer's "Experiments in vital registration and sample surveys of births and deaths in Kenya", paper presented to the E.C.A. Seminar on Vital Statistics, Addis Ababa, December 1964.

[^101]:    * For discussions of the use of sex ratios for assessing and adjusting faulty age distributions, see "Accuracy tests for census age distributions tabulated in five-year and ten-year groups", Population Bulletin, No. 2 (United Nations publication, Sales No.: 52.XIII.4), pp. 59-79, and N. H. Carrier and A. M.

[^102]:    7 United Nations, Demographic Yearbook 1962 (United Nations publication, Sales No.: 63.XIII.1), p. 17.

[^103]:    8 This is particularly true of Nyeri District, where the process of "land consolidation", which was initiated in the $1950^{\prime} \mathrm{s}$, resulted in the creation of a class of completely landless Africans on a scale pre-

[^104]:    ${ }^{9}$ Strictly speaking, these boys should have been shown on the survey schedules as not normally resident in the area, and would thus have been excluded from the de jure population. Unfortunately, the survey enumerators failed to do this.

[^105]:    ${ }^{1}$ This is a summary of the report submitted by the author to the Advisory Planning Group (Organization of American States, Inter-American Development Bank, United Nations Economic Commission for Latin America) at the end of a technical assistance mission to Uruguay in July-October, 1962. The report was published by the Investments and Economic Development Commission in Estudio Economico del Uruguay, Analisis Demogratico (Motevideo, 1963), and also by the Latin American Demographic Centre (Celade) in La Situacion Demografica del Uruguay en 1957 y Proyecciones a 1982 (Santiago, Chile, 1964).
    ${ }^{2}$ The following may be consulted: United Nations, The Population of South America, 1950-1980 (United Nations publication, Sales No.: 55.XIII.4); S. Garcia and A. Gaudiano, Algunos Aspectos Demograficos del Uruguay (Latin American Demographic Centre, document B.58/4-5, Santiago, Chile, 1958) ; A. Cataldi, Determinacion de la comosistion por sexo y edad de la poblacion del Uruguay, 1953 (Latin American Demographic Centre, document B. $60 / 1 / 5$, Santiago, Chile, 1961).

[^106]:    ${ }^{3}$ The term is applied to those who enter the country with the authorization of national migration authorities.
    ${ }_{4}$ United Nations, Demographic Yearbook, 1957 (United Nations publication, Sales No.: 57.XILILi).

[^107]:    * United Nations, Methods of estimating population, manual IIl: methods for population projections by sex and age (United Nations publication, Sales No.: 56.XIII.3).

[^108]:    ${ }^{6}$ Ibid.
    7 A. Campbell, A method of projecting mortality rates based on post-war international experience, United States Bureau of the Census (U.S. Government Printing Office, Series P.91, No. 5, Washington, D.C., 1958).

[^109]:    1 J. F. Holleman, Experiment in Swaziland, Swaziland Sample Survey 1960 (Institute for Social Research, University of Natal).

[^110]:    1 See P. H. Leslie, Biometrika, vol. XXXIII (1945), pp. 183-212, and vol. XXXV (1948), pp. 213245, for a detailed account of the matrix presentation of age-specific birth and death rates.

[^111]:    2 J. Johnston, Econometric methods (New York, McGraw-Hill, 1963), pp. 249 ff.

[^112]:    3 Olav Reiersol, "Identifability of a linear relation between variables which are subject to error," Cowles Commission Papers, New Series, No. 39.

[^113]:    1 Pakistan, National Planning Board, The First Five-Year Plan: 1955-1960 (Karachi, 1957), p. 191; The Second Five-Year Plan: 1960-1965 (Karachi, 1960), p. 331; Pakistan, Population Census, 1961, Census Bulletin No. 2; Ser, Urban-Rural, Religion, Non-Pokistanis (Karachi, 1961), p. 4; Karol J. Krotki, "Population size, growth, and age-distribution: fourth release from the 1961 Census of Pa kistan", The Pakistan Development Review, vol. III, No. 2, p. 302; and Pakistan, Outline of the Third Five-Year Plan: 1965-1970 (Karachi, August 1964), p. 204, paragraph 20.
    ${ }^{2}$ Karol J. Krótki and Nazim Ahmed, "Vital rates in East and West Pakistan: tentative results from the PGE experiment", The Pakistan Development Review, vol. IV, No. 4 (in press).

[^114]:    3 The actual process is less precise than the words "handing over" would suggest. Here, and in related parts of this paper, the writer draws heavily on a monograph, whose author, however, must not be held responsible for the conclusions suggested in the present paper. See Elizabeth Gustafson, Official Registration Systems of Vital Events in Pakistan, Studies Series PGE No. 9 (Karachi, Central Statistical Office, August 1964).

[^115]:    ${ }^{4}$ In circumstances where, because of economic and personnel restraints, a choice must be made, the collection of vital statistics must come before the determination of causes of death. However, see Ives Biraud, "Une méthode d'enregistrement des causes approximatives de décès dans les régions sous-développées" (A method of registration of approximate causes of death in the under-developed regions), InLernational Population Conference, New York, 1961, vol. II (London, International Union for the Scientific Study of Population, 1963), pp. 348-354.
    ${ }^{5}$ United Nations, Methods of Population Projections by Sex and Age (United Nations publication, Sales No.: 56.XIII.3), paragraph 88. For a similar preference for age group 5-9 when estimating births by the reverse survival method, see United Nations, Provisional Report on World Population Prospects, as assessed in 1963 (United Nations publication, Sales No. : 66.XIII.2), p. 22.

[^116]:    6 C. Chandrasekaran, "Fertility indices from limited data", Proceedings of International Population Conference, Ottarea, 1963 (Liège, International Union for the Scientific Study of Population, 1954), pp. 92 and 94.

[^117]:    ${ }^{7}$ M. K. H. Khan, "Assessment of birth rate in West Pakistan from the statistics of primary vaccination against smallpox", in M. L. Qureshik, ed., Population Groweth and Economic Development with Special Reference to Pakistan (Karachi, The Institute of Development Economics, 1960).

    8 Pakistan, Central Statistical Office, Notional Sample Survey (First Round) 1959 (Karachi, November 1960), pp. 11, 12, 15 and 16.

[^118]:    ${ }^{9}$ C. Chandra Sekar and W. Edward Deming, "On a method for estimating birth and death rates and the extent of registration", Journal of the American Statistical Association, vol. LXIV, No. 245, pp. 101-115.
    10 The Population Council, New York City; the US National Center for Health Statistics, Washington, D.C.
    ${ }^{11}$ It must not be assumed that the population growth estimation provisions do not meet special situations of respondents or contingencies of the recording process merely because they have not been described in this brief paper, especially if they refer to some of the more obvious situations, such as those in Helmut V. Muhsam, "Moderator's introductory statement", Proceedings of International Population Conference, Ottawa, 1963 (Liège, International Union for the Scientific Study of Population, 1964), p. 43. ${ }^{12}$ C. Chandra Sekar and W. Edward Deming, op. cit.

[^119]:    14 Elizabeth Gustafson, op. cit.
    ${ }^{15}$ Medical Social Research Projection Population, Third Annual Report (Lahore, West Pakistan, February 1964).

[^120]:    ${ }^{1}$ Government of India, "Vital rates", National Sample Survey, No. 54 (New Delhi, 1962).

    2 Government of India, Estimation of birth and death rates in India during 1941-1950, Census of India, paper No. 6 of 1954 (New Delhi, 1954).

    3 Government of India, Final Population Totals, Census of India, paper No. 1 of 1962 (New Delhi, 1962).
    ${ }^{4}$ Ajit Das Gupta, et al., "Couple fertility", National Sample Survey, No. 7 (Government of India, New Delhi, 1955).

[^121]:    5 The infant mortality rate came to 151 compared to 182 obtained from second and fourth round fertility data in respect of births to the marriage cohorts of the years 1946-1951; the under-reporting of still-births seemed to be even greater, the still-birth ratio coming to only 6 per 1,000 live births. The sex ratio at birth did not, however, indicate any sexselective lapse in reporting.

[^122]:    "Government of India, "Vital rates", National Sample Survey, No. 54 (New Delhi, 1962).

    7 Ajit Das Gupta, "Determination of tertility level and trend in defective registration areas", Bulletin of the International Statistical Institute, vol. XXXVI (1958). A curve of the type $y=c . e-a k^{2}$ fitted to the data, where $y$ devotes the number of births in the $k^{\text {th }}$ month preceding the day of survey, gave the birth rate as 40 and the death rate as 23 at $k=1$. See S . Sen Gupta, A. K. De and R. K. Som, On Recall Lapse in Birth Reporting, Indian Statistical Institute (mimeographed, 1958), also R. K. Som, "On recall lapse in demographic studies", International Population Conference, Vienna, 1959 (Vienna, International Union for the Scientific Study of Population, 1959).

[^123]:    Source: Government of India, "Preliminary estimates of birth and death rates and of the rate of growth of population", National Sample Survey, No. 48 (New Delhi, 1961).

[^124]:    8 Government of India, "Rates of birth, death, and growth of rural population", National Sample Survey No. 110 (draft).

[^125]:    Source: Office of Statistical Coordination and Standards, National Economic Council, Manila. a One municipality selected twice.
    b Three municapilities each selected twice.
    c One precinct selected twice.

[^126]:    ${ }^{1}$ National Economic Council, Monogroph No. 4 (Manila, Philippines), p. 3.
    2 B. T. Onate, "The role of statistics in Philippine development", Proceedings Issue of the Seminar on the Social and Economic Aspects of Agricultural Development (College of Agriculture, University of the Philippines, May, 1964.)
    ${ }^{3}$ D. C. Alonzo and M. B. Concepcion, Design of the National Household Sample Survey, Report to the Project Director (National Economic Council, January, 1956.)
    ${ }^{4} \mathrm{~B}$. T. Onate, "Development of multi-stage designs for statistical surveys in the Philippines", Statistic Reporter, vol. IV, No. 4 (October 1960).
    ${ }^{5}$ E. D. Makanas, On the Sample Design of the Philippine Statistical Survey of Households, M.A. Thesis (University of the Philippines Statistical Center, April, 1961.)

[^127]:    ${ }^{6}$ B. T. Oñate, Statistics in Rice Research, part III (The International Rice Research Institute Library, 1964), chapters IX, X, and XI.
    ${ }^{7} \mathrm{~B}$. T. Oñate, "Estimation of population count by province with the 1960 Philippine population census as the sampling frame: the Visayan region." Philippine Sociological Review, vol. III, Nos. 1 and 2 (April 1964.)
    ${ }^{8}$ B. T. Onate Estimation of Population Count by Province with the 1960 Philippine Poptlation Census As the Sampling Frame (The International Rice Research Institute Library, December, 1964).

[^128]:    ${ }^{9}$ Bureau of the Census and Statistics. The Urban Population of the Philippines, 1960, mimeographed paper (Manila, Philippines ${ }_{\mathbf{y}}$ 1963).

[^129]:    1 United Nations, United Nations Development Decade: a programme for international economic cooperation (I), Resolution 1710 (XVI) adopted by the General Assembly 19 December 1961 (United Nations publication, General Assembly Official Records, Sixteenth Session, Supplement No. $17-A / 5100$ ).

[^130]:    $*$ United Nations, Handbook of Population Census Methods (United Nations publication, Sales No: 58.XVII.6).

[^131]:    3 United Nations, United Nations Development Decade; a programme for international economic cooperation (I), Resolution 1710 (XVI) adopted by the General Assembly, 19 December 1961 (United Nations publication, General Assembly Official Records, Sixteenth Session, Supplement No. 17-A/5100).

[^132]:    4 United Nations, Report of the Second InterAmerican Seminar on Civil Registration (United Nations document E/CN.12/704).
    ${ }^{5}$ United Nations, Report of the African Semmar ort Vital Statistics (United Nations document E/ CN.14/333-E/CN.14/CAS.4/VS/14).

[^133]:    6 United Nations, Handbook of Household Surveys: A Practical Guide for Inquiries on Levels of Living (United Nations publication, Sales No.: 64. XVII.13).

[^134]:    ${ }^{1}$ S. Koller and L. Herberger, "Der Mikrozensus", Allgemeines Statistiches Archiv, No, 3 (1960), pp. 205-254.
    ${ }^{2}$ R. Deininger, "Repräsentativ-statistik der Bevölkerung und des Erwerbslebens (Mikrozensus)", Stichproben in der amtlichen Statistik (1960), pp. 135-175.
    ${ }^{3}$ United Nations, "Sample survey on population and economic activity (microcensus)", in Sample Surveys of Current Interest (Ninth Report) (United Nations publication, Sales No: 62 XVII. 3 ).
    ${ }^{4}$ United Nations, Sample Surveys of Currens Interest (Tenth Report) (United Nations publication, Sales No.: 64.XVII.11).

[^135]:    ${ }^{5}$ H. Schubnell, "Die Volks-und Berufszählung 1961, Methodische und Organisatorische Probleme", Allgeneines Statistisches Archiv, No. 1 (1962), pp. 22-51; No. 2 (1962), pp. 141-148.

[^136]:    ${ }^{1}$ Adapted in a simplified form from: M. H. Hansen, W. N. Hurwitz and M. A. Bershad, "Measurement errors in censuses and surveys", Bulletin of International Statistical Institute, vol. XXXVIII (1961), pe. 359-374.

[^137]:    2 P. C. Mahalanobis, "Recent experiments in statistical sampling in the Indian Statistical Institute", Journal of the Royal Statistical Society, vol. CIX (1946), pp. 325-370; reprinted by Asia Publishing House (Bombay, 1960).
    ${ }^{3}$ R. K. Som, A. K. De, N. C. Das, B. T. Pillai, H. L. Mukherjee, and S. M. U. Sarma, Preliminary Estimates of Birth and Death Rates and of the Rate of Growth of Population (New Delhi, Government of India, 1961).

    4 The Central African Statistical Office, Report on the Demographic Sample Survey of the African Population of Southern Rhodesia (Salisbury, 1951).

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    0 For a detailed study on recall lapse, see: United Nations Economic Commission for Africa, Technical Paper on Non-Sampling Errors and Biases in Retrospective Demographic Enquiries, E/CN.14/CAS.4/ VS/3 (1964). (Non-sales item.)
    ${ }^{7}$ P. C. Mahalanobis and A. Das Gupta, "The use of sample surveys in dernographic studies in India," Proctedings of the World Population Conference, Rome, 1954, vol. VI (United Nations publication, Sales No.: 55.XIIL.8).
    ${ }^{8} \mathrm{R}$. K. Som, "On recall lapse in demographic studies, International Population Conference, Vienna, 1959 (Vienna, International Union for the Scientific Study of Population, 1959).

[^139]:    ${ }^{9}$ A. Das Gupta, R. K. Som, M. Majumdar and S. Mitra, Couple Fertihty (New Delhi, Government of India, 1955).

[^140]:    10 Simplified from: W. Brass, Uses of Censts or Survey Data for the Estimation of Vital Rates, United Nations Economic Commission for Africa, E/CN.14/CAS.4/VS/7 (1964). (Non-sales item.)

[^141]:    18 United Nations, The Mysore Population Study (United Nations publication, Sales No.: 61.XIII.3). ${ }^{10} \mathrm{~K}$. Krotki, "First report of the population growth estimation experiment", International Population Conference, Ottazer, 1963 (Liège, International Union for the Scientific Study of Population, 1964).

[^142]:    20 Som, et al., op. cit.
    21 Linder, op cit.
    ${ }_{22}$ Das and Som, op. cit.
    23 Linder, op. cit.

[^143]:    1 Population data of Greece are labelled as "unreliable" in the United Nations Demogrophic Yearbooks.

[^144]:    Sources: United Nations, Demographic Yearbooks, 1953-1959 (United Nations publications, Sales Nos..: 53.XIII.9; 54.XIII.5; 55.XIII.6; 56.XIIL.5; 57.XIIL.1; 58.XIII.1; 59.XIII.1).
    a Registration area.

[^145]:    ${ }^{1}$ A. Jensen, "Report on the representative method in statistics", Bulletin de linstitut international de statistique, vol. XXII, première livraison (Rome, 1926), p. 360.

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[^146]:    ${ }^{3}$ P. Thionet, Méthodes statistiques modernes des administrations fédérales au. $\mathbf{v}$ Etats-Unis (Paris, Hermann et cie, 1946).

[^147]:    ${ }^{4}$ R. Blanc, Manuel de recherche démographique en pays sous-développés (France, Ministère de la coopération et Institut national de la statistique et des études économiques, 1962).
    ${ }^{5}$ United Nations, "Studies in methods", Handbook of Vital Statistics Methods. Series F. No. 7 (United Nations publication, Sales No.: 55.XVII.1), p. 155.

[^148]:    6 Ibid., p. 167.
    7 R. Blanc, op. cit, p. 213 et seq.

[^149]:    ${ }^{1}$ This question is studied in detail in the article by L. Henry, "Réflexions sur l'observation en démographie", Population, No. 2 (1963), pp. 233-262.

[^150]:    ${ }^{1}$ M. T. Sadler, The Law of Popwlation, vol. II (London, 1830), pp. 593-607.
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[^159]:    32 P. A. P. Moran, Proceedings Royal Society, Series B, vol. CXLIX (1958), pp. 102-112.
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[^161]:    39 A. T. Bharucha-Reid, Elements of the Theory of Markoy Processes and their Applications (New York, McGraw-Hill, 1960).

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    ${ }^{44}$ D. Basu, Sankhya, vol. XV, 1955), pp. 251-252.
    ${ }^{45}$ V. M. Dandekar, Sankhya, vol. XV (1955), pp. 237-250.
    ${ }^{46}$ W. F. Taylor, Proceedings Third Berkeley Symposium Statistics and Problems, vol. IV (1961), pp. 347-368.

[^163]:    1 Non-mathematical models (reduced-scale models of ships or aircraft, towing-tank or wind-tunnel tests, etc.) are rare in demography. However, there is an example of this kind of model at the Institut national d'etudes démographiques (INED). It consists of a plaster surface representing the numerical development of the French male population by age for the period 1930-1980. This is an example of a nonmathematical demographic model.

[^164]:    2 Example taken from P. Vincent, "Recherches sur la fécondité biologique. Etude d'un groupe de familles nombreuses", Travaux et docwnents, cahier no. 37 (Paris, Institut national d'études démographiques, 1961).

[^165]:    3 The probabilities in the formula are per 1,000 .

[^166]:    4 Example taken from H. Hyrenius and I. Adolfson, A fertility simulation model (Göteborg, 1964).

[^167]:    ${ }^{1}$ See paper by Sully Ledermann, "Models in demography," Proceedings, vol. III.

[^168]:    2 With an office machine.

[^169]:    ${ }^{3}$ Most of these programmes are published by IBM in its catalogues, together with references, authors and, in some cases, a summary of the content of the computations. There are special periodicals, such as Technonetrics (The American Society for Control and American Association), the Communications of the Association for Computing Machinery and the Abstract of Statistical Routine, which publish new programmes regularly.

[^170]:    ${ }^{1}$ The IPNS design, which has been used extensively in India since 1935 or 1936, has been discussed in P. C. Mahalanobis, "On large scale sample sur-

[^171]:    veys" in Philosophical Transactions of the Royal Society (London, 1944); and "Recent experiments in statistical sampling in the Indian Statistical Institute" in Journal of the Royal Statistical Society, vol. CIX, part 4 (1946). See also United Nations, Recommendations for the Preparation of Sample Survey Reports, provisional issue (United Nations publication, Sales No.: 64.XVII.7). Reports have also been published of the National Sample Survey of India in Sankya: the Indian Journal of Siatistics.

[^172]:    ${ }^{\text {a }}$ Each with 1 d.f. The symbol ( $r$ ) indicates error/party or error/time in $F$-ratio.
    b Significant at 5 per cent level: $F 5$ per cent $(1,1)=161.4$; at 1 per cent level : $F 1$ per cent $(1,1)=4,052$.

[^173]:    iB. Woolf, "On estimating the relation between blood group and disease": Anmols of Human Genetics, vol. XIX (1955), pp. 251-253.

[^174]:    2 J. M. Kennedy, "Linkage of birth and marriage records using a digital computer", $A E C L$ Report, No. 1258 (Chalk River, Ontario, Atomic Energy of Canada Limited, 1961).
    ${ }^{3}$ H. B. Newcombe, J. M. Kennedy, S. J. Axford and A. P. James "Automatic linkage of vital records", Science, vol. CXXX (1959), pp. 954-959.
    ${ }^{4}$ H. B. Newcombe and J. M. Kennedy, "Record linkage: making maximum use of the discriminating power of identifying information", Communications of the Association for Computing Machincry, vol. V (1962), pp. 563-566.

[^175]:    ${ }^{1}$ A selected list of the demographic publications of the United Nations is annexed to this paper.

[^176]:    ${ }^{1}$ Pakistan, National Planning Board, The First Five-Year Plan 1955-1960 (Karachi, 1957), chapter 13, section 34, p. 196.

[^177]:    2 The Family Planning Association of Pakistan, Knowledge of and Attintules Towards Family Planning (Lahore, 1961).
    ${ }^{3}$ Pakistan, Planning Commission, The Second FiveYear Plan 1960-1965 (Karachi, 1960), chapter 13, sections 10 and 13, pp. 334-335.

[^178]:    1 D. V. Glass, The University Teaching of Social Scionces: Demography (UNESCO publication: SS. 57.VIII.9A).

[^179]:    2 The syllabus is improved with experience, as is shown by the successive curricula of the Institut d'étude du développement économique et social and the Institut des sciences sociales du travail in Paris.

[^180]:    ${ }^{1}$ Food and Agriculture Organization, State of Food and Agriculture, recent annual volumes (Rome).

    2 Ibid.

[^181]:    ${ }^{3}$ United Nations, World Energy Supplies in Sem lected Years 1929-1950 (United Nations publication, Sales No.; 1952.XVII.3); United Nations, Statistical Yearbook, various issues; other United Nations sources.

[^182]:    ${ }^{4}$ Hans H. Landsberg, Leonard L. Fischman and Joseph L. Fisher, Resources in America's Future (Baltimore, Johns Hopkins Press, 1963), p. 35.

[^183]:    5 Joseph L. Fisher and Neal Potter, World Prospects for Natural Resources: Some Projections of Demand and Indicators of Supply to the Year 2000 (Washington, D.C., Resources for the Future, Inc., 1964).

[^184]:    6 From United Nations and other sources, as reported by the Population Reference Bureau, Washington, D.C., in Population Information for 129 Counthes, World Population Data Sheet (December 1964).

[^185]:    7 In this connexion, the establishment of a world resource development institute has been proposed, Which, among other things, could sponsor comprehensive and systematic projections of resource demand and supply, improve analytical techniques for evaluating resource projects, investigate the uses of new resource technology and otherwise assist in the effective planning of resource development. See Joseph L.

[^186]:    Source: minerals data from United States Bureau of Mines, 1963 Minerals Yearbook (Washington, D.C., 1964).

[^187]:    ${ }^{1}$ Theodore A. Wertime, "Man's first encounter with metals", Science, vol. 146 (1964), pp. 1,257-1,267.

[^188]:    ${ }^{2}$ Paul Averitt, "Estimated remaining coal reserves of the world by region and principal coal-producing countries" (1961), as reproduced in M. King Hubbert, Energy Resources, Publication $1000-\mathrm{D}$ (Washington, D.C., National Academy of Sciences, National Research Council 1962), p. 37, table 3.

[^189]:    3 Frank Wigglesworth Clarke, "The data of seochemistry", Builletin of the United States Geological Survey, vol. 770 (Washington, D.C., Government Printing Office, 1924), p. 34 .
    ${ }_{4}$ Elmer W. Pehrson, Man and Raw Materials, Edgar Marburg Lecture, 1958 (American Society for Testing Materials, 1959), p. 3. This material is based in part on the work of Ferdinand Friedensburg, "The future supply of metals", Zeitschrift für Erabergbau und Metallhuittenwesen (December 1957), pp. 573-576.

[^190]:    1 United Nations: 1. The status of permanent sovercignty over naturai wealth and resources; $I I$. Report of the Commission on Permanent Sovereignty over Natural Resources (United Nations publication, Sales No.: 62.V.6).

[^191]:    ${ }^{2}$ Report of the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, 8 vols. (United Nations publication, Sales No.: 63.1.21-28).

[^192]:    ${ }^{1}$ National Academy of Sciences, "Report on energy resources", reviewed in Chemical and Engineering Nezes, vol. 41, No. 4 (1963), pp. 25-26.
    ${ }^{2} \mathrm{~J}$. Gottman, Marches de matières premières ( $\mathrm{Pa}-$ ris, Armand Colin, 1957), p. 428.

[^193]:    3 The statistics given in the following paragraphs are based on a world population of 3,135 million in 1962. The United Nations classification of countries into industrialized and less-industrialized groups was followed. The centrally planned economies are not included in this classification, owing to lack of sufficient data. The 1962 population of the industrialized groups was 583.6 million; that of the centrally planned economies is 917 million; and that of the lessindustrialized group, 1,635 million. Thus, the lessindustrialized countries accounted for 73.6 per cent of world population, excluding the centrally planned economies, and numbered 2.38 as many inhabitants as the industrialized countries.
    ${ }^{4}$ United Nations Statistical Yearbook, 1963 (United Nations publication, Sales No.: 64.XVII.1), table 12.

[^194]:    5 United Nations, "Recommendation on minerals and fuels", Proceedings of the United Nations Cons ference on Trade and Development, Geneva 1964, vol. I (United Nations publication, Sales No.: 64.11. B.11), annex A.II.9.

[^195]:    ${ }^{6}$ G. Meir and R. Baldwin, Economic Development (New York, John Wiley \& Son, 1963), part 3.

[^196]:    1. Michel Cépède, Du prix de revient au produit net en agriculture, preface by André Mayer (Paris, Presses universitaires de France, 1946).
    ${ }^{2}$ François (de Neufchâteau), Circulaire du 25 Ven démiaire an VII.
    3 A. Woiekoff, Verteiling der Bevolkerung auf der Erde unter dem Einfluss der Naturverhaltnisse und der menschlichen Tätigkeit, Peterlann's Mitteilungen (Gotha, 1905).
    4 R . J. Turgot. Mémoire sur les mines et les carrieres; Lucien Febvre and L. Bataillon, La terre et r'évolution humaine. Collection: L'évolution de l'humanite, 2nd edition (Paris, 1924).
    ${ }^{6}$ Stuart Chase, Rich Land, Poor Land (New York, 1937).
[^197]:    - Henri Prat, Métamorphose explosive de l'humanité (Paris, 1960).
    ${ }^{7}$ M. Cépede, F. Houtard and L. Grond, Nourrir les hommes, preface by François Perroux (Brussels, Editions du CEP, 1963 ; English edition: Population and Food, New York, Sheed and Ward, 1964).

[^198]:    8 M. Cépède and M. Lengellé, L'économie de l'alimentation (Paris, Presses universitaires de France, Series "Que sais-je", No. 639).
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[^199]:    ${ }^{10} \mathrm{~V}$. Volterra, Legons sur la théorie mathématique de la lutte pour la vie (Paris, 1931).
    ${ }^{11}$ E. W. Zimmermann, World Resources and Industries (New York, 1933).

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    ${ }^{13} \mathrm{E}$. Lecouteux, Economie rurale, 2nd edition (Paris, 1889).

    14 P. Gourou, La terrs et l'homme en ExtrêmeOrient (Paris, Libraire Armand Colin, 1940),
    15 Michel Cépède, op. cit.
    16 M . Cépède, $\mathrm{F}_{\text {. Houtard and L. Grond, op. cit. }}$
    17 Michel Cépède, op. cit.
    $18 \mathrm{R} . \mathrm{J}$. Turgot, Mémoire sur les mines et les carrières.

[^200]:    18 Michel Cépède, op. cit.
    20 First World Congress for Rural Sociology (Dijon, August 1964), Sociologia Ruralis, vol. IV, No. 3-4 (1964).
    ${ }_{21}$ Sir James G. Frazer, The Golden Bough (trad. Stiebel et Toutain, Paris, 1910-1911).
    ${ }_{22}$ Michel Cépède, op. cit.
    ${ }^{25}$ Michel Cépede, op. cit.
    24 Stuart Chase, op. cit.

[^201]:    ${ }^{25} \mathrm{M}$. Cépède, L’agriculture dans les relations Europe-Etats-Unis (ISEA, Série Progrès et Agriculture, 1964).
    ${ }^{26}$ Stuart Chase, op. cit.
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[^202]:    32 M . Cépède and M. Lengellé, Economic alimentaire du globe, preface by André Mayer (Paris, éditions Genin, 1953) (Spanish edition: Economia Mundial de la Alimentacion, Barcelona, Salvat, 1956).

[^203]:    Source: United States of America, Department of Agriculture, The World Food Budget, 1970, Foreign Agricultural Economic Report No. 19, table 6 .

[^204]:    1 United States of America, Department of Agriculture, The World Food Budget, 1970, Foreign Agricultural Economic Report, No. 19, table 36.

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[^205]:    3 Food and Agriculture Organization, Development through Food: A Strategy for Surplus Utilization, rev. ed., Freedom from Hunger Campaign, Basic Study No. 2 (Rome, 1962).

[^206]:    ${ }^{1}$ International Labour Office, Why Labour Leaves the Land (Geneva, 1960); Organization for Economic Co-operation and Development, "Report on problems of manpower in agriculture" (Paris, 1964, in process).

[^207]:    2 United Nations, The Economic Development of Latin America in the Post-War Period (United Nations publication, Sales No.: 64.II.G.6), table 24, p. 29.
    ${ }^{3}$ Based on indications of share of agricultural population prepared by the Food and Agriculture Organization (FAO) of the United Nations. See FAO, Production Yearbook, vol. 15 (Rome, 1961); and United States of America, Department of Agriculture, Economic Research Service, Man, Land and Food, by L. R. Brown (Washington, D.C., 1963), Foreign Agricultural Economic Report No. 11, p. 84.

[^208]:    ${ }^{4}$ Data on agricultural employment and total labour force in Canada were supplied by the Government of Canada, Bureau of Statistics.

    5 There are differences in definitions of rural and urban populations, and of what constitutes a farm. In the census practices of Canada and the United States of America, however, these differences do not affect the broad trends shown.

[^209]:    Source: United Nations, The Economic Development of Latin America in the Post-War Period (United Nations publication, Sales No.: 64.II.G.6), pp. 28-29.

    Localities of more than 2,000 inhabitants.
    b Includes also forestry and fishing activities.

[^210]:    B For discussion of the role and contributions of agriculture to economic growth, see, for example, W. W. Rostow, The Stages of Economic Groweth (Cambridge, Cambridge University Press, 1960); S. Kuznets, "Economic growth and the contribution of agriculture", Proceedings of 11th International Conference of Agricultural Economics (London, Oxford University Press, 1963), pp. 39-61; United States of America, Department of Agriculture, Economic Research Service, Agriculture and Economic Growth (Washington, D.C., 1963). For an analysis challenging the view that agricultural development is a prerequisite for industrial development and emphasizing that it can be concurrent, see K. Ohkawa, "Concurrent growth of agriculture with industry: the Japanese case", International Explorations of Agricultural Economics (Ames, Iowa, Iowa State University Press, 1964), pp. 201-212.

[^211]:    7 United Nations, The Economic Development of Latin America in the Post-War Period (United Nations publication, Sales No. 64.II.G.6), tables 6, 103 and 111.

[^212]:    ${ }^{1}$ Sir Norman Wright, address to the British Association for the Advancement of Science (Cardiff, 1960).

[^213]:    ${ }^{2}$ United States of America, Department of Agriculture, Economic Research Service, Mans, Land and Food, by L. R. Brown (Washington, D.C., 1963), Foreign Agricultural Economic Report No. 11 .

[^214]:    Source: Food and Agriculture Organization of the United Nations, Production Yearbook, Vol. 15 (Rome, 1961). a Excluding China (mainland).

[^215]:    3 Food and Agriculture Organization, Possibilities of Increasing World Food Production, by W. H. Pawley (Rome, 1963).

[^216]:    4 Food and Agriculture Organization, Production Yearbook, vol. 14 (Rome, 1960).

[^217]:    ${ }^{5}$ Food and Agriculture Organization, Fisheries Division, Provisional Estimate Based on Partial Returns to Statistics Section (Rome, 1964).

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[^218]:    7 Food and Agriculture Organization, Third World Food Survey (Rome, 1963).

[^219]:    1 To simplify the problem the difference between the dynamics of the total product of agriculture and the dynamics of the agricultural product earmarked for consumption by the population has not been taken into account.
    ${ }^{2}$ A simplified assumption has been made that the rate of growth of the net product of agriculture is identical with the rate of growth of the output of agriculture. The author has used Kalecki's formula of the relation between the growth of the national income and investment. See Michal Kalecki, Zarys teorï wazosiu gospodarki socjalistycznje (An outine of the theory of growth of socialist economy) (Warsaw, 1963).

[^220]:    3 A high level of average food consumption does not preclude under-nourishment of some population groups, owing to the uneven distribution of food among various groups of society.

    4 This analysis completely disregards investment outlays relating to the substitution of farm machines and equipment for labour. Such outlays have grown very rapidly during the last two decades in the developed countries of Western Europe and North America.

    5 In the developing countries, a decline in the proportion of active farm population in total poptiation increase not only restricts development prospects in agricultural production, but also adds to the food demand in the country, since the per capita food consumption is higher for urban than for rural population.

[^221]:    ${ }^{6}$ The problem was discussed by Lenin, who wrote: "Of course, additional investments of labour and capital" may and do take place on a relatively small scale even when the technique of production has remained at the same level. In such cases, the law of diminishing returns' is applicable to a certain degree, i.e., in the sense that the unchanged technique of production imposes relatively very narrow limits upon the investment of additional labour and capital". N. Lenin, Writings, vol. 5 (Warsaw, 1950), p. 115.

[^222]:    ${ }^{7}$ Apart from this, when the increase in farm population is accompanied by an increase in disguised unemployment and agricultural incomes bear the burden of feeding the unemployed, possibilities of financing investment are further reduced.

[^223]:    8 In Poland, the rate of growth of the final agricultural product in peasant farms exceeds the rate of growth of the net product; this entails large investment outlays in the sector manufacturing capital goods for agriculture.

    9 It is assumed that in the developing countries, where the outlays of factory-made capital goods are low, the rate of growth of the final product is nearly the same as the rate of growth of the net product.

[^224]:    ${ }^{10}$ Josué de Castro, The Geography of Hunger (Boston, Little, Brown, 1952).

[^225]:    11 Ragnar Nurkse considers the agricultural overpopulation a potential source of accumulation of the economic development; he writes, "... One may say that the disguised unemployment of the over-populated regions of the peasant economy presents an enviable source of savings, which may be used for financing economic developments".. Ragnar Nurkse, Problems of Capital Formation in Underdeveloped Countries (Warsaw, 1962), p. 72.

[^226]:    a Exclusive of 455 million tons of grain used for sowing and as fodder for commercial livestock and draught animals.
    b Taking account of the utilization of secondary grain production.

[^227]:    1 Food and Agriculture Organization, Development through Food. A Strategy for Surplus Utilization (Rome, 1962), p. 1.
    ${ }^{2}$ New Scientist (London, 2 July, 1964), p. 36.
    3 Population Bulletin (Washington, May 1962), p. 55.

[^228]:    ${ }^{4}$ Food and Agriculture Organization, The State of Food and Agriculture, 1963 (Rome, 1963), p. 18.
    ${ }^{5}$ Food and Agriculture Organization, Monthly Butletin of Agricultural Economics and Statistics, No. $7-8$ (Rome, 1964), p. 18.

[^229]:    © United Nations, Boletin Económico de América Latina, vol. VIII, No. 2 (United Nations publication, Sales No.: 64.II.G.1), p. 172.
    ${ }^{7}$ Food and Agriculture Organization, Population and Food Supply (Rome, 1962), p. 26.

    8 Revista de Estadistica, No. 8 (Mexico, 1963), p. 891.

    9 Food and Agriculture Organization, Report of the Fourth Conference on Nutrition Problens in Latin America (Rome, 1959), p, 66.

[^230]:    10 United Nations, Report on the World Social Situation, 1963 (United Nations publication, Sales No.: 63,IV.4), p. 41.
    ${ }^{11}$ Calculated from data in United Nations, Compendium of Social Statistics: 1963 (United Nations publication, Sales No.: 63.XVII.3), p. 165.
    12 Panorama Econonico Latinoanericano, No. 52 (Havana, 1962), pp. 7-12.

[^231]:    13 P . George, Géographie de la consommation ( $\mathrm{Pa}-$ ris, 1963), pp. 11-13.

    14 United Nations Educational, Scientific and Cultural Organization, Social Aspects of Economic Development in Latin America, vol. 1 (United Nations Educational, Scientific and Cultural Organization, 1963), p. 138.

    15 United Nations, Boletín Económico de América Latina, vol. VIII, No. 2 (United Nations publication, Sales No.: 64.II.G.1), p. 181.

[^232]:    16 Lester B. Brown, Man, Land and Food (Washington, United States Department of Agriculture, 1963), p. 88.
    ${ }^{17}$ Food and Agriculture Organization, Production Ycarbook 1962 (Rome, 1963).

[^233]:    18 United Nations, Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, working paper No. 1582 C. 1.2 and No. 92 C.5.3.

    19 Food and Agriculture Organization, The State of Food and Agriculture 1962 (Rome, 1962), p. 11.

    20 United Nations, Boletin Estadistico de América Latina, vol. I, No. 1 (United Nations publication, Sales No.: 64.II.G.9), p. 109.
    ${ }_{21} \mathrm{~F}$. Benham, H. A. Holley, A Short Introduction to the Economy of Latin America (London, New York, Toronto, 1960), pp. 19-20.

[^234]:    25 Raúll Prebisch, "Hacia una dinámica del desarrollo latino-americano", Política No. 75 (Mexico, 1963), pp. 1-11.

[^235]:    1 Bertram Hutchinson, "The migrant population of urban Braxil", América Latina, vol. If (1963), pp. 41-72.

[^236]:    2 Waldemiro Bazzanella, "Industrialização e urbanização no Brazil" ("Industrialization and urbanization in Brazil"), América Latina, vol. I (1963), pp. 3-28.

[^237]:    Source: BNDE-Mercado Brasileiro de Fertilizantes.

[^238]:    ${ }^{3}$ Maria Leda Rodrigues de Almeida, "A produção de alimentos: tarefa para a agricultura brasileira" ("The production of food: tariff for the Brazilian agriculture") - CIDA-CLAPS study, mimeograph (1963).

[^239]:    ${ }^{4}$ The oligopolic characteristic of the market facilitates the control of the food production, imposing, when it wishes, a price increase on the consumer and a price decrease on the producer.

[^240]:    1 "The Forests Ordinance regards as stool land all lands which are at the disposal of any native community whilst the Local Government Ordinance defines stool lands as lands or interests in land which are controlled by a person or body of persons for the benefit of their subjects or by a tribal head or a company captain for the benefit of tribal or company subject", R. J. H. Pogucki, "The main principles of rural land tenure", in Agriculture and Land Use in Ghana (London, Oxford University Press), p. 181.

    2 "In areas where there is a pressure on land created by dense population, or where land is in demand because of its potential value, rights are per-

[^241]:    manently linked with defined parcels. On the other hand, where an abundance of available land combined with a scant population makes it easy to obtain land, or where the productivity of the soil, or the imponderabilia of environment do not foster profitable cultivation, rights consist rather of the power to use any piece of land within an area", ibid., p. 180.
    ${ }^{3}$ Polly Hill, The Gold Coast Cocoa Farmer: A Preliminary Survey (London, Oxford University Press, 1956).

[^242]:    ${ }^{4}$ Another system of group-land purchase which existed was known as "family land". In this case the buyers were all members of the same family. It is said that the system of family land-purchase was practised mostly in matrilineal societies, whereas company land-purchase was popular with patrilineal societies.

[^243]:    5"It used to be said (among the Akims) that lands about three miles away from a town might be safely sold without danger of the inhabitants starving for land", J. B. Danquah, Gold Coast: Akan Laws and Customs (London, Routledge, 1928), p. 213.

[^244]:    ${ }^{1}$ A. J. Coale and E. M. Hoover, Population Groweth and Economic Development in Low-Income Countries (Princeton, N.J., Princeton University Press, 1958).

[^245]:    2 V. N. Patwardhan, Dietary Allowances for Indians, Calories and Proteins, Special Report Series No. 35 (New Delhi, Indian Council of Medical Research, 1960 ).

    3 V. G. Panse, "Food availability and requirement for India", Bulletin of the International Institute of Statistucs, 33rd session (Paris, 1961).
    ${ }^{4}$ P. V. Sukhatme, "Food and nutrition situation in India", Indian Journal of Agriculiural Economics, vol. 17, No. 2 (New Delhi, 1962).

[^246]:    a In the case of Gujarat and West Bengal, the first two years of the period under consideration were somewhat abnormal. Leaving out these two years, the growth rates for the period 1954/55 to 1961/62 are given in brackets.

[^247]:    1 Grahame Clark, Archeology and Society, 2nd ed. (London, 1947) as cited in Colin Clark and M. Haswell, The Economics of Subsistance Agriculture (London and New York, 1964), p. 25.
    ${ }^{2}$ Clark and Haswell, op. cit.
    ${ }^{3}$ J. A. van Beukering, Het Ladangvraagstuk, Een Bedrijfs - en Sociaal Economisch Probleem, Mededeelingen van het Department van Economische Zaken in Nederlandsch-Indie, No. 9 (1947).

[^248]:    ${ }^{4}$ Clark and Haswell, op. cit., pp. 37-47.
    5 This assumes some additional food from "gathering in the field", as well as production from small gardens.
    ${ }^{6}$ Clark and Haswell, op. cit., p. 46.

[^249]:    ${ }^{7}$ B. N. Slicher van Bath, De agrarische geschiedenis van West Europa (1500-1850) (Utrecht/Antwerpen, 1960).

[^250]:    * C. W. Previté-Orton, The Shorter Cambridge Medieval History, vol. I (Cambridge, 1953), pp. 171172.

[^251]:    ${ }^{9}$ Slicher van Bath, op. cit., p. 17.

[^252]:    1 T. Yajima, Farmers' Health and Agricultwral Labour-Power in the Paddy-field Farming, Hokkaido University Bulletin (1954).

[^253]:    ${ }^{3}$ See, for example, Paul Henry Landis, Rural Life in Process, 2nd ed. (New York, McGraw-Hill, 1948), p. 194.

