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THE DEMOGRAPHIC STATE  
OF THE WORLD

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## FORWORD

Roughly 1.6 billion people, 40 percent of the world's population, live in urban areas today. At the beginning of the last century, the urban population of the world totaled only 25 million. According to recent United Nations estimates about 3.1 billion people, twice today's urban population, will be living in urban areas by the year 2000.

Scholars and policy makers often disagree when it comes to evaluating the desirability of current rapid rates of urban growth and urbanization in many parts of the globe. Some see this trend as fostering national processes of socioeconomic development, particularly in the poorer and rapidly urbanizing countries of the Third World; whereas others believe the consequences to be largely undesirable and argue that such urban growth should be slowed down.

This paper, originally written by Nathan Keyfitz for the U.S. National Academy of Sciences volume entitled *Five Year Outlook on Science and Technology*, was slightly revised by him during his stay at IIASA earlier this year and is being issued as a working paper with the kind permission of the Academy. It links together a number of topics of interest to the HSS Area and sets out an agenda of research that is congruent with our future plans.

A list of the papers in the Population, Resources, and Growth Series appears at the end of this report.

Andrei Rogers  
Chairman  
Human Settlements  
and Services Area

## PREFACE

The following pages have been drafted as Chapter I of the U.S. National Academy of Sciences second *Five Year Outlook on Science and Technology*. I had the help of Parker Mauldin, William Petersen, Samuel H. Preston, and Ronald Ridker in the drafting, but they are not responsible for the result. The responsibility is ultimately to be taken by the National Academy of Sciences, which will be interested in your comments, and particularly your correction of errors that remain.

The question with which this chapter deals is nothing less than world population and its relation to resources. Writing as I did under NAS sponsorship, I was not free to go into aspects of that problem on which there could be disagreement. With the amount of possible disagreement being great much had to be omitted, and considered as an attempt to resolve what is perhaps the major policy issue of our time, the present treatment is superficial. It is offered to IIASA officials in the hope that their researches will enable them to come closer to solving at least some of the many issues that my text leaves open.

On the one hand, there is a large literature, mostly written by natural scientists, that shows our industrial civilization undercut within a generation or two by lack of materials and particularly of energy. As the IIASA energy group has shown, the transition from fossil fuels on which we now operate to whatever their successor is to be will be enormously expensive, in energy terms as well as in money terms. We badly need the oil reserves to provide the energy that will build the nuclear generating stations, design and construct solar installations, grow the fuel for biomass. A hiatus in the transition could severely, perhaps irreparably, damage world industry. There is no assurance that such a hiatus will not occur.

Population numbers play an important part in analyzing the resources position. It is people who use energy, and with a given pattern of consumption and production twice the people use twice as much oil and twice as much of everything else. That the present crisis comes with a world population of 4.4 billion, of whom about one quarter are the high consumers of the developed countries, is significant and suggests what is ahead when the world figure has doubled and all of the large population demand, as they have the right to, the high consumption that is today the prerogative of a minority.

On the other hand, there is a voluminous and largely reassuring literature that points to the secular fall in prices of raw materials, when considered in terms of the price of labor and finished goods, and shows that when shortages are about to occur they are anticipated by the market, so that there will be both a warning of trouble ahead and an incentive to enterprise to proceed to the next phase in mankind's economic evolution. We have not even had such a warning yet--much of the price rise in the 1970s has been due to monopoly, and the problem is the monopoly rather than the shortage of materials.

Population causes difficulties in this view also, but not primarily as a threat to the environment and to supplies of raw materials. Population growth is troublesome because it prevents the accumulation of capital needed for the emergence from poverty.

Both viewpoints are represented in IIASA, as they are in the National Academy of Sciences. Yet it is possible that IIASA may be able to come closer to a resolution. Its distance from governments will help in this, as will the fact that much of its research is done in-house and hence by people better able to communicate with one another than the outside writers of the NAS *Outlook*.

What is clearly needed is to seek out those elements of resilience in biological and other natural systems, with which natural scientists are well acquainted, and somehow bring them into coherence with the resilience of economic systems, from which social scientists ask us to take comfort. If any research group is qualified to do this it is IIASA.

The following pages may be taken as a challenge to go further into the issues and to bring IIASA's intellectual equipment to bear on their resolution.

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## THE DEMOGRAPHIC STATE OF THE WORLD

### INTRODUCTION

Most of the more developed countries have birth rates\* too low to replace their populations. Their low rates of birth are associated with high proportions of women in the labor force, the diminishing stability of marriage, and a high consumption society that emphasizes the production of goods rather than the reproduction of people. Americans see no great need to arrest the approach of a stationary population; the governments of France, Austria, and especially the countries of Eastern Europe are doing what they can to reverse the downturn of fertility. The population problem in the advanced countries is not too few or too many people, but a prospective disadvantageous age distribution, some effects of internal and external migration, and a spatial distribution not everywhere congruent with economic opportunities.

These problems are slight compared with those that face the two-thirds of the planet counted as the less developed countries. Many of these show rapid technological and economic progress but, at the same time, the number of their poor is

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\*Demographic terms are defined in the glossary at the end of this paper.

increasing; this certainly applies to India and possibly to Brazil. Population growth handicaps their ability to accumulate capital and presses on resources. Recent energy and materials shortages have brought this aspect to general consciousness. But population also hurts in another way that did not arise in the 19th century when masses of workers were important for the early stages of industrialization. In the more advanced and automated production of the late 20th century, human muscles lose their economic value. Unemployment becomes a major problem of the poor countries.

Only a small part of the population problem reveals itself in the planetary figures. On the optimistic supposition that bare replacement will be reached early in the 21st century and that mortality will continue its present decline, the ultimate world population will be 9 billion, attained late in the 21st century. It will thus double from the present total. Current progress in agriculture and industry suggests that world food and other production could also double in the next century. On a global view, one could be moderately sanguine about the population-resource relation and even the population-capital ratio for an ultimate 9 billion people.

Such optimism is not justified when individual countries are considered. At present growth rates, Bangladesh has little prospect of attaining a satisfactory balance between its population on the one side and land and capital on the other. Not many of its 90 million people are likely to be able to sustain themselves by selling television sets, automobiles, and ships to the rest of the world. Egypt is creating a modern industrial machine and sending out skilled labor to the oil-producing countries, but the growth of Cairo presents intractable difficulties, as does the narrowly circumscribed tillable area of the Nile valley. Mexico, despite even more advanced industry as well as oil wealth, has some of the same crushing difficulties as Egypt; both require increasing food imports for their rapidly expanding urban populations. Brazil is more advanced industrially than either Egypt or Mexico, but the energy price increases of the 1970s have deferred the hope that its phenomenal economic



advance would soon reach the poor part of its population. Brazil's plans to use alcohol derived from sugarcane for fuel raise in a crucial form the conflict between expanding the industrial sector and feeding the poor. Nations of rising income from Poland to Tanzania suffer from chronic balance of payments deficits.

The increase in life expectancy, at the rate of half a year per calendar year in less developed countries, while births have remained high has produced crowding in areas that up to World War II had abundant space. Thus Burma, with 15 million people before World War II, could export 3 or 4 million tons of grain; today, with over 30 million people, Burma has no surplus for the world grain market; add another 15 million and it probably will have to import food. In a further stage, one can imagine its forests overcut and its oil reserves exhausted, so that it will have no funds to pay for food imports. This is what can happen with dynamic population numbers and a static economy.

Therefore it is inevitable that a realistic discussion of population will refer to individual countries. The compactness and simplicity of a global overview have to be relinquished if the implications of today's population trends are to be approached. A fresh-water shortage for the world as a whole could not occur for centuries, but it is here now for parts of the United States, not to mention Egypt. If the forests of the U.S.S.R. were accessible to the population of Bangladesh, there would be no firewood problem in either country. With free movement of grain around the world no one would be hungry, and the reserves needed to cover year-to-year fluctuations could be small.

If the problem disappears when one considers issues globally rather than nationally and regionally, it is in some sense created artificially when one disregards possible technical changes. Just as the world's population will at least double before it becomes stationary, so the world's resources will be multiplied by advancing technology in the century ahead. Some of the difficulty is only apparent, created by acknowledging that population will grow but neglecting the corresponding changes in resources. The technical progress of recent centuries

is going to be maintained in some degree, although difficulties in spreading the technology to poor countries can be expected. The trouble is that it is easier to visualize population growth than it is to picture technical and economic change. In this paper an effort is made to take both into account.

No one studying population should forget that technological advances could overcome all of the concerns about a population growing from 4 to 9 and perhaps to 12 billion. If nuclear or solar energy on a sufficiently large scale were to become available, or if tomorrow someone were to find a means of extracting energy inexpensively by controlled fusion, then cheap fertilizer and hence cheap food would be provided. Hydrolysis of water would bring about the hydrogen economy, with indefinite amounts of clean-burning fuel for transport, heating, lighting, and industry. Materials could not possibly be scarce once fuel was cheap, since much of the earth's crust could be used. Alternatively, many billions of people could live prosperously with present-day technology if capital were accumulated with single-minded determination.

The disappointments of the last decade have demonstrated the inadvisability of counting on technical leaps. Such leaps are hard to plan, and if they come they can have unexpected unfavorable consequences. It is possible to learn to extract coal cheaply and use it within acceptable limits of pollution, but it is not possible to learn to burn coal without producing carbon dioxide. Given that the distribution of population over the earth's surface has taken account, however roughly, of local food productivity, any major change could be disastrous even if the world's total food supply were increased--which there is no reason to assume would result from a rise in temperature.

To have faith in science and technology and to pursue promising leads that would relieve shortages of energy and materials and enable larger populations to live better is one thing; to count on near miracles that would solve the population problem at one stroke is quite another. The serious student of population wants to see intense activity in basic science and its technological applications, as well as in the operation

of the economy, that would make the globe fit for more people to live on; to go after single dramatic solutions is not as promising a strategy as making smaller changes along many lines, with emphasis on those lines that are labor intensive.

An encouraging feature of the postwar period is the rapid increase of human capital in virtually all countries. The spread of education at the several levels and the accumulation of industrial skills, are probably more important than any shortages of physical capital or resources.

Applications of science and technology are too large a subject for the present paper; they are treated elsewhere in the *NAS Outlook* volume. Here it is enough to say that it is never sufficient to ask whether the earth can sustain 4 or 9 or 12 billion people. The question is always whether the advance of technology can keep extending resources at a rate that will accommodate the population increase and permit a rising standard of living, country by country, in an imperfectly coordinated world.

In this paper, emphasis is placed on the components of population change. Thus it begins with mortality--the present levels, differentials among countries, between the sexes, and among social classes. It continues with fertility, where the range of uncertainty is greater and the implications for future population are larger than for mortality. Migration is then treated in some detail. A few years ago it was thought that, with the filling up of the Americas, the last great international movement--across the Atlantic from east to west--was over. That has proved to be wrong. Refugees from East to West Germany and from Cuba and Vietnam to the United States, guestworkers from southern Europe and western Asia to northern Europe, legal and illegal movement (across the U.S.-Mexican border, from Bangladesh to northern India, from ex-colonies to ex-metropolises) these are a few of the migration currents since World War II. It would be idle to suppose that the total movement will diminish in the future although the directions of the streams will change. Finally, the relation of population to resources is reported on briefly.

## MORTALITY

Deaths are one component of population change, the others being births and migrations. Changes in the death rate have been responsible for most of the change in human population growth during the 20th century. At the turn of the century, the death rate of the human population was on the order of 30-35 deaths per 1,000 population per year. By 1950-55, it had declined to about 19 per 1,000 and, by 1975-80, to about 11 per 1,000 (United Nations Population Division 1979). Most of the recent change has occurred in less developed regions, where crude death rates declined from approximately 23 per 1,000 in 1950-55 to an estimated 12 per 1,000 in 1975-80. During the same period, more developed countries as a group experienced a decline from only 10 to 9 per 1,000, their decline being counter-balanced by the aging of their populations. Only a small fraction of the decline in death rates in less developed regions has been offset by declines in birth rates during this century; the result is that world population grew at unprecedented rates in the period 1950-80.

Other measures of mortality are better indicators of a population's health and longevity. Life expectancy at birth has increased from approximately 47 years in 1950-55 to about 57 years by 1975-80 for the human population as a whole. For less developed regions, the corresponding figures are 43 and 55 years; in more developed regions, 64 and 71 years. The magnitude of these achievements is suggested by the fact that no one country in the world in 1900 had a life expectancy as high as the world average of 57 years in 1975-80.

These mortality improvements are distributed unevenly. As indicated by the above figures, improvements have been slower in more developed countries as they approach the limits to longevity under current medical knowledge and practice. Male longevity has improved more slowly than female in the post-World War II period in these countries. For example, in the United States male life expectancy grew by 3.7 years between 1950 and 1977 (from 65.6 to 69.3), while female life expectancy grew by 6.0 years (from 71.1 to 77.1 years) (U.S. Bureau

of the Census 1979b). Among developing regions, Latin American populations appear to have experienced a slower than average mortality decline in the last decades but, once again, the explanation may lie at least for some countries (Cuba, Puerto Rico, Costa Rica, Uruguay) in their location at the upper end of the range of observed life expectancies, where progress is less striking.

For countries in sub-Saharan Africa neither trends nor current levels are known with precision. The evidence on mortality levels in the region supports only the crudest assessment of current conditions. The United Nations estimate of life expectancy of 47.1 years in sub-Saharan Africa in 1975-80, which is probably the most reliable estimate available for the region, must be viewed in this light. All one can say is that mortality, especially in West Africa, is very high.

There is even less information about mortality levels in China, for which the United Nations assigns a life expectancy of 64 years in 1975-80. A more recent, unpublished analysis of data covering a part of the Chinese population in 1975 indicates for that part a life expectancy of 60-65 years and a crude death rate (total deaths divided by total population) of 8-10 per 1,000. The largest less developed country with reasonably reliable data on mortality is India. Its nationally representative Sample Registration System (SRS) probably includes about 90 percent of deaths that fall within the sample frame. It yielded a crude death rate of 16.5 per 1,000 in 1970-72 and 15.0 in 1976. SRS data have been combined with those from other sources to produce an estimate of life expectancy in India for the 1961-71 period of 45.5 years for females and 47.9 for males (Dyson 1979 and Registrar General of India 1979a). Life expectancy has probably increased by several years since that period.

#### Factors Influencing Mortality Trends in Less Developed Countries

The factors responsible for declines in mortality vary from time to time and from place to place. Much of the research that attempts to identify these factors for less developed countries in the postwar period has focused on the island of Sri Lanka.

The reasons for this concentration are a dramatic decline in mortality and presumptive causal factors, particularly the prevalence of malaria before and after a successful antimalarial campaign. The current consensus is that the antimalarial campaign of 1946-47 reduced the island's crude death rate by 4-5 per 1,000, representing 40 to 50 percent of the decline that occurred in crude death rates between 1936-45 and 1946-70.\* Other important contributors were improved nutrition and better organization of health facilities. This order of magnitude for the effectiveness of antimalarial campaigns is probably not seriously in error for Mauritius, Venezuela, Guatemala, India, and other countries with moderate malaria endemicity and successful antimalarial campaigns.

Longevity is rapidly increasing in many poor countries and regions. Kerala state in India, Sri Lanka, and Cuba all had life expectancies in the upper 60s or above in 1970-75 despite quite low levels of income (less than \$200 per capita in U.S. dollars in Kerala and Sri Lanka). Each of these populations has a health system oriented toward delivering basic services to the entire population, with emphasis on rural areas; each has a large-scale, government-sponsored nutritional supplementation program; and each has achieved unusually high levels of literacy.\*\* But each is also a relatively small population with a well-organized administrative structure commanding popular support. It is not clear how readily their success can be transferred to other areas.

#### Prospects for Mortality in Poor Countries

With an average life expectancy of about 55 years, less developed countries have completed about two-thirds of the transition from preindustrial mortality levels to those characteristic of a modern developed country. But they still show an

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\*The bibliography of studies of mortality decline in Sri Lanka is quite lengthy. The most authoritative analysis is Newman (1977).

\*\*On Kerala, see Ratcliffe (1975 and 1978), on Sri Lanka, see Isenman (1978), and on Cuba, see Diaz-Briquets (1978).

enormously high death rate among their poorest population sectors, as revealed by recent information on socioeconomic differences in mortality. Their white collar or well-educated urbanites enjoy life expectancies similar to those of more developed countries, while rural illiterate groups have levels that are 15-30 years lower.\* Multivariate analyses of several bodies of data suggest (they cannot prove) that the literacy (or educational attainment) of mothers is one of the most important factors in a household's mortality level (Caldwell 1979).

The death rate from diarrheal diseases in infancy and the second year of life continues to be high. These diseases are more prominent than they were in more developed countries at equivalent mortality levels, and they may help to explain why mortality below the age of 5 is often high relative to mortality above the age of 5 in less developed countries (Preston 1976). Problems become particularly acute around the time of weaning, when a child often first comes into contact with contaminated food and loses immunities transmitted through breast milk or acquired *in utero*. These problems sometimes result in a local peak in the age-curve of the death rate around the time of weaning, as in Guatemala and Senegal.

Whereas Latin American and Asian countries have reduced malaria death rates to a small fraction of their earlier levels, the same is not true of tropical Africa by some 4-8 years; infectious mosquitoes continue to be many times more common in parts of Africa than in other regions. Low incomes, a widely dispersed population, and weak health services contribute to the malaria death rate. What can be done is vividly illustrated by an insecticide spraying campaign in a village in Kenya, where the crude death rate was reduced from 24 per 1,000 to 13.5 per 1,000 in two years; no change in mortality occurred in the control village (Payne, et al. 1976). Unfortunately international initiatives against malaria have lost much of their momentum since the 1950s.

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\*These relations are best documented in Latin America. See the series United Nations (1976-1979).

Continued progress in reducing mortality in less developed countries does not require scientific or technical breakthroughs, but only the spread of a relatively few basic preventive and curative procedures throughout entire populations: oral rehydration in treatment of diarrheal disease, boiling of drinking water where piped clean water cannot be made available, construction of pit privies, immunization, and insecticide spraying are probably the keys to success over the next five years and beyond.

#### Mortality in More Developed Countries

Recent declines in fertility in more developed countries have greatly increased the leverage that mortality conditions exert on the size and structure of the population. These countries have reached the stage where approximately 93 percent of those born survive to their 50th birthday. Therefore, subsequent declines in mortality will not greatly increase the number of births occurring in these countries, a number that is projected to be steady or to decline in many of them. Without the youthful bias typically imparted to age distributions by high fertility, what happens to life expectancy at the age of 50 obviously has major implications for future populations.

Important changes seem to be occurring in mortality rates at older ages, particularly in the United States. For example, life expectancy at age 50 increased from 24.5 years in 1949-51 to 27.6 in 1978. Much of the recent improvement is attributable to declining death rates from diseases of the heart. The age-adjusted death rate from heart diseases declined slowly from 3.08 per 1,000 in 1950 to 2.86 in 1965. Thereafter, the decline accelerated rapidly and the rate reached 2.16 in 1976 (U.S. Bureau of the Census 1979b and U.S. Department of Health, Education, and Welfare 1978).

Several factors are involved in this rapid recent advance against heart disease mortality. There is evidence that Americans are increasingly heeding warnings about the adverse effects of practices such as cigarette smoking and high consumption of animal fats. For example, the proportion of the adult



male population that smokes cigarettes has declined from 52.4 percent in 1965 to 41.9 percent in 1976. U.S. Department of Agriculture figures show large declines between 1963 and 1975 in per capita consumption of animal fats.

Perhaps more important than these changes in personal habits is the diffusion of improved methods of treating hypertension. The percentage of people with hypertension who are receiving treatment has increased greatly over the last decade. This increase is spread throughout all race-sex groups and may account for the fact that improvements in life expectancy among blacks have exceeded those among whites in the last decade (U.S. Department of Health, Education, and Welfare 1979).

The United States is still behind several other developed countries. Table 1 displays estimates of life expectancy at birth for the latest available years in five developed countries. United States males fall three years short of male life expectancy in Japan, Sweden, or Norway. The U.S. female deficit is about half as large as the male. In general, the national differences shown in this table (as well as the sex differences) are dominated by differences in heart disease mortality. Some of these differences may have genetic components; it is instructive, for example, that Japanese-Americans have even higher life expectancies than the population of Japan itself (Kitagawa and Hauser 1973).

The relatively rapid decline in U.S. mortality from heart disease in the last 15 years is more than an erratic fluctuation. But there is still scope for additional progress. Much of this progress probably will occur through "risk factor intervention," in which large groups are persuaded to modify behavior in longevity-enhancing ways. Some community programs of this type have been successful (Breslow 1978). Whether a breakthrough in understanding and a slowing down of the aging process will occur in the next decade remains to be seen.

Infant and youthful mortality still demand attention. Although infant mortality has fallen in recent years in the United States, a number of countries still do much better than we do.

Table 1 Ranking of selected more developed countries according to life expectancy at birth in years for males and females (1970s).

Males			Females		
Country	Year	Life expectancy at birth	Country	Year	Life expectancy at birth
Japan	1977	72.69	Japan	1977	77.95
Sweden	1976	72.12	Sweden	1976	77.90
Norway	1975-76	71.85	Norway	1975-76	78.12
United States	1976	69.1	United States	1976	76.7
U.S.S.R.	1971-72	64.	U.S.S.R.	1971-72	74.

SOURCE: United Nations Population Division, drawn from official publications and files of the United Nations Statistical Office.

Accidents, homicides, and suicides are not causes of death on which medical advances will have much effect but one can hope for various kinds of nonmedical alleviation.

One can expect some major social adaptations to current and prospective mortality trends:

- As the life cycle lengthens, the need for individual adaptiveness increases. The lengthening of life is associated with more changes in the course of the life cycle: changes in careers, spouses, and residences, as well as reeducation. Life expectancy at birth for females in 1900 was 48 years, the same as life expectancy at age 32 today. Instead of being terminated by the death of a spouse, many marriages end in divorce. Education of adults is useful in proportion to the length of life remaining to them.
- Mortality declines at older ages will change the ratio of the retired to the active labor force. According to official U.S. Census Bureau projections that employ conservative mortality assumptions, the number of persons aged 65 and above is expected to increase by nearly 50 percent between 1975 and 1995. The ratio of the population 65 and over to that aged 15-64 will increase

by more than 50 percent before the end of the first quarter of the 21st century. Faster-than-expected mortality declines will put upward pressure on the age at retirement, a pressure that will be accommodated partly by the increased vitality of the elderly.

- More older people will have to concern themselves with support for and care of a parent. Under recent mortality and fertility conditions in the United States, 34 percent of persons aged 60 would have a living parent; if cancer were eliminated as a cause of death, this figure would increase to 42 percent.
- The sex difference in mortality is creating very different life cycles for males and females. Under recent U.S. conditions, a newborn American girl can expect to spend nine years of her life as a widow and has a 60 percent chance of dying in that state; for males, the corresponding figures are two years and 22 percent. Recent mortality changes show no sign of narrowing these sex differences.

Mortality conditions at older ages will stand close watching in the years ahead. In 1977, the U.S. Bureau of the Census modified its population projections from those produced in 1975 to incorporate several more years of data on mortality declines. The result was that the projected number of persons over the age of 65 in 2000 grew from 28.8 million to 31.87 million, a 10 percent increase in the projection over the course of two years (U.S. Bureau of the Census 1977). But the 1977 projection already appears extremely conservative in its assumption that male life expectancy will increase from 69.1 years in 1976 to 71.8 years by 2050; three countries have already surpassed the latter figure and U.S. males gained the 2.7 years that are projected for the next 75 years between 1960 and 1977 alone. Mortality conditions among the elderly will become particularly significant when the baby boom cohort reaches retirement age.

#### FERTILITY

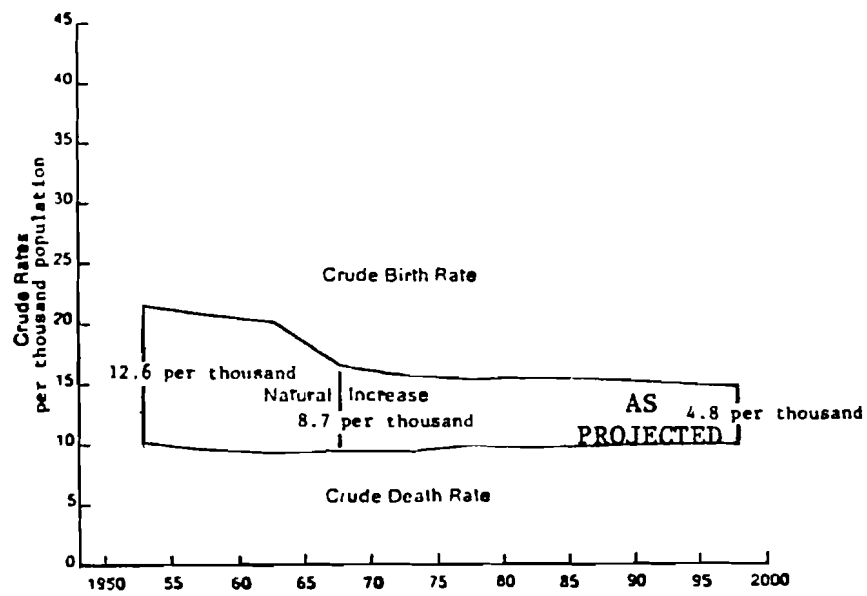
The world's crude birth rate (total births divided by total population) was about 36 births per 1,000 per year in 1950;

it has been reduced by about 20 percent during the past 30 years and is below 30 today. That is perceptible progress towards the goal of stationarity, where a crude death rate of 15 would correspond to a crude birth rate of 15.

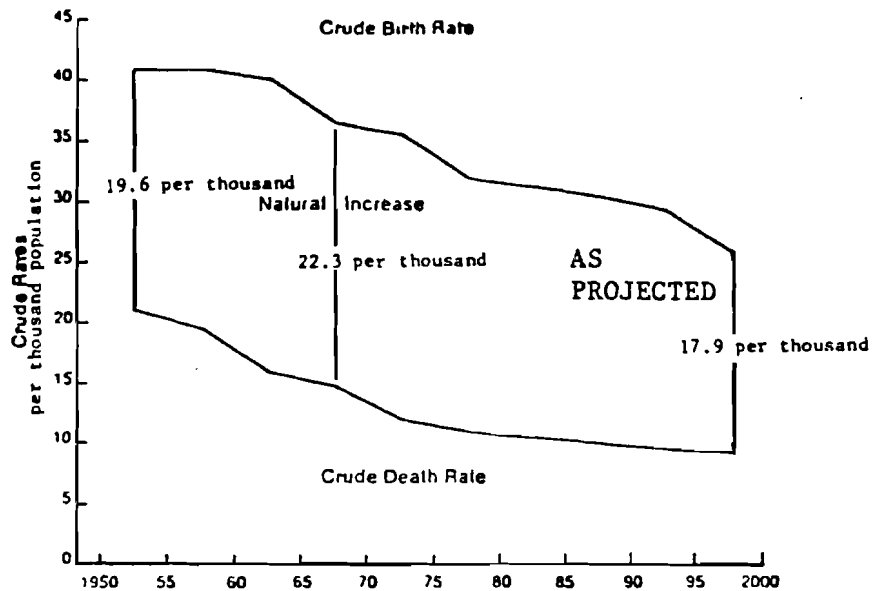
The more developed countries, with one-quarter of the world's population, had an average crude birth rate of about 23 in 1950. There has since been a decline of 32 percent, and the level of crude birth rates today is about 16 (see Figure 1).

A few of the more developed countries, including both West and East Germany, have more deaths than births, and many have rates of reproduction that, if continued, would result in a decline from present population levels. Population growth among the more developed countries poses no serious problem of total numbers but there are many problems of urbanization and distribution.

The less developed countries present a different picture. In 1950, the populations numbered 1.7 billion, and death rates were high--more than 23 per 1,000. The revolution in mortality has reduced the crude death rate almost by half to 11 or 12. Fertility was high in 1950, about 42 per 1,000. Thus the rate of growth was slightly less than 2 percent per year in 1950. The crude birth rate has declined from 42 to about 33--a decrease of nine points, or about 20 percent. Changes in fertility have been dramatic in Asia and the Pacific, substantial in Central and South America, and hardly noticeable in Africa. In Asia, where the bulk of the population lives, the crude birth rate declined by 25 percent from more than 41 to 31. In the Americas south of the Rio Grande, the decline was about 16 percent--from more than 41 to less than 35. Data for many African countries are inadequate, but what information exists suggests a crude birth rate of about 48 in 1950, perhaps dropping a couple of points to 46 by now. Only two countries in Africa, Tunisia and Mauritius, have shown appreciable changes in fertility over the 30-year period. Egypt's crude birth rate declined in the late 1960s and very early 1970s but, since that time, it has increased to 41 in 1979, about the same level as in 1965.



MORE DEVELOPED COUNTRIES



LESS DEVELOPED COUNTRIES

Figure 1 Crude birth and death rates and percentages of natural increase 1950-2000 (United Nations medium assumptions).

## More Developed Countries

With the sole exception of Ireland, all of the more developed countries experienced declines in fertility from 1950 to 1978. Declines ranged from about 10 percent in Spain to more than 25 percent for 22 countries (see Table 2) and were common to large and small countries, to capitalist and socialist nations, to European and non-European populations, to Catholics and Protestants. Most of western and northern Europe, Canada, the United States, and Japan have below replacement levels of fertility.

A number of more developed countries, chiefly in eastern Europe (where legalized abortion came to be associated with, or indeed produced, the low birth rate), are making determined pronatality efforts, using both negative and positive means. Negative measures include tightening restrictions on induced abortion and reducing the availability of contraceptives. Positive measures are a liberal increase in wages for couples having three or more children, interest-free loans for the purchase of an apartment or house and household furnishings with, for example, 20 percent of the loan being canceled at the birth of the first child, 30 percent for the second child, and the remaining 50 percent for the third child if born within eight years. Czechoslovakia, East Germany, Bulgaria, Hungary, and Romania have shown that such policies are not without effect.

In addition, a number of other developed countries have pronatalist ambitions or mild policies: Israel, for obvious internal and regional reasons of a politico-ethnic character; France, with a target since 1975 of attaining replacement fertility or slightly higher; Finland, with quantitative targets to prevent a decline in population in any of its counties; Greece, with a target of ensuring a population growth rate not much lower than 1 percent per annum; and Argentina, with pronatalist measures such as cash subsidies, housing and medical benefits, and others. The Netherlands reports the goal of achieving a stationary population, and Japan, that a stationary population is "estimated and expected."

Table 2 Population (1980) and changes in crude birth rates (1950-1978) in selected more developed countries.

Country	Population 1980 (thousands)	Crude birth rate 1950	Crude birth rate 1978	Percent change in crude birth rate 1950-78
The Americas				
Canada	24,073	27	15	-44
United States	<u>222,159</u>	<u>24</u>	<u>16</u>	<u>-33</u>
Subtotal	246,232	24	16	-34
Asia and the Pacific				
Australia	14,487	23	16	-33
Israel	3,950	35	25	-27
Japan	116,364	28	14	-50
New Zealand	<u>3,268</u>	<u>26</u>	<u>17</u>	<u>-35</u>
Subtotal	138,069	28	15	-47
Europe and the U.S.S.R.				
Bulgaria	9,007	25	16	-38
Czechoslovakia	15,336	23	18	-21
France	53,450	21	14	-32
Germany, Dem. Rep.	16,864	17	14	-17
Germany, Fed. Rep.	60,903	17	10	-42
Greece	9,329	20	16	-22
Hungary	10,761	21	15	-28
Ireland	3,307	21	22	+ 2
Italy	56,959	20	13	-36
Netherlands	14,082	23	13	-45
Poland	35,805	31	19	-38
Sweden	8,262	17	12	-30
United Kingdom	55,888	17	12	-25
U.S.S.R.	266,666	27	18	-32
Yugoslavia	<u>22,328</u>	<u>30</u>	<u>17</u>	<u>-43</u>
Subtotal	746,163	22	16	-31
TOTAL	1,130,463	23	16	-34

Very soon in the advanced countries--and ultimately in the less developed countries--the inevitable approach of a stationary population will bring important changes, not all of them desirable. There will be far more old people in relation to the labor force; the projections of the U.S. Bureau of the Census go from 11 persons 65 and over in 1940 for each 100 persons 18-64 years old to 17 by 1960, then a slow rise to 19 by the end of the century. Even the slow rise is causing trouble in the United States social security system. What, then, can be expected when the baby boom cohort comes of age and the number of persons 65 and over per 100 persons 18-64 years old goes to 24 in 2020 and 29 in 2030? A lowering of benefits, or people working to older ages, are the only means of avoiding tax increases.

In a sense, the aging will be offset by the community spending less on raising and educating children; however, in practice, savings on the young are not available to the old.

Within industry and business, the labor force will be older than in a time of rapid population increase, and this could have an effect on innovation. We do not know to what degree the creation and implementing of new ideas calls for new people.

#### Less Developed Countries

There are 92 less developed countries with a population of a million or more, but 2.6 billion, or 80 percent of the population of all less developed countries, live in 16 countries with over 35 million people each. Population data, crude birth rates, and percentage changes for 1965 and 1975 for these countries (except Vietnam) are given in Table 3.

Less developed countries vary enormously in culture, level of development, population policy, and changes in fertility. Brazil and Nigeria do not seek to reduce the rate of population growth but, in recent years, have adopted a policy of supporting family planning for reasons of health and as a human right.



Table 3 Population (1980), crude birth rates, and crude birth rate declines 1965-1975 (or later) in less developed countries with populations of 35 million or more.

Country <sup>a</sup>	Population 1980	Crude birth rate		Percent change in crude birth rate
	(millions)	1965	1975 <sup>b</sup>	1965-1975 <sup>b</sup>
China	975	34	20 (1978)	-41
India	694	43	36	-16
Indonesia	152	46	36	-22
Brazil	122	42	33 (1977)	-21
Bangladesh	89	48	48	<i>c</i>
Pakistan	82	47	47	<i>c</i>
Nigeria	77	49	49	<i>c</i>
Mexico	70	44	37 (1978)	-16
Philippines	51	44	34 (1977)	-23
Thailand	48	44	33	-26
Turkey	45	41	34	-16
Egypt	42	41	41 (1979)	<i>c</i>
Iran	38	45	45	<i>c</i>
South Korea	38	33	23	-31
Burma	<u>35</u>	<u>40</u>	<u>40</u>	<u><i>c</i></u>
TOTAL	2,523	40	31	-23

<sup>a</sup> Excludes Vietnam with an estimated population of 52 million; information on vital rates over time is not thought to be reliable.

<sup>b</sup> The crude birth rates and percent changes are for 1975 unless a later year is specified.

<sup>c</sup> No significant change.

Iran has tried to reduce its rate of population growth, but it is unlikely that the present government will continue that policy. Burma is frankly pronatalist. It recognizes family planning on maternal and child health grounds, but contraceptives are not easily available and family planning clinics are banned. All of the other countries have adopted policies intended to reduce the population growth rate.

There has been no significant reduction in fertility in Bangladesh, Burma, Iran, Pakistan, Nigeria, or Egypt, but there is evidence of change in each of the other nine countries of 35 million or more population. The decline has been particularly strong (more than 25 percent) in China, South Korea, and Thailand, and also has been impressive (more than 20 percent) in Brazil, Indonesia, and the Philippines.

The rate of population growth in less developed countries as a whole is down only slightly from its recent peak (see Table 4). It is now about 2.2 percent per year with a country range from about 1 percent to well over 3 percent.

Fertility declined more rapidly than mortality after 1965 in Asia and Latin America, and the rate of natural increase was smaller in Latin America and much smaller in Asia during the last five years than in 1960-65. Fertility and mortality declines were about equal in North Africa and the Middle East, but in sub-Saharan Africa fertility did not decline, whereas mortality probably did; so the rate of natural increase there continued to climb to an estimated 2.9 percent per year.

The net effect of these differing trends in the less developed countries was a modest decrease of about 6 percent in the rate of natural increase, from 2.35 percent in 1960-65 to 2.21 percent in 1975-80 (see Table 4).

A brief overview will be given of the eight largest developing countries. Together, these have a population of almost 2.25 billion, or about half that of the world, and about two-thirds of the population of all of the less developed countries.

Table 4 Percent of natural increase in population, 1950-1980.

Area	1950-55	1960-65	1975-80	Percent change 1960-65/1975-80
World	1.77	1.99	1.81	- 9.0
More developed countries	1.28	1.19	0.67	-43.7
Less developed countries	2.00	2.35	2.21	- 6.0
Africa	2.16	2.49	2.91	+16.9
Latin America	2.72	2.77	2.66	- 4.0
Asia	1.88	2.06	1.37	-33.5

#### *China*

China (975 million) has managed to reconcile Marxist tradition with population control. Population growth is viewed as detrimental to capital accumulation; it hinders the elevation of scientific and cultural levels and improvement of the level of living (Muhua 1979). The official goal is to lower growth from 1.2 percent in 1978 to 0.5 percent in 1985 and to zero by the year 2000. Third and higher order births are to be reduced and then eliminated and termination of childbearing after one rather than two children is to be promoted. The means are mobilization of party committees on all levels, strengthened propaganda and education, a system of rewards and penalties, and improved family planning services.

Most estimates of the population of China fall within the range of 950-1,000 million, but a reasonably firm figure must await the 1981 census. The government has announced a crude birth rate of 18.34 and a death rate of 6.29, and thus a growth rate of 1.2 percent in 1978. These figures are said to be estimates derived from incomplete data, and there may be some undercounting. In default of accurate knowledge, the crude birth rate is shown as 20 in Table 3. Some scholars speculate that the crude birth rate might be as high as 22 and the death rate as high as 8 per 1,000 population. Whatever the precise figures, it is evident that China has achieved remarkable improvements in health conditions and in the reduction of fertility.

## *India*

India (694 million) has a long history of population censuses; its total population is known with moderate accuracy, but the registration of births and deaths is incomplete. Prior to the mid-1960s, most estimates of vital events were necessarily based on the censuses. Now, and for the last 15 years, the Sample Registration System has produced estimates of birth and death rates for most states of India and for the country as a whole.

Analysts estimate that the average annual crude birth rate in India was about 45 per 1,000 population for the decade 1951-61 (Jain 1974). The latest estimate from the SRS is 34 for 1977, but the SRS probably undercounts, and a figure of 36-37 is more commonly accepted. These figures suggest a decline in the crude birth rate of about 10 percent from 1951-61 to 1961-71, and another decline of 10 percent from 1961-71 to about 1977. In 1976-78, the crude death rate was 14.5 per 1,000 (Registrar General of India 1979b).

There is great diversity in fertility in India. Rural rates average 5-7 points higher than urban rates, and in states the range is from the mid-20s to a high of 40. Six states report rates below 30 and four have rates of 35 or more. Uttar Pradesh, with a population of more than 100 million, has the highest crude birth rate, 40; Mahareshttra, with a population of 60 million, has a crude birth rate of 26.

A distinctive feature of the Indian family planning program has been its reliance on vasectomy, particularly in some states. Starting late in 1970, sterilization "camps" were organized in Kerala. These camps brought temporary facilities for sterilization into rural areas. They were accompanied by considerable publicity and usually by incentives for acceptors, partly in cash and partly in simple gifts. The cash value of incentives was of the order of \$15-20. These camps became quite popular and were introduced into 16 states by 1972-73. But a number of problems arose, primarily because of lack of adequate postoperative follow-up. There were some cases of death from tetanus following a vasectomy in one of the camps, and the program was discontinued.

During the emergency period, family planning was pushed to the point of coercion. The number of sterilizations increased to 8 million during 1976-77. With the change of government in 1977, the number of sterilizations decreased dramatically to 950,000 in 1977-78, and then increased to 1.6 million in 1978-79, still below the early 1970s.

Although India's crude birth rate has fallen significantly in recent years and, according to United Nations projections, may fall to about 26 for the period 1995-2000, a decrease of almost 29 percent from the estimated figure of 36.9 for 1975-80, the population will continue to grow rapidly. The population base is about 694 million, and an increase of just under one-half by the end of the century would take the population past the billion mark to 1,037,000,000.

#### *Indonesia*

The fertility of Indonesia (152 million) changed little from 1950 until the late 1960s. A large-scale family planning program, initiated in 1968 and well organized since 1970, has brought substantial change during the 1970s. This is reflected by a drop in the crude birth rate from 46 per 1,000 in 1965 to 36 in 1975.

The success of family planning has led to optimism about future fertility. The United Nations projects a decline from 37.9 in 1975-80 to 24.5 for the period 1995-2000. Although mortality is expected to decrease substantially (the crude death rate was 15 per 1,000 in 1978 [U.S. Bureau of the Census 1980b]), the Indonesian authorities are considering a target of replacement level fertility by the end of the century. The United Nations figures project a 35 percent increase in the population from just over 150 to just over 200 million.

#### *Brazil*

Until recent years, Brazil (122 million) has had high fertility and a rapidly growing population. During the past decade

and a half, however, fertility rates have decreased appreciably. The crude birth rate declined from 43 to 37 between 1960 to 1970 and more rapidly since 1970; the crude birth rate is estimated to be in the range of 31-33 for 1976-77 (U.S. Bureau of the Census forthcoming). Other estimates are even more hopeful, with one statistician stating that Brazilian fertility fell 26 percent from 1970 to 1976 (Berquo 1979).

In spite of recent fertility declines, the momentum of population growth in Brazil remains strong. Contributing to it is a low crude death rate of 8-9 per 1,000 (1978) (U.S. Bureau of Census 1980b). The country's population is projected to be about 200 million in the year 2000, with replacement fertility to be reached in the year 2015 (World Bank 1979). If that materializes, Brazil's population could stabilize at 341 million. Thus Brazil is likely to become the most populous country in the Americas sometime during the 21st century.

### *Bangladesh*

Although there is no evidence that fertility rates have begun to fall in Bangladesh (89 million), the United Nations projections (medium assumptions) assume a decrease in the crude birth rate from 47 to 35 by the end of the century. Its crude death rate is about 16.

Projecting these figures, the population would exceed 150 million by the year 2000. If Bangladesh does not achieve replacement fertility before the year 2035, as the World Bank projection assumes, the population would ultimately stabilize at 334 million. These hypothetical figures illustrate the problem ahead.

### *Pakistan*

Like Bangladesh, Pakistan (82 million) has a low per capita income, a low adult literacy rate, and a relatively low life expectancy at birth. Although there are differences of opinion on the level of the crude birth rate, it is clearly above 40. In 1979, the crude death rate was 16 (U.S. Bureau of the Census 1980a).

The World Bank projects a population of 139 million in the year 2000 and an ultimate population of 335 million.

### *Nigeria*

The crude birth rate of Nigeria (77 million) is around 50 and its death rate 17-20 (U.S. Bureau of the Census 1980b). The World Bank assumes that Nigerian replacement fertility will not be reached until 2040 and that the population would be 157 million in the year 2000--and ultimately 435 million. One can be skeptical whether such a population is possible; the fear is that, if fertility does not decline, mortality will increase.

### *Mexico*

Mexico (70 million), with a population of 70 million, had high fertility rates and high rates of population growth at least until the early 1970s. Since then, the crude birth rate has fallen by 13-15 percent to 37 in 1978 (the age structure acts as a brake on crude birth rate decline in a high fertility society). In 1977-79, the crude death rate was 8 (U.S. Bureau of the Census 1979a). The major decreases in fertility did not occur until a large-scale national family planning program was launched.

### Causes of Fertility Decline

Low fertility is always found in societies that have become industrialized and modernized, but a high degree of modernization does not seem to be a necessary condition for achieving low fertility, as the case of China shows. Some degree of consensus is emerging to the effect that:

- Marital patterns (age at marriage, proportion of reproductive years spent within marriage) account for a substantial part of the recent decline, perhaps one-third in developing countries, but marital fertility itself is the major component.
- Social setting, especially health and education status, has a close relationship to fertility decline.

- Family planning programs have a significant independent effect, at least in less developed countries with favorable social settings, including the three largest: China, India, and Indonesia.

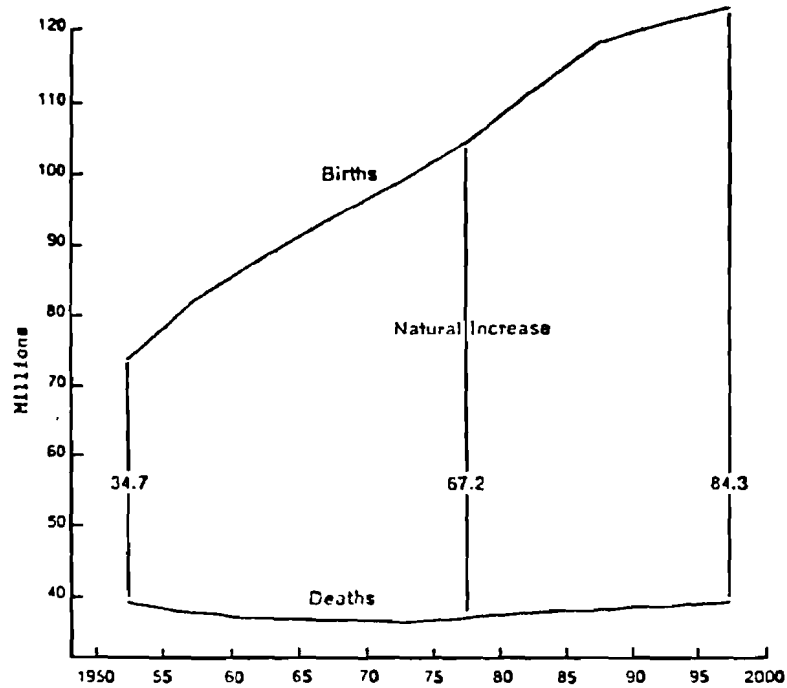
## Prospects

Population growth rates in less developed countries are high. Although they will moderate somewhat during the next two decades, the momentum of population growth is high and will lead to larger and larger absolute increases in the populations of the less developed countries during the remainder of this century, even though fertility rates will continue to decline (see Figure 2). A typical country with past high fertility and a current crude birth rate of about 40 would increase its population by 60 percent even if replacement fertility were achieved immediately.

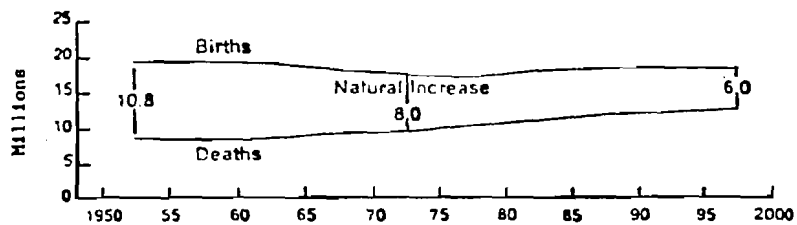
Population projections for the year 2000 center on 6 billion. Thus it is projected that the population of the world will increase by about 1.5 billion during the next 20 years. Africa is expected to have the most rapid growth, more than 75 percent, and Latin America the next most rapid, with about 65 percent growth. South Asia would grow by 55 percent and East Asia by 24 percent, according to these projections. North America and the U.S.S.R. would grow by 17-18 percent. Europe would grow very slowly, by only 7 percent.

No one knows when fertility will begin to decline, and at what rate in sub-Saharan Africa, Bangladesh, and Pakistan. Nor is there consensus as to what the size of the world's population will be when (and if) it ceases to grow. If replacement fertility were reached in every country of the world by the year 2000, the world population would not exceed 8.5 billion. But such a rapid decline in fertility seems unlikely. If replacement fertility were achieved by the period 2020-25, the population of the world would grow to 10.7 billion.





LESS DEVELOPED COUNTRIES



MORE DEVELOPED COUNTRIES

Figure 2 Average annual number of births, deaths, and population increase (United Nations medium assumptions).

## MIGRATION

Each year, the United Nations *Demographic Yearbook* supplements a general review of population statistics with a more detailed survey of one particular topic. In 1977, for the first time, it featured international migration. The data are poor, however, and not easily interpreted. For example, the number of recorded immigrants from Economic Commission for Europe (ECE) countries,\* into other ECE countries was 57 percent greater than that of the corresponding emigrants, partly because of time lags, but mainly because "emigrant" and "immigrant" are not defined consistently. With that much inaccuracy in the documentation of "normal" *legal* migration within the region with generally the best population statistics in the world, one must be wary of conclusions about refugees and illegal, or quasilegal, migrants.

Statistics on internal migration are usually even poorer, particularly in a country like the United States with no identity cards. Data are collected in sample surveys and, inferentially, from questions in the census on where respondents were living one or more years previously. The "mobile population," defined as those who resided in different houses within the United States on two successive dates, is divided by the Bureau of the Census into "movers" within a single county and "migrants" from one county to another. The latter category is further divided according to whether the migration was within the same states, to a contiguous state, or to a noncontiguous state, with international migrants classified separately. This differentiation is intended to distinguish shifts in residence that are and are not accompanied by changes in job, school, type of neighborhood, and so on; but it is not possible to mark these social-economic boundaries clearly by a geographical index.

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\*The 34-member countries of the Economic Commission for Europe are Albania, Austria, Belgium, Bulgaria, Byelorussian S.S.R., Canada, Cyprus, Czechoslovakia, Denmark, Finland, France, German Democratic Republic, Federal Republic of Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, Turkey, Ukrainian S.S.R., U.S.S.R., United Kingdom, United States of America, and Yugoslavia.

Perhaps the best estimate of the number of refugees in the world is given in the annual report of the U.S. Committee for Refugees, a private organization. By its count, the wars since 1945 have resulted in a flight of more than 60 million persons, of whom about 15 million still were not resettled in the mid-1970s. Although the figures obviously are not accurate enough to make precise comparisons, there has been a discernible upward trend. The total can be compared with the entire emigration from all of Europe between 1800 and 1950--also 60 million. Refugees are apparently the largest category of migrants in the world today.

But clandestine movements are widespread. According to a working estimate used in the late 1970s, one-tenth of the alien workers in European Common Market countries,\* or a total of some 600,000 persons, were at their current locations illegally. Following the decision of an international commission, anyone who knowingly organized illegal movements or employed illegal immigrants was to be subject to a punishment to be specified by each member country. Such controls are hampered by the citizenry's typical ambivalence toward illegal aliens and often by an ambiguity of the illegality itself. Britain, for example, reacted to the large influx of unskilled former colonials by imposing new controls--without, however, entirely abandoning the prior goal of free migration within the Commonwealth.

A somewhat similar situation developed in the region of the United States bordering on Mexico, where "illegal" immigrants are spoken of as merely "undocumented." Although the western hemisphere was formally excluded from the Immigration Acts adopted in the 1920s, consuls in Mexico were instructed to enforce rigorously the existing laws limiting visas to literate persons who would not engage in contract labor or become public charges. But, over the longer run, the influx of Mexicans continued to respond to the demand for agricultural labor in the southwestern United States.

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\*The nine Common Market countries are Belgium, Denmark, France, Federal Republic of Germany, Ireland, Italy, Luxembourg, Netherlands, and the United Kingdom.

By definition, the number of undocumented migrants is unknown. The number of undocumented Mexicans apprehended rose very slowly from a few thousand in the mid-1920s to well over a million in 1954, then fell to several tens of thousands in the following decade, rising again from under 100,000 in 1966 to over 500,000 in 1973. No useful estimates of the total flow or numbers present in the United States are available.

As far back as we have records, some migrants have been in temporary status. Chinese, as a prime example, generally left their home village with the intention of eventually returning; the large numbers who settled throughout southeastern Asia and elsewhere did so more or less reluctantly. In Africa, as another example, a villager would spend some years working in the mines, in order to acquire the means of establishing himself in village life. Even at the height of immigration to the United States, from around 1880 to 1914, a sizable proportion of immigrants--and of some nationalities even a majority--came as sojourners and, after amassing modest sums, returned home and were able to move up one notch in their village or small town.

Temporary migrants in Europe, usually called by their German designation of *Gastarbeiter* (guestworker), have received labor permits of varying duration, with which they have moved usually from one of the Mediterranean countries to one in northwestern Europe. By 1974-75, West Germany had a resident alien population of diverse nationalities of 4.1 million, over 60 percent male, scattered through most of the country but concentrated in urban-industrial regions. Because of their favorable age structure, the aliens' birth rate was almost three times that of the natives, and their death rate was less than a fifth of the native one. Moreover, although juridically the aliens were temporary, they were in fact becoming, or so it seemed, a part of the society. The 15 million or so alien residents of northwestern Europe in the early 1970s comprised what was often called the tenth member of the Common Market, larger in total population than several of the member countries.

The *Gastarbeiter* institution, however, proved to be more flexible than some critics believed it to be, as well as a more

serious problem than its proponents had anticipated. In Switzerland, with a higher proportion of temporary aliens than any other western European country, the world-famous amity among language and religious groups was seriously damaged. *Überfremdung* (in French, *hyperxénie*; in a possible English translation, "hyperforeignization") became a large issue in several elections and resulted in some major revisions in immigration laws. In Switzerland and in Germany, however, it was possible both to import labor when it was needed and to reduce the flow substantially when the need dried up. That there was more difficulty in France and Britain was due mainly to the fact that those countries imported labor from former colonies, persons who claimed--in some cases with a degree of success--full equality with natives. The question is whether the economic benefit of the *Gastarbeiter* program outweighs its small social cost.

Among permanent legal migrants, as stressed in the United Nations *Demographic Yearbook*, there also has been a marked change from the past. The major new fact is that emigration is from the world's less developed areas. In mid-1974, an estimated 9.5 million emigrants from those countries were residents of northwestern Europe, northern America, and Oceania. Latin America, which once had been second only to the United States as a target of immigration, has become a region of net emigration. Between 1960 and 1974, the international migration from Asia more than tripled.

The United States is still a significant country of immigration with nearly 400,000 newcomers per year. After the national quotas enacted in the 1920s were abandoned by the Immigration Act of 1965 (which went into effect in mid-1968), the sources of immigration shifted enough to affect the composition of the foreign stock almost immediately. Even when the nationality is the same by bureaucratic count, there may be significant differences between earlier and more recent immigrants. Virtually all of the Chinese residents in the United States before the change in law, for instance, spoke Cantonese, reflecting the province from which their forebears had come. The new immigrants from (or often through) Hong Kong speak Mandarin, and they

often feel as alien to the Chinese-American community as to the general American culture.

The advisory committee to President Nixon on population, known as the Rockefeller Commission, recommended more stringent measures to block illegal immigrants, including the statement that every two years Congress consider whether "the impact of immigration on the nation's demographic situation" indicates that the number admitted should be cut. Implementation of this will raise complex issues.

As a country develops, its urban sector grows by its own natural increase, by the annexation of new territory, and by the massive migration of countrymen out of agriculture into city occupations. Those who make this move successfully are rewarded with better jobs and incomes, and more varied and comfortable living. Although the rapid urban growth of less developed countries also derives in part from the better-paying jobs available in cities, the prevalent rural stagnation provides a strong impulse. Nonindustrial countries have enjoyed a remarkable decline in rural mortality; medicines, technicians, and death-control measures, disseminated from advanced nations through international agencies, have shattered the prior balance between the traditional economy and the rural population. The effects of the growing disparity between the countryside's resources and the numbers dependent on them, moreover, have been aggravated by a rise in expectations so rapid as to outstrip any conceivable improvement in the actual situation.

A very large proportion of this new type of migrant pushed out of the countryside lacks access to the most elementary urban facilities. Almost all large cities in less developed countries are ringed by squatter settlements, shantytowns of self-constructed huts which, in Latin America, for instance, may constitute a third or even half of the city's population. That as many as 50 percent of the Latin Americans in cities live in these conditions does not imply the shift in the economy, the degree of literacy, and the overall urbanity that this datum once would have suggested.

As one of the most significant elements of cities' innovating history, the small-family pattern arose there and then diffused among other sectors of society. In the historic West, urban fertility was lower everywhere than in the countryside; for, as a part of their effort to move up the social ladder, most of the villagers who came to cities reduced their family burden. The lower urban fertility that has been routine in the West, however, is only one of several patterns now to be found in less developed areas. In various countries, according to the data available, the differences between urban and rural fertility are very small.

According to several sample surveys by the Bureau of the Census, migration within the United States retains a characteristic behavior pattern. Most migrants are, as before, young adults, and the proportion of young children has become almost as high as that of persons in their 20s. In other words, there is now a greater family migration. Although the population in retirement areas is growing very fast, the persons who move to them are only a relatively small proportion of the country's older people. From 1965 to 1978, there was a net movement of 1.4 million persons out of the Northeast and the North Central region to the South and West; that is, the historical trend of westward movement has continued, and the migration out of the South has been reversed. This combination is typically explained as a drift to "the sun belt," but along with the attraction of climate in the southern and southwestern states is their relatively favorable attitude toward business, their frequently lower taxes, and their proximity to sources of energy.

By now, it has become a commonplace that urban areas have been growing in a new way. From about 1920 on, there has been a backflow from the central cities of metropolitan areas, both to residential suburbs and to smaller industrial or commercial cities, the so-called satellites in the standard metropolitan statistical areas (SMSA's). By 1970, two-thirds of the national population lived in SMSA's but, over the period 1970-77, the annual growth of the metropolitan population was 0.7 percent, while that of the nonmetropolitan population was 1.2 percent.

Within the SMSA's, central cities lost population and suburbs grew at a substantially higher rate than the nation as a whole. That some central cities have become black is well known; but, in spite of the stereotype of Mexicans as field workers, Hispanics are more metropolitan than either whites or blacks, with an estimated 84 percent of the Hispanic population living in SMSA's in 1978.

The immigration to American cities has changed in a way analogous to that of the urban centers of less developed countries. In many cases, the rural-urban migration of blacks and Hispanics has been based less on qualifications for city-based occupations than on such factors as displacement from cotton farming by the mechanical picker, a lag behind the rest of the country in the South's recognition of civil rights, and growing population pressures in Puerto Rico, other Caribbean and Central American countries, and especially Mexico.

In sum, both international and internal migration have been undergoing fundamental change. The models derived from past experience, usually at least implicit in the interpretation or even the perception of what is happening today, are at best deficient, at worst obsolete. The most common migrant in the world today is the refugee, and generalizations derived from economically motivated movements hardly apply to this politically generated flow.

The illegal flow of immigrants, partly overlapping with that of refugees, is not a temporary phenomenon that can be disposed of with either an absolute ban or total relaxation. Whatever its troubles, the American economy still provides so much better a life than most parts of the world that, given unlimited access, the world's destitute would submerge this country. What limit to place on access will continue to preoccupy the American government and public.

## RESOURCES

From a rudimentary viewpoint, population and resources present two sides of the same problem. With double the resources, including capital, double the population can be sustained at a given level of comfort. If resources and the techniques for converting them are fixed and population grows, then a declining



level of consumption is certain. If technology expands indefinitely, then so can both population and the standard of consumption. It is the prospects for technological and economic growth that distinguish those who see a 12 billion population living comfortably at equilibrium on the earth's surface from those who see the present population at most doubled and largely continuing in poverty, with the nations engaged in a bitter struggle for the world product.

Since resources are unevenly distributed over the surface of the planet, and by no means in proportion to population, the division of the world into partially closed national states adds a political factor to economic and technological ones. Trade is the means by which availabilities and needs can be made to coincide. Political and social obstacles to trade and the rational use of resources ought in some sense not to exist; and yet they are no more to be wished away than physical limitations.

With only a moderate degree of optimism, we may grant that the planet *ultimately* will be able to hold comfortably 9 to 12 billion people, but the immediate question is whether the pace of the growth of population can be matched by the pace of the advance in materials, energy, and capital. Any realistic discussion must be largely concerned with the bridge between the present state of affairs and the ultimate stationary one. Is agriculture expanding fast enough so that the 90 million Bangladeshis now in place (not to mention the 150 million expected in the year 2000) are moving toward a satisfactory diet? Will net sources of energy be available before oil supplies are exhausted? Energy is the key to the release of materials; will energy supplies and the efficiency with which they are extracted and used increase fast enough to provide the aluminum and steel that 6 billion people will need by the end of the century and that 9 to 12 billion will require in 2100? The following discussion concerns prospective rates of change rather than absolute levels of resources.

Global per capita production of cereals has continued erratically upward. But it has grown more rapidly in a few more developed countries than it has in the majority of the less

developed countries. The latter have compensated by increases in imports which make them more vulnerable to shifts in terms of trade, balance of payments problems, and shortfalls abroad. Whether this situation can continue in countries faced with mounting energy import bills and limited export potential depends on the availability of foreign credit and grants. The uncertainties in the situation are perplexing and worrisome. While they are exacerbated by population growth, they would be there even if population growth were to cease. Given the fluctuations of output in the United States and abroad, and the demand for our cereals in countries with strong economies, the dependence of some poor countries on American agriculture could give rise to some difficult ethical and political problems in the next few years.

Agricultural production can be efficient in a variety of ways. The Japanese have achieved high productivity levels by using relatively little land but a great deal of labor and chemical input. In contrast, the U.S. uses little labor but much land and mechanized input to achieve similar productivity levels (Ruttan 1978).

Both approaches, however, are based on a highly developed scientific infrastructure and substantial inputs of energy. Given these two ingredients, there appears to be sufficient flexibility in agricultural production techniques to achieve reasonable levels of productivity in most countries.

Roger Revelle (1975) has asked how many people could be fed and fed well if yields comparable to those obtained by Iowa corn farmers--which are not the highest in the world--were achieved globally on all arable land. His answer is a large multiple of the present population. Such production levels may never be feasible because of organizational and institutional limitations, but his analysis is useful to make it clear that the sheer availability of land is not the central problem in feeding the world's growing numbers. Rather, it is the persistent disparities in the distribution of people on the one side, and production capacity on the other. Production capacity depends on all the factors contributing to the production

of food--capital, scientific expertise, trained manpower, and adequate institutions, as well as land, energy, water, and other physical elements.

The U.S. National Academy of Sciences has made contributions to knowledge through the several volumes of its report on food resources (Revelle 1978). One contribution has been made through calling attention to the possibilities of *Leucaena*, a leguminous tree that can fix some 500 pounds of nitrogen per acre per year, with some strains growing to 65 feet in height. It puts down deep roots that enable it to tolerate drought. Cattle feed on its leaves; its wood is used for timber and fuel; it holds down soil on slopes that have been subject to erosion; its pods and seeds are used as human food in Central America and Indonesia. When cut, the stumps produce shoots that in some varieties reach 18 feet in 12 months. There are few more effective converters of sunlight; the chief problem is to get this valuable tree disseminated (National Academy of Sciences 1977).

Worldwide per capita production of petroleum appears to have peaked in 1974. This is the result of the four-fold increase in prices in 1973-74 which dampened demand rather than a sign of impending global depletion. Since World War II, depletion of older working fields in the United States and elsewhere, along with discoveries in the Middle East, led to concentration of production in a small group of countries which, for political as well as economic reasons, banded together to raise the price. There are very serious dangers in the current world energy situation, stemming more from the fact that importing countries have become increasingly dependent on supplies from a politically unstable area of the world than from the likelihood of imminent exhaustion.

According to Goeller and Weinberg, a reasonable standard of living for 10 billion people would require 60 terawatts of energy (Goeller and Weinberg 1976). This figure compares to about 7.5 terawatts used today and is about 1/2,000 of the energy absorbed from the sun. Can a 60-terawatt world be reached and sustained?

It can, insofar as the sheer availability of energy is concerned. Coal alone could supply the energy needs of 10 billion people for several hundred years. Nuclear and solar sources could eventually do the same for even longer. But each of these sources has potentially serious problems. Coal dirties the environment. Continued and expanded combustion of fossil fuels along with deforestation could lead to increased atmospheric carbon dioxide levels which could increase world temperature levels. Carbon dioxide in the concentration that would follow the spread of industrial civilization based on coal could warm the planet, change the windstreams of the atmosphere and the currents of the oceans, raise the temperature of some cold countries, and make some wet countries dry. While the effects on agriculture would be negative in some regions and positive in others, there is little doubt that severe social disruptions could ensue. If the worst fears of some are realized, we will not be able to use all of the coal and fossil fuels we have available to us.

Nuclear fission avoids increasing carbon dioxide, but it raises a further set of difficult and dangerous issues, from the risks of catastrophic accidents to the diversion of fissionable materials into atomic weapons. If the secrets of nuclear fusion can be unlocked and applied at reasonable cost, most of these concerns will be resolved (although some radiation and waste disposal problems will remain). But for practical purposes fusion is several decades away.

Solar energy creates only minor environmental problems; the large land areas it requires would be available in deserts useful for little else. It is the one source that gives promise of production by the household for its own use. But to utilize it in large quantities will require a substantial lowering of cost, especially in the direct generation of electricity, as well as storage devices not now available. To produce significant quantities of biomass for energy use with today's technology would bring energy production into direct competition with agriculture for arable land. Still, solar energy in its various forms, plus fission, are the best hopes we have for a sustainable energy future.

Nonfuel minerals are not likely to run short. While current plus prospective reserves of some important minerals would be exhausted in a few decades at present relative prices, if there is no technological change, and no change in recycling rates, these conditions will probably not hold. In the worst case global prospective reserves of bauxite (from which aluminum is derived), for example, might be exhausted around 2040, but there are many other sources of aluminum. If they had to be used today, production costs would rise by at least 20 and perhaps as much as 80 percent; with prospective technological improvements, the crossover price is likely to decrease significantly over time, certainly before bauxite is exhausted. For some other nonfuel minerals, substitutes can be found easily at costs only marginally higher than current levels.

Can more abundant minerals be substituted for less abundant ones without substantial increases in cost? With three exceptions, Goeller and Weinberg argue that they can--that societies can turn to nearly inexhaustible minerals with little loss of welfare (Goeller and Weinberg 1976). Detailed studies of cadmium, zinc, lead, copper, tin, and mercury indicate that a number of materials such as iron, aluminum, silicon, magnesium, titanium, and others can be substituted in many uses. Other studies find that these abundant materials can be acquired from lower grade ores which are in nearly inexhaustible supply, provided that sufficient energy is available at reasonable costs, both economic and environmental. In addition, glass and cement from virtually unlimited sources (sand, soda, clay, limestone), plastics, and some materials derived from renewable wood and plant sources can be substituted for many of the minerals that might eventually be exhausted.

The exceptions--important resources that are not in unlimited supply--are fossil fuels, phosphorus, and a few elements essential in trace amounts for agricultural production, such as copper, zinc, and cobalt. While reserves and prospective reserves of coal, phosphorus, and these trace elements are adequate for several hundred years, they are not inexhaustible.

Ultimately, phosphorus and some portion of the trace elements may have to be reserved for agricultural use and returned to the soil by recycling agricultural and animal wastes, and perhaps even bones. But fossil fuels cannot be recycled; eventually, a replacement must be found, even for coal.

Recycling can stretch supplies of nonfuel minerals. It has the advantage that the energy required to put materials back into productive use is generally less than that needed to reduce and refine ores. Goeller and Weinberg point out that, for magnesium, the remelt energy is only 1.5 percent of the energy required to win the metal from virgin ore; for aluminum, it is 3 to 4 percent; and for titanium, it is 30 percent (Goeller and Weinberg 1976).

There are signs that forestry and fisheries are being overexploited. One sign is the downward trend in per capita wood production since 1965; another is the decline in the surface area of the globe covered by forest. Most of the deforestation is occurring in less developed countries where energy price rises, population growth, and the need for additional agricultural land are intensifying pressures on fuel wood and forested land, especially in the delicate ecosystems of tropical forests. But production techniques are changing rapidly in forestry as well as in agriculture. Settled farming techniques are beginning to be applied. The change is most marked in the forestry sectors of more developed countries, but even in less developed countries isolated examples of successful reforestation and village woodlot programs can be found. The fishing industry is further behind in applying farming techniques, in large part because the technological problems are more difficult; but research and commercial activities in this area are increasing. Some changes are clearly necessary; there has been no increase in the world fish catch since 1970, despite great increase in fishing effort.

Water, air, and land pollution pose serious problems for environmental resources in those countries that have not mounted the effort necessary to avoid or offset deterioration. Both population and economic growth tend to have adverse effects on

the environment. But environmental protection programs are halting many forms of deterioration at affordable costs.

Possibilities for the more sparing use of materials, and conservation both by producers and by households, are extensive. The answer to the question of whether growth of demand is outstripping supply is inconclusive. There are some signs of deterioration on a global level but also some signs of improvement.

The key to the long-run sustainability of life on earth is energy. If there is sufficient low-cost energy, and if it can be utilized without adverse environmental effects, land can be reclaimed, seawater can be desalted, fertilizers produced, low-grade ores mined, metals recycled, and substitutions made between minerals.

#### CONCLUSION

Population problems take very different forms in the more developed and the less developed countries. The less developed countries still face much infectious disease, to which malnutrition makes many of their citizens more susceptible; in the more developed countries, the question is rather how to bring heart disease and cancer under control. For the less developed countries, the prime question on fertility is when childbearing will come down to levels at which the population would just replace itself; more developed countries are mostly below replacement already.

The stability and wholesomeness of the environment are prominent in the minds of those in comfortable economic circumstances; for the poor of the world such considerations are subordinate to sheer survival--an issue that reveals itself in different attitudes to the use of DDT against insect pests and in many other ways. For the more developed countries, the ocean's minerals represent an immediate opportunity to supplement expensive terrestrial resources; less developed countries would like to see those minerals left where they are until they themselves are in a position to join in their exploitation.

The list of real differences is a long one and finds expression in lively ideological and political exchange.

The less developed countries have shown rapid progress in extending life expectancy over the post-war period, many increasing it by six months in each calendar year. Among more developed countries, progress has been slower; the United States, for instance, gained 26 years since 1900 to reach 73.2 years by 1977. Differentials are still found everywhere; for the United States, the most favored sex-race group is white females, with 77.7 years' life expectation at birth and a median age at death of 81.1 years. This means that half of the white girl children born would live to 81.1 years or more, according to the mortality rates of 1977.

The resistance to further advance can be illustrated by the effort to eradicate cancer in the United States. The utmost that complete eradication of cancer could do is to increase the expectation of life by about 2 years. Increase in some forms of cancer in recent years is in part because people who are saved from heart disease are of the age to fall victim to cancer. Aside from this, the basic biology of cell reproduction is not well enough understood that one can confidently proceed to specifics for the prevention or cure of cancer with the unknowns described in detail in the second chapter of this report. How to allocate research resources between increasing knowledge of the basic biology on the one side and devising specific therapies on the other will continue to be a problem of scientific administration.

Although no exact figures are available, a recent Presidential Commission on World Hunger reports that the number of hungry people in the world is increasing. Mortality increase through famine is a possibility, but more to be feared is the susceptibility to disease brought about by chronic malnutrition. Malnutrition is only one of the conditions that raise the possibility of a reversal of the downward trend in deaths for the world as a whole. The complex ecology of snails and of the anopheles mosquito may be another, and the interaction with malnutrition is especially threatening.



Unprecedentedly low birth rates have started to appear in the industrial countries. The Federal Republic of Germany shows 9 per 1,000 population in 1978 (against a death rate of 12); Austria and Sweden show 11; the United Kingdom 12; the United States 15. Whether such low rates are a temporary dip, or are a durable feature of advanced industrial societies, no one can yet say. It is known that, with increasing wealth, children come into conflict with other expenditures, and parents see them as too expensive. But the apparent cost of children is only one element in the decline of the birth rate.

The falling birth rate is associated with important changes in the institution of the family, in which the United States may be in the lead. Between 1960 and 1975, two-worker husband-wife families without children increased from 23 percent to 30 percent of all American households; one-worker husband-wife households dropped from 43 percent to 25 percent; one-worker households of other types--those with female heads, and men and women living alone--increased from 14 percent to 20 percent of households. It can be expected that the one-worker household containing husband and wife will continue to fall throughout the remainder of the century.

Women increasingly prefer work outside the home to child-bearing. The divorce rate is high, and the prospect of divorce is itself a deterrent to childbearing. A child is a handicap, both for work and for remarriage, to whichever member of the couple has to look after it. Divorce is only one reason for the numerous single-person households; another is children leaving the parental home at young ages, long before they contemplate marriage. In recent decades more people have had the means to live alone, and evidently the wish to do so is widespread. Households consisting only of a woman and her one or more children are increasing, partly because of divorce, but also because of a great rise in illegitimate births.

Should the United States have a national population policy? Some industrial countries do--particularly those of Eastern Europe; others, for instance West Germany, do not. If present tendencies continue, the native United States population will

taper off at only 20 to 40 million more than we have now, and then will slowly decline. A variety of incentives--income tax exemptions, housing loans, subsidies for child-care centers--are now in effect, but they do not constitute a population policy; they are far too mild to motivate childbearing at the expense of jobs and careers. Very large sums would be required to counteract the cost of rearing and educating children and the wages foregone in looking after them. In the Russian part of the U.S.S.R., despite enormous state expenditures on day-care for children, free medicine, pregnancy leave, and so forth, birth rates are about as low as those of the United States.

When, during the late 1950s, the United States was showing birth rates that would have led to nearly four children per couple, U.S. promotion of family planning in less developed countries was unconvincing. Considerable controversy developed in the press around the world, with frequent use of such words as genocide and cannibalism. Now the United States is well below replacement, our good example is appreciated, this kind of criticism of our efforts is seldom heard. The fear of excessive urbanization in the less developed countries has helped make birth control more acceptable to citizens and to governments; overpopulated cities are more conspicuous and more politically exigent than an overpopulated countryside.

The Committee on Demography and Population of the National Academy of Sciences and its staff are seeking more precise information on levels and changes of fertility in the world. With World Fertility Survey data, and refined techniques for making indirect inferences on birth rates where direct information is unavailable or incomplete, we should attain more knowledge of current changes on the several continents.

Demographers watch those numbers with great concern. When an increase in income occurs, two opposite responses are possible. One, which might be called the Malthus effect, is to turn the increase in income into more children. The other, which might be called the demographic transition effect, turns the increment in income into a higher standard of living, and then goes on to reduce births in order to preserve and increase

the higher standard. Current fertility rates tell how far the demographic transition is taking over from the Malthus effect.

Europe's fertility decline was accomplished not only without governmental encouragement, but mostly without contraceptive apparatus. A sufficiently strong motivation can overcome material shortcomings. Conversely, if people want to reproduce--for instance, in intertribal or international competition, or for old age security--no amount of contraceptive equipment will make much difference. Yet the incipient motivation to reduce fertility in the less developed countries can be strengthened by technical advance. A safe, once-a-month pill for women, and something corresponding for men, would accelerate the decline of the birth rate in many countries. Improving the technology of contraception is one of the ways in which the United States can make a contribution.

As the number of births in the more developed countries falls toward the number of deaths, migration will constitute an increasing fraction of their population increase. In the United States, the present excess of births over deaths of about 1.5 million will last only a generation or so, unless current tendencies are reversed. As migration comes to provide the largest part of the increment to the United States population, it will receive increasing attention.

Nowhere do the dilemmas of policy show themselves more clearly than in migration. Migration has changed from a free movement in search of a better life, one in which the ancestors of most Americans were welcomed to these shores, to a movement dominated by refugees and illegal entrants. Illegal migration is a response to genuine economic need--not only the need of the migrants but of the receiving economy. To keep illegal migrants out would require either a severity of border control for which Americans are not prepared, or else making employers responsible for identifying their workers, which again seems politically unacceptable. Even if measures severe enough to be effective were congenial to American public opinion, they would be found offensive by the countries from which the migrants come.

On the other hand, the forces in place do not point to any easy legalization of the migrant flow. Some of the migrants' economic utility to employers would be lost if they were legalized and subject to taxation, unionization, and so on. A current report by the Comptroller General has the title "Prospects Dim for Effectively Enforcing Immigration Laws." The many constituencies involved impede any clearcut solution to the problem of illegals. The size and persistence of the flow of illegal migrants may well depend less on our government than on how rapidly Mexico and other countries expand their economies and control their births.

The future population of the United States depends on births, deaths, and migration. Extrapolating on the basis of considerations such as the preceding, the U.S. Bureau of the Census gives for the year 2000 a middle estimate of 260 million, and low and high figures of 246 and 283 million, respectively. The low, medium, and high estimates assume that we are moving toward 1.7, 2.1, and 2.7 lifetime births per woman from the present level of 1.8.

For the more developed countries, a rise is likely from the present 1.1 billion to an ultimate 1.4 billion or so, predicted to be reached within the next two or three generations. The major variation among estimates is with respect to the less developed countries; for these, everything depends on how soon they go through demographic transition. If they have dropped to bare replacement by 2000-05, they will stand at 7.4 billion in 2075 (from their 1975 2.8 billion); if replacement is 15 years later, they will reach 9.8 billion by 2075. That puts world population in the range of 8.8 to 11.2 billion.

The above estimates take the continuing decline of mortality for granted and vary only on fertility. But it is legitimate to suppose that if the higher birth rates persist, then mortality will rise. There are already signs of a slowdown in the fall of mortality in some countries. Some parts of the world are making real progress in birth control; those that are not could be facing a major increase of mortality.

The population problem is not one and the same for the world and for separate countries; each country has its own. Bangladesh has the classical problem of too many people on too little arable land. Burma has a good deal of land and rich agricultural production, but a population that is rapidly filling the land; the combination of a dynamic population and a static economy will bring a crunch within a very few years. Some have problems of population distribution: two-thirds of Indonesia's population is concentrated on Java and Bali. The Soviet Union has a fast increasing Asian population; in the last census, the Russian part had dropped to less than half of the total, at least in children under 10, and this is a concern to the regime. France sees itself as threatened by its low birth rate.

It is easy to rationalize away the population problem. If the poorest countries would show as high rates of economic advance as Japan and Korea have done, they would quickly approach their demographic transition. If there were no national restrictions on trade, then even at the present time food would be adequate for all. If the Javanese would only eat corn rather than rice, they could get enough carbohydrate per acre; if they could attain the yields of Japan or Iowa, they could eat plenty of whatever they want.

It is fair to say that the population problem consists of the fact that these things are not done easily. Nationalism, cultural preferences in food, inefficient agriculture, and urban-centered development are very persistent. So is the large-family culture in many parts of Latin America, Asia, and especially Africa. To wish these things away is as unrealistic as to ignore shortages of physical resources. The control of oil supplies by a dozen countries, to promote what they conceive to be their national interests, is as much a part of the energy problem as the ultimate exhaustion of the oil fields.

Many of the time series bearing on the physical capacity of the earth to sustain population have tended to level off during the 1970s, including the world grain yield per hectare and the world fish catch. The increases of national economies that were

taken for granted in the 1960s are no longer in prospect. Famines or near famines have occurred in Ethiopia, Bangladesh, Haiti, India, and the Sahel (involving six countries just south of the Sahara). After a long period of decline, relative prices of raw materials have on the whole increased in the 1970s. No one knows to what extent these changes will prove to be temporary, or whether the growth of the 1960s will resume. This may be the beginning of a long epoch of hard times; on the other hand, the world's numerous resource, environment, and population problems may be solved quickly, and growth rates of 10 percent may return.

It is not even certain that the climate will allow present grain yields to continue. Climatic records suggest that, in the perspective of historical and geological time, conditions in the present century have been exceptionally favorable to cereal crops. And overall climate could be favorable but soil and water in short supply in particular areas. Increasing CO<sub>2</sub> could raise the global temperature and make things worse for many countries by changing the main currents of the atmosphere and oceans. Unstable tropical soils are being pressed into service for needed subsistence crops; in this situation, more people work the land harder and produce more desert, which results in further pressure on the ecology of the remaining good land. There are large areas where crops are limited more by water than by land; in parts of the United States, the use of ground and fossil waters is lowering the water table at an alarming rate, while in Pakistan and elsewhere irrigation and poor drainage are waterlogging and salinizing the soil.

One should not make these statements--least of all in a report on science and technology--as though the techniques of agriculture and the knowledge of ecology are going to be frozen in their present position. Holding technique constant and allowing population to rise is a way of creating spurious problems. New sources of energy would free oil and gas to become feedstock for synthetics and fertilizers. Cereal plants that fix their own nitrogen, as do present legumes, are being developed. Oil-based energy to distill the ocean waters for agriculture is now unlikely, solar energy will have to continue to

produce rainfall for that, as it has from time immemorial. However, the timing and place of rainfall to increase yields might be influenced by cloud-seeding now under investigation.

The question is not whether such things can be done, but whether they can be done at a rate that will keep up with population and provide the minimum increase in welfare that is expected. On the population side, there will be stability sooner or later; on the resources side, technology will produce plenty, sooner or later. The question is whether the technical improvements can occur at a pace that will bridge the time to this balanced condition.

This is where the United States can bring enormous power to bear--that of its scientific and technological establishment. It is no longer the world's richest country in per capita income, but its research capacity is unequaled. It could develop new technologies that would multiply resources and make the present surplus labor of the poor countries fruitful.

#### SUMMARY AND OUTLOOK

The mismatch of population, resources, and capital will continue to hold the world's attention for the next five years and much longer. A supposed population excess can only be relative to the means of sustaining population. It is this linkage that makes the problem so controversial. Those who think that the earth contains rich resources waiting to be discovered do not foresee population pressures. Those who think that capital can be multiplied easily with a different social organization see no reason for population restraint.

Yet recent experience has dampened the optimism that would let population grow without limit because new resources and capital can be found or created easily. We have now lived for eight years in a general energy crisis. It is difficult to extract coal and burn it without polluting the atmosphere. Some 23 percent of the earth's land surface is desert, and an additional 25,000 square miles become desert each year. The local impact of this in sub-Saharan Africa and Asia south of the Himalayas is catastrophic. Arable land per capita is declining

everywhere and the energy needed to raise yields is more and more costly. Demand for lumber and firewood causes overcutting and a potentially disastrous shrinkage of the world's forest area. The world's fish catch seems to have peaked and could well have entered a long-term decline, despite more ships engaged.

Even if resources and capital were ultimately unlimited, there is a clear ceiling to the pace at which they can be expanded. That is what gives importance to statistics of the increases in population, resources, and capital, country by country. One way of making the problem disappear is by taking a global view and showing, for instance, that for over two decades cereal production has been going up by 2.7 percent per year, and population increases by only 1.7 percent per year. Detailed data not only for the world as a whole, but for individual countries, are needed. By recognizing that there are independent national states and an unequal distribution among them of population and resources, the center of the problem can be approached.

This paper has taken up in some detail the components of population increase--birth, death, and migration--for major countries. It finds that the fertility rates of the advanced countries have mostly dropped below replacement levels, but with considerable variation among them. American birth rates were higher than those of western Europe during the 1950s, but they have fallen more sharply since then. American mortality was discouragingly level during the 1950s and 1960s but, during the 1970s, took a turn downward. Soviet mortality has been rising.

At first, the birth rates in the less developed countries did not decline as their death rates dropped. There seemed to be an impasse--no fall in births before development, but development held back by high birth rates and large populations. Experience of the late 1970s suggests that there may be an escape. In China, Indonesia, and several other countries, effective government action along with social changes are resulting in a dramatic decline in birth rates. The fall is recent and the means



of measuring it are inadequate, but evidence shows that birth rates can be made to decline before full economic development occurs. One of the factors that brought about the changes in recent years has been American-aided family planning programs.

However, even if things continue to go well on the population control front, the world's population will be 6 billion by the end of this century, and 9 billion by the latter half of the 21st century. Population projections are notoriously uncertain, but assuming continued progress in the spread of contraception simple arithmetic shows that the present annual increase of 70 million or so will exceed 90 million by the year 2000. The transition to a happier balance between the human population and the earth that is its habitat will not be easy. If the Chinese can reach their stated objective of a one-child family, already virtually attained in West Germany, and the example is followed elsewhere, a stationary world population living in security and prosperity may indeed be possible by the late 21st century--but one must not underestimate the effort and restraint needed.

The United States has had some part in the progress made to date and should have a larger part. Yet the public and its leaders are disillusioned about the benefits of outright gifts of money to the less developed countries. In what is the largest (if unintended) social experiment of all time, enormous transfers have gone to a dozen countries through the operations of OPEC (Organization of Petroleum Exporting Countries), but they have not produced a proportional gain in the welfare of the people of those countries. An investment in their own human capital is far more decisive for development than any physical or financial capital can be. American assistance generates the highest returns in the welfare of the poor countries when educational, scientific, and technical leadership, rather than money transfers, are provided. This country's capacity to devise better methods for activities ranging from village industry to contraception to satellite systems that reveal new resources is unparalleled. Improved ways of using biogas and solar energy, new plant sources of protein, textiles, rubber,

firewood, and other necessities will help to raise living standards in poor countries, especially if they can be applied with local capital.

Through the United Nations and elsewhere, the less developed countries have shown a strong nationalism. They have taught rich countries the principle of noninterference, and have stressed that only domestic effort can solve population and other developmental problems. The principle is a sound one, and it will be severely tested by growing populations, increasing urbanization, fuel shortages, environmental deterioration, and rising foreign debts. Again, the help that the United States can provide which will be most effective as well as most consistent with the independence of the poor countries is new discoveries and inventions contributed to the worldwide pool of science and technology.\*

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\*That contribution is the subject of the remaining chapters of the volume as written for the U.S. National Academy of Sciences.

## GLOSSARY

### MORTALITY

Demography has developed ways to avoid the misunderstanding that can easily arise because populations have different or changing *age distributions*. Thus, the *crude death rate* (total deaths divided by total population) of the United States is higher than that of Venezuela: 9 per thousand against 6 per thousand. To make a proper comparison between the two countries, *age-specific death rates* (for example, the deaths of people aged 20-24 at last birthday divided by the population aged 20-24) are compared; it will be found that, at each age taken separately, the United States' rate is lower. A convenient summary of the death rates is the *expectation of life* for a particular year. That for the United States in 1977 at age zero was 73.2; for Venezuela, less than 70. Hypothetical individuals subject to U.S. 1977 mortality would live 73.2 years. Real individuals will live longer on the average than this because they will be subject to mortality declining from 1977 levels. The hypothetical expectation is a good way of comparing countries as well as different times in the same country.

To see the effect of particular diseases, we calculate *cause-deleted life tables*; one of these shows that, if there

were no cancer deaths and all other mortality were the same as the current rates in the United States, the expectation of life would be increased, but only by about 2 years. That the amount is so small is due to *competing causes*: people whose lives are saved by eliminating cancer are old enough that they soon would die of heart disease. Such competition among causes applies less to accidents because these occur in large part to younger people; it does not apply to infectious diseases, whose virtual elimination, combined with other public health measures, has raised the expectation of life by 20 or more years since the beginning of the century.

#### FERTILITY

Some of the same considerations apply with respect to *fertility*. Thus, the *crude birth rate* (total births divided by total population) has been rising in the United States over the last few years largely because an increasing proportion of the population happens to be in the marrying and childbearing ages. (These are the baby boom cohorts of the 1950s.) Demographers examine *age-specific birth rates*, for example, births to women aged 20-24 years at last birthday divided by total number of women aged 20-24. They combine mortality and fertility to calculate the *net reproduction rate*, which is the expected number of girl children that would be born to a girl child with the life table and the age-specific birth rates of a given year. This is the *replacement ratio* of the population; it tells how many girl children a girl child is replaced by in the next generation. In the United States now, it is about 0.9. The total fertility rate is a little over double this, or about 1.8 children of both sexes per woman--not enough to maintain the population in the long run. That means that the U.S. population is failing to replace itself, even though it is still increasing by virtue of *population momentum* that reflects the age distribution resulting from previous high fertility. If present age specific rates of birth and death continue, the native population would ultimately drop off 10 percent per generation.

Sooner or later, all populations must become *stationary*, meaning that on the average they would neither increase nor decrease; over the long run, their net reproduction rate would be unity. A long-run stationary condition would take the form of fluctuations in births around a net reproduction rate of unity. All of this applies to the *closed population* consisting of the present inhabitants of the United States and their descendants, and disregarding migration; migration at present rates would offset any shortfall of natural increase.

Very different is the condition of the less developed countries, many with a net reproduction rate of 2 or more. This means that they double in a generation, where the *length of generation* (approximately the mean age at childbearing) is usually 25 to 30 years. The rate of increase of Mexico a few years ago, and of some African countries now, is as high as 3.5 percent, which implies a *doubling time* of  $70/3.5 = 20$  years. A country that doubles in 20 years multiplies by 32 in a century. In the *demographic transition*, the decline of deaths is followed at a longer or shorter interval by the decline of births; each decade of delay in the fall of births can increase the population fully by one-third. For the poor countries, the rapid population increase is made even more difficult by *internal migration*, specifically, the flow of population to the cities, or *urbanization*. The cities of many poor countries are increasing at 4 percent or more per year, which is to say that they double in less than 18 years.

*Population forecasts* used in this report and elsewhere are essentially *projections*, the working out of consequences of certain sets of assumptions. If past forecasting experience is a guide we cannot know the world population by the end of the century even within half a billion, nor that by the middle of the 21st century within 2 or 3 billion. The projections here provided are hypothetical or illustrative only.

## REFERENCES

- Berquo, E. (1979) *Veja*. Page 139. Sao Paulo.
- Breslow, L. (1978) Risk Factor Intervention for Health Maintenance. *Science* 200(4344):908-912.
- Brown, H. (1954) *The Challenge of Man's Future*. New York: Viking Press, Inc.
- Caldwell, J.C. (1979) Education as a Factor in Mortality Decline: An Examination of Nigerian Data. *Population Studies* 33(November):395-414.
- Coale, A.J. and E.M. Hoover (1958) *Population Growth and Economic Development in Low-Income Countries. A Case Study of India's Prospects*. Princeton, N.J.: Princeton University Press.
- Diaz-Briquets, S. (1978) *Income Redistribution and Mortality Change: The Cuban Case*. Paper presented to Population Association of America Annual Meeting, April 13-15, Atlanta, Georgia.
- Dorfman, R. and N.S. Dorfman, eds. (1977) *Economics of the Environment. Selected Readings*. Second edition. New York: W.W. Norton & Co., Inc.
- Dyson, T. (1979) *A Working Paper on Fertility and Mortality Estimates for the States of India*. Paper presented at Workshop, Panel on India, National Academy of Sciences Committee on Population and Demography, New Delhi, November.

- Ehrlich, P.R., A.H. Ehrlich, and J.P. Holdren (1970) *Ecoscience: Population, Resources, Environment*. San Francisco: W.H. Freeman & Company.
- Goeller, H.E. and A.M. Weinberg (1976) The Age of Substitutability. *Science* 191(4228, February 20):686-688.
- Isenman, P. (1978) *The Relationship of Basic Needs to Growth, Income Distribution, and Employment: The Case of Sri Lanka*. Manuscript. Policy Planning and Program Review Department, The World Bank.
- Jain, A.K. (1974) An Appraisal of Family Planning in India. *Population in India's Development 1947-2000*. A. Bose, et al, eds. Indian Association for the Study of Population.
- Kitagawa, E.M. and P.M. Hauser (1973) *Differential Mortality in the United States*. Cambridge, Massachusetts: Harvard University Press.
- Muhua, C. (1979) Birth Planning in China. *Family Planning Perspectives* 11(6, November/December).
- National Academy of Sciences (1977) *Leucaena: A Promising Forage and Tree Crop for the Tropics*. Washington, D.C.: National Academy of Sciences.
- Newman, P. (1977) Malaria and Mortality. *Journal of the American Statistical Association* 72(June 12):257-263.
- Payne, D., B. Grab, R.E. Fontaine, and J.H.G. Hempel (1976) Impact of Control Measures on Malaria Transmission and General Mortality. *Bulletin* 54:369-377. World Health Organization.
- Preston, S. (1976) *Mortality Patterns in National Populations*. New York: Academic Press.
- Ratcliffe, J. (1975) *Poverty, Unemployment, and Development Policy: A Case Study of Selected Issues with Reference to Kerala*. New York: United Nations.
- Ratcliffe, J. (1978) Social Justice and the Demographic Transition: Lessons from India's Kerala State. *International Journal of Health Services* 8(1):123-144.
- Registrar General of India (1979a) *Selected Indicators of Mortality and Fertility in India, 1976*. Paper presented at Workshop, Panel on India, National Academy of Sciences Committee on Population and Demography, New Dehli, November.
- Registrar General of India (1979b) *Sample Registration Scheme Bulletin XIII(2, December)*.

- Revelle, R. (1975) Will the Earth's Land and Water Resources Be Sufficient for Future Populations? *The Population Debate: Dimensions and Perspectives, Papers of the World Population Conference, Bucharest, 1974. Vol. II.* New York: United Nations.
- Revelle, R. (1978) Flying Beans, Botanical Whales, Jack's Beanstalk, and Other Marvels. *The National Research Council in 1978: Current Issues and Studies.* Washington, D.C.: National Academy of Sciences.
- Ruttan, V. (1978) *The Prospect for Agricultural Growth.* Paper presented at the Conference on Economic and Demographic Change: Issues for the 1980's, Helsinki.
- United Nations (1976-1979) *La Mortalidad en los Primeros Años de Vida en Paises de la America Latina.* Santiago: Centro Latinoamericano de Demografia.
- United Nations Population Division (1979) *Demographic Estimates and Projections for the World, Regions, and Countries as Assessed in 1978.* Tables 2A and 2B, January.
- U.S. Bureau of the Census (1977) *Projections of the Population of the United States: 1977 to 2050.* Current Population Reports Series P-25(704, July). Washington, D.C.: U.S. Government Printing Office.
- U.S. Bureau of the Census (1979a) *Country Demographic Profiles: Mexico.* ISP-DP-14. Washington, D.C.: U.S. Government Printing Office.
- U.S. Bureau of the Census (1979b) *Statistical Abstract of the United States.* Page 70. Washington, D.C.: U.S. Government Printing Office.
- U.S. Bureau of the Census (1980a) *Country Demographic Profiles: Pakistan.* ISP-DP-24. Washington, D.C.: U.S. Government Printing Office.
- U.S. Bureau of the Census (1980b) *International Population Dynamics, 1950-79.* ISP-WP-79(A). Washington, D.C.: U.S. Government Printing Office.
- U.S. Bureau of the Census (forthcoming) *Country Demographic Profiles: Brazil.* Washington, D.C.: U.S. Government Printing Office.
- U.S. Department of Health, Education, and Welfare (1978) *Health: United States: 1978.* National Center for Health Statistics.
- U.S. Department of Health, Education, and Welfare (1979) *Proceedings, Conference on Decline in Coronary Heart Disease.* Publication No. 79-1610. Bethesda, Maryland: National Institute of Health.
- World Bank (1979) *World Development Report.* Washington, D.C.



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