Chapter 2

Population Growth to the year 2000

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Population Growth to the Year 2000

Abstract

Rapidly declining death rates combined with continuing high birth rates are producing unprecedented world population growth, some 92 percent of which is occurring in less developed countries (LDCs). The current world population of 4.4 billion is projected to reach about 6.2 billion (range: 5.9 billion to 6.5 billion) in 2000. Eighty million people are being added to the world annually; this number is expected to rise to 9s million per year by 2000 [range: TO million to 120 million). Growth will be greatest in Africa, Latin America, and Asia. Three quarters of this growth is expected to take place in 18 countries (listed by the magnitude of their projected growth): India, China, Brazil, Nigeria, Indonesia, Bangladesh, Pakistan, Mexico, Philippines, Thailand, Vietnam, Turkey, Iran, E~pt, Ethiopia, Burma, South Africa, and Zaire. At current rates of growth, many LDCs will double their populations within 25 years. The difference between the low and high projections for the year 2000 is roughly three times the size of the current U.S. population. The United States is expected to grow from today's 226 million to 260 million in 2000, and 290 million in 2050, but to fall from 4.9 percent of the world's population today to 4.0 percent in 2000, and 3.5 percent in 2050. The impact of global population growth on the united States will thus be greatest from beyond its borders.

The demographic transition from high to low birthrates experienced earlier by more developed countries (MDCs) is taking place in LDCs under very different conditions: death rates have declined at a more rapid pace; LDCs have far greater momentum of population growth because large proportions of their populations are reaching reproductive age; international migration Can no longer serve as an outlet for rapidly growing populations; LDCs have more limited development opportunities than did MDCs in the past, and LDCs have higher levels of unemployment that were experienced earlier in MDCs. LDCs do have three major new advantages, however: many LDC governments are taking direct actions to reduce birth rates; highly effective fertility planning methods are now available; and the international transfer of appropriate knowledge and technology is now organized.

Trends in population growth

The fundamental cause of today's rapid population growth is becoming widely known: death rates have declined rapidly while birth rates have continued at high levels. The overwhelming proportion of this growth is taking place in the developing world. Birth rates have begun to edge downward in these countries, but declines in death rates have been dramatic.

The downward trend of birth and death rates in developing countries follows a path traveled earlier and much more slowly by the industrial-

ized nations. This historic transition from high to low rates, which began in western Europe some 200 years ago, combined with the industrial revolution to sharply divide the world into one-quarter rich and three-quarters poor. A number of terms—more and less developed; developed and developing; North and South; First, Second, and Third Worlds; industrialized and underdeveloped—describe this division. This report uses those terms most commonly used by international agencies: more developed countries and less developed countries.

Although the dichotomy is real, the terms oversimplify. The two groups of nations are vastly different in terms of income, health, education, and rates of natural increase, but differences within each group are also wide, as shown in tables 4 and 5. Awareness of the heterogeneity and individuality of LDCs is vital to understanding their levels of development and population growth.

Table 4.—Selected Population Data for the 25 Most Populous LDCs

Country	(Medium variant) population (millions) 1981	2000	1981 rate of natural increase	1981 doubling time[a]
China	969	1,190	0.8	59
India	710	1,040	2.1	33
Indonesia	155	221	2.0	35
Brazil	130	212	2.4	29
Bangladesh	91	153	2.6	27
Pakistan	85	145	2.8	25
Nigeria	80	149	3.2	22
Mexico	72	132	2.5	28
Vietnam	54	79	2.8	25
Philippines	53	83	2.4	29
Thailand	49	76	2.0	35
Turkey	46	69	2.2	32
Egypt	43	65	3.0	23
Iran	39	65	3.0	23
South Korea	39	51	1.7	41
Burma	36	55	2.4	29
Ethiopia	33	55	2.5	28
South Africa	30	48	2.4	29
Zaire	29	46	2.8	25
Colombia	28	42	2.3	33
Argentina	27	33	1.6	43
Afghanistan	23	37	2.7	26
Morocco	21	36	3.0	23
Algeria	19	36	3.2	22
Sudan	19	31	3.1	22
All LDCs	3,357	4,926	2.1	34
All MDCs	1,138	1,272	0.6	113
World	4,495	6,199	1.7	41

[a]Number of years to double population (at current growth rate)

SOURCE: *U. N., 1979-World Population Trends and Prospects by Country, 1950-2000: Summary Report of the 1978 Assessment* for 1981 and 2030 population figures; Population Reference Bureau 1981 *World Population Data Sheet* for rate of natural increase and doubling time figures.

Table 5.—Selected Socioeconomic and Quality of Life indicators for the 25 Most Populous LDCs and Selected MDCs

Country	1978 GNP (dollars)	1975 adult literacy rate (percent)	1981 life expectancy (years)	1981 infant mortality
China	230	NA	68	56
India	180	36	52	134
Indonesia	360	62	50	91
Brazil	1,570	76	64	84
Bangladesh	90	26	47	139
Pakistan	230	21	52	142
Nigeria	560	NA	48	157
Mexico	1.290	76	65	70
Vietnam	'170	87	62	115
Philippines	510	87	61	65
Thailand	490	84	61	68
Turkey	1,210	60	61	125
Egypt	400	44	55	90
Iran	2,160[b]	50	58	112
South Korea	1,160	93	66	37
Burma	150	67	53	140
Ethiopia	120	10	39	178
South Africa	1,480	NA	60	97
Zaire	210	15	46	171
Colombia	850	81	62	77
Argentina	1,910	94	69	41
Afghanistan	240	12	42	185
Morocco	670	28	55	133
Algeria	1,260	37	56	127
Sudan	320	20	46	141
United States	9,590	99	74	13
Japan	7,280	99	76	8
UnitedKingdom	5,030	99	73	13
	8,260	99	73	10

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Following World War 11 the world experienced a sudden, sustained drop in deaths which, combined with little change in births, produced unprecedented growth in numbers of people. Today, about 80 million persons—the equivalent of an additional Mexico or Nigeria—are added to the planet every year (7). By the end of the century, despite reduced birth rates, this annual increase is expected to reach 95 million. Most of this increase in numbers is taking place in the LDCs, where expectations of a better life are also rising.

The timing, intensity, and effects of population changes have varied greatly among LDCs, but, beginning with India in the early 1950's, more than 40 percent of LDC governments have become concerned about their rapid growth and its detrimental impact on national development, and have sought means to reduce their birth rates.

Although the most immediate effect of rapid population growth in LDCs has been to limit their ability to raise living standards, the negative consequences of population growth are not confined to these countries. MDCs are increasingly concerned about their own population growth. The congressionally established Commission on Population Growth and the American Future concluded in 1972 that: "the stabilization of our population could contribute significantly to the Nation's ability to solve its problems." National assessments in Great Britain and Japan have reached similar conclusions. A few countries in Europe are worried about their s1OW population growth, but overall there is growing concern that world population is pushing against the Earth's carrying capacity. The Independent (Brandt) Commission on International Development (4) warned of the global consequences of population growth and its increasingly severe pressure on many basic resources.

The demographic transition

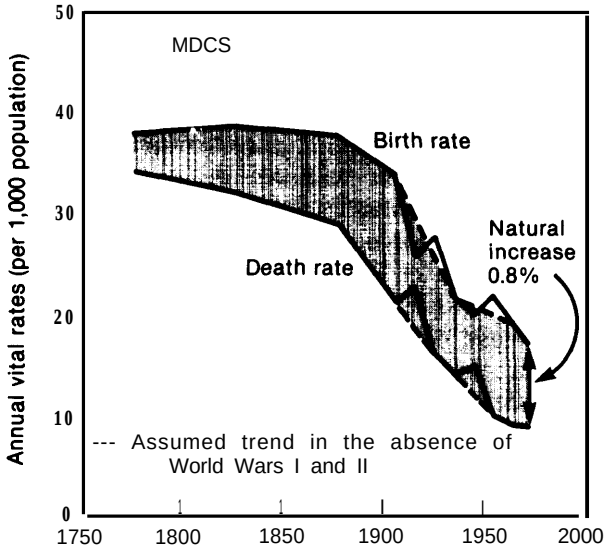
Although the timing of the transition from high to low birth and death rates varies among countries, the chronology of the phases is similar:

1. an early phase of rising growth as death rates fall and birth rates do not;
2. a peak growth phase as death rates continue to fall and birth rates begin to fall;
3. a falling growth phase as death rates stabilize at lower levels and birth rates continue to decline; and
4. a stabilization phase of low, nearly equal, death and birth rates. (See Tech. Note A, ch. 4)

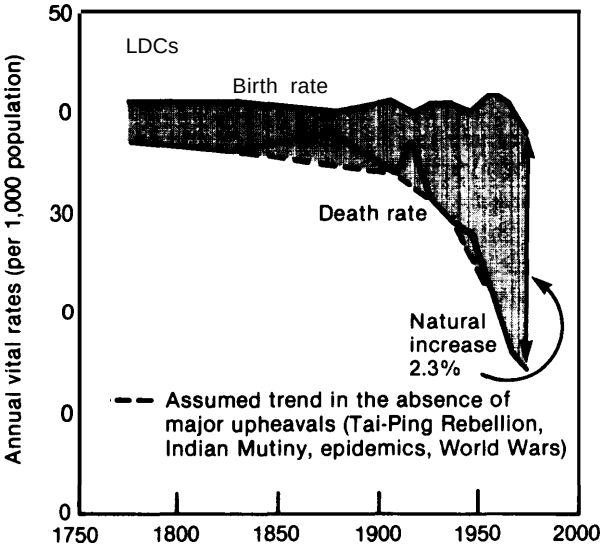
Differences in timing have produced much higher growth rates at the beginning of the transition in LDCs than those experienced by MDCs (fig. 4). Conditions in Africa, Asia, and Latin America today therefore differ from those of the MDC demographic transition in several very important ways:

- *Death rates declined much faster in LDCs than they did earlier in MDCs.* The decline in annual death rates from 30 to 15 per 1,000 population that took 150 years in Great Britain, Sweden, and the United States, took only about 35 years in India. Declines in LDC death rates from major causes such as cholera, malaria, and smallpox have been facilitated by new large-scale international transfers of health and agricultural technologies from MDCs.
- *As a result, population growth has been much more rapid in LDCs in both rates and absolute numbers than it was in MDCs.* Great Britain's growth rate fell slowly from 1.4 to 0.4 percent between 1800 and 1921; the annual increase in numbers did not deviate greatly from 200,000. By contrast, India's annual growth rate rose from about 1.5 to 2.5 percent between 1950 and 1970 as its annual increase in numbers soared from about 5 to 11 million in just 20 years.
- *LDCs have greater momentum of population growth built into their age structures than MDCs had earlier.* Sustained higher birth

Figure 4.—Comparisons of the Demographic Transition in LDCs and MDCs



In MDCs death rates declined slowly beginning in the late **18th century. Birth rates followed closely. Population growth rates rarely** exceeded 1.5 percent per year.



In LDCs birth and death rates remained high through the first decades of the 20th century. Then death rates began to drop. Birth rates stayed high and populations grew at 2.5, 3.0, and 3.5 percent or higher a year. Since the mid-1960's some countries' birth rates have begun to decline.

SOURCE: State Department Bulletin, "The Silent Explosion," fall 1978.

rates have produced large proportions of children who will soon reach reproductive age. Thus, even if average family size is reduced dramatically in this generation, national birth rates will fall more slowly because such a large proportion of people are of reproductive age.

- *International migration can no longer serve as an outlet for rapidly growing populations as it did for much of Europe.* There are no more '(empty" lands to colonize or to accept great numbers of immigrants. Nevertheless, population pressures in LDCs and income opportunities in MDCs are likely to result in sizable illegal migration and its attendant problems as long as rapid population growth in LDCs continues.
- *LDCs have far fewer opportunities for development than did MDCs.* Most LDCs have little unutilized arable land, are unevenly endowed with natural resources, and face stiff competition from MDCs in international markets for industrial products.
- *LDCs face higher levels of unemployment than were experienced earlier in MCs.* The opportunities for employment (or migration) that were available earlier in MDCs are not available in LDCs, where unemployment and underemployment are widespread.

In sum, LDCs have not only encountered population growth unlike anything in MDC experience, but have fewer opportunities for accommodating this growth than were available to MDCs a century earlier. They do, however, have three major new developments in their favor:

1. *Many LDC governments, unlike MDCs earlier, are taking direct actions to reduce birth rates by utilizing new fertility planning technologies and by other means.* Although family planning programs vary greatly in effort and effects and most governments allocate less than 1 percent of governmental expenditures to them, more than 92 percent of the world's population live in countries whose governments provide some form of family planning services for their people. (See ch. 7.)

z. *There are more effective technologies for the planning of births than existed in 1800 or even 1950.* These technologies—the pill, IUD, and new voluntary sterilization techniques–have replaced less effective methods in MDCs and are beginning to be used in LDCs. (Technological development is now lagging, however; although concerted research efforts to develop better contraceptive technologies increased appreciably during the 1960's, financial support for such efforts has fallen in real purchasing power since 1970.) (See ch. 6.)
3. *international transfer* of *knowledge and technologies to reduce birth rates is now organized.* The proportion of total international development assistance devoted to population activities rose from virtually none in 1960 to 2 percent in 1979. MDCs now provide about $450 million annually for population assistance. (See ch. 9.)

This assessment focuses on policies of the U.S. Government now and during the next 20 years, which will be a pivotal period in global population history. LDCs receive greatest consideration because problems arising from rapid population growth are particularly acute in these countries and because their population growth between 1980 and 2000 will account for more than 90 percent of the rise in world numbers. How fertility can be changed takes precedence because it is the most viable option for countries that wish to lower population growth rates.

Projections of world population growth

The size of world population during the next 20 years can be predicted with greater certainty than most future events because about 60 percent of the people who will be on Earth in 2000 A.D. are already here, and—barring a possible global nuclear catastrophe or unexpected great epidemic or famine—experts differ little on how many will die in the coming two decades. The uncertainties lie in how many people will be born. Their numbers will depend to a great extent on what the LDCs do to modify their national birth rates. There is a consensus that population growth has such a powerful, built-in momentum that actions taken or not taken now will determine the size of world populations far into the future.

World population is projected to grow from an estimated 4.5 billion in mid-1981 to 6.2 billion (between 5.9 and 6.5 billion; much will depend upon the rates at which fertility declines) in mid-2000. Despite decreasing growth rates, the total number of persons added to the world's population each year is expected to increase from some 80 million in 1981 to about 95 million (between 70 and 120 million) in 2000. This growth will be distributed very unevenly among different regions and countries. Close to 92 percent is expected to occur in LDCs, cutting the MDC proportion of world population from 26 percent in 1980 to 21 percent in 2000 (and the U.S. proportion from 4.9 to 4.0 percent).

The LDCs differ greatly in population size and growth both by individual countries and by geographic regions. Growth will be greatest, according to current projections, in Africa (76 percent of the 1980 population added in 20 years), Latin America (65 percent), and Asia (43 percent), However, more of the increase in absolute numbers will occur in Asia (63 percent) than in Africa (22 percent) or in Latin America (15 percent), simply because many more **people al**ready live in Asia. Three-quarters of all 1980-2000 LDC growth is expected to occur in just 18 countries: India, China, Brazil, Nigeria, Indonesia, Bangladesh, Pakistan, Mexico, Philippines, Thailand, Vietnam, Turkey, Iran, Egypt, Ethiopia, Burma, South Africa, and Zaire, listed here by the magnitude of their projected growth. Much of future world population growth thus depends upon what happens in these few large countries.

The interval during which some of these countries will double their populations, if present fertility trends continue, is very brief: Kenya may double the numbers of its people in 18 years, India in 33, Bangladesh in 27, and Egvpt in 23 (table 4). (See Tech. Note B.)

Sources and bases of population projections

The projections used here are those of the United Nations (U.N.), the principal source of information about world population. Its Population and Statistical Divisions publish current population, birth, and death data annually and prepare periodic global assessments and projections.

Projections based upon a 1978 assessment were published in 1979; revised projections based upon a 1980 assessment were published in 1981. The projections include high, medium, and low variants. The medium variant is designed to represent likely demographic trends based on past demographic changes, expected social and economic progress, ongoing government population policies, and prevailing public attitudes toward population issues. The high and low variants are intended to represent the effects of plausible variations in these factors.

The U.N. projections are similar to those produced by five other major sources (table 6). Each set of projections starts from estimated 1975 base populations, fertility rates, and life expectancies. Each uses similar assumptions about death rates and assumes no major wars, famines, or epidemics, and all except the U.N. exclude international migration. All depend on data from individual nations—sources whose frequency, accuracy, and completeness of information vary greatly. (See Tech. Note A.)

The projections prepared by the U.S. Bureau of the Census also include high, medium, and low series, and are based on current levels of fertility, development, and family planning; government policy on population matters; and experience in countries with similar social, economic, and political settings. These projections assume that fertility will decline more or less continuously throughout the period, that all

Table 6.—Alternative Projections of Population in 2000 (millions)

	Source					
Region	U.S. Bureau of the Census 1980	United Nations 1979	World Bank 1979	University of Chicago (6) 1977	Harvard University (5) 1977	Population Council[c] 1981
World:						
High	6,520	6,508	–	5,974	—	6,353
Medium	6,175	6,199	6,004	5,883	5,882	—
Low	5,799	5,855	–	5,752	—	6,046
MDCs						
High	1,324	1,319	–	1,266	—	1,135
Medium	1,272	1,272	1,261a	1,263	1,275a	—
Low	1,225	1,229	–	1,250	—	1,054
LDCs						
High	5,196	5,189	–	4,706	—	5,218
Medium	4,903	4,926	4,743	4,620	4,807	—
Low	4,574	4,626	—	4,501	—	4,992
China:						
High	1,425	1,228	—	1,135	—	—
Medium	1,284	1,189	1,210[b]	1,131	1,129	NA
Low	1,141	1,132	—	1,109	—	—
India						
High	995	1,105		971	—	—
Medium	959	1,037	973	951	1,009	NA
Low	922	983	–	923		—

NA = Not available.
[a]Excluding temperate South America.
[b]Including Taiwan, as the others do.
[c]SOURCE: T. Frejka, and P. W. Mauldin, unpublished manuscript, November 1980.
SOURCE: Office of Technology Assessment.

countries will have adopted some kind of family planning program by 2000, and that the effectiveness and coverage of such programs will increase.

The World Bank's single population projection was prepared by estimating, for each country, the year in which fertility would reach replacement level. For all countries except those in sub-Saharan Africa, fertility decline toward the replacement level is assumed to have started in 1975 if not before. For the sub-Saharan countries, the declines are expected to begin in 1980-85.

The University of Chicago projections also include high, medium, and low variants. The projected fertility rates are based On specified relationships between the rate of fertility decline and the strength of family planning efforts. The high projection assumes that each country maintains its present level of family planning effort. The medium projection assumes that strong family planning efforts eventually are implemented in all nations by the year 2000. The low projection assumes that all countries have strong family planning programs by 1995.

The Harvard University projections assume that fertility will decline to replacement levels by 1990-95 in MDCs and by 2000-05 in LDCs. The Population Council projections assume attainment of replacement level fertility at varying times from 1980-85 to 2040-45. Differences among the six sets of projections summarized in table 6 are mainly in base data used, in assumptions about future LDC birth rates, and in interpretations of incomplete data about China and central Africa. Despite these differences, the outcomes in world, LDC, and MDC population estimates for 2000 are quite similar among the first five. The university scholars and the World Bank expect slightly less growth in LDCs than do the U.S. Census Bureau and the U.N. Population Division.

Much of the uncertainty about China should be resolved by its 1982 census and pending improvements in and availability of its birth, death, and birth planning program data. Meanwhile, special population projections for China (l)—based upon China's new emphasis on the one-child family to achieve population stabilization by 20()()-come close to the low estimates in table 6.

The U.N. projections have been used as standard reference figures in most of this report but have been supplemented by new national data where available and relevant.

For policy makers concerned with modifiying population growth, the most meaningful population information is the difference in numbers of people added to the world's population if governments do or do not take feasible actions to reduce birth rates in addition to those already under way. The actual amount attributable to additional governmental actions that reduce birth rates is neither accurately' known nor explicitly stated by most demographic experts who make projections. There is general agreement, however, that if gotvernments intensify current actions to reduce growth rates, the low variant projection is more Iikely to be achieved. The total difference between the high and low variants is sizable-650 million persons—and is equivalent to the addition of three times the current U.S. population in just 20 years (table 6 and fig. 5).

The tendency of demographers to follow past trends and to underestimate changes in birth rates means that the low variant projections for 2000 are probably not low' enough. New information has already led to downward revisions of these low variants. The 1980 Census Bureau low series projection for lvorld population in 2000 was 2-percent lower than in 1977. Some of this change in predictions can be attributed to governmental actions.

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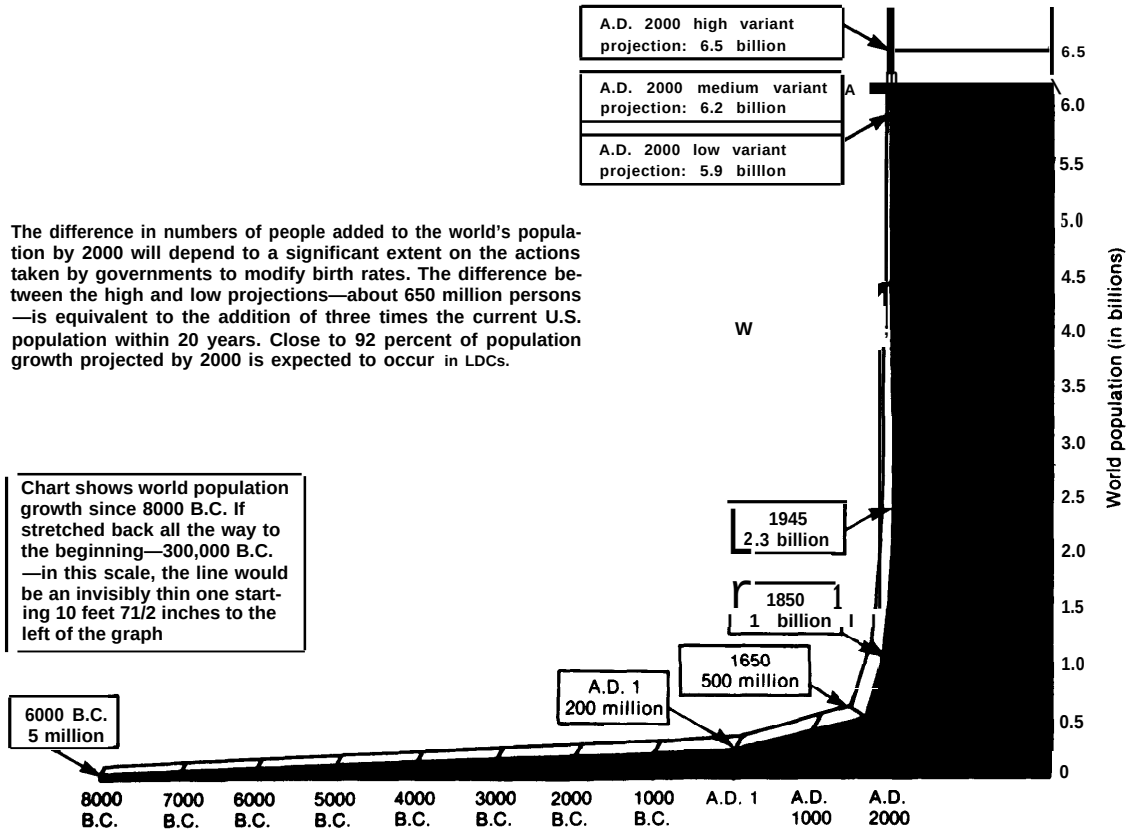
Figure 5.–World Population Growth From 8000 B.C. to 2000 A.D.



SOURCE: United Nations, *World Population Trends and Prospects by Country, 1950-2000: Summary Report of the 1978 Assessment,* New York, 1979, projections 1980-2000; Arthur H. Westing, "A Note on How Many Humans Have Ever Lived," *Bioscience,* vol. 31, 1981; graph adapted from "Population Growth from 8000 B.C. to the Present," Oct. 6, 1981, © 1981 by the New York Times Co. Reprinted by permission.

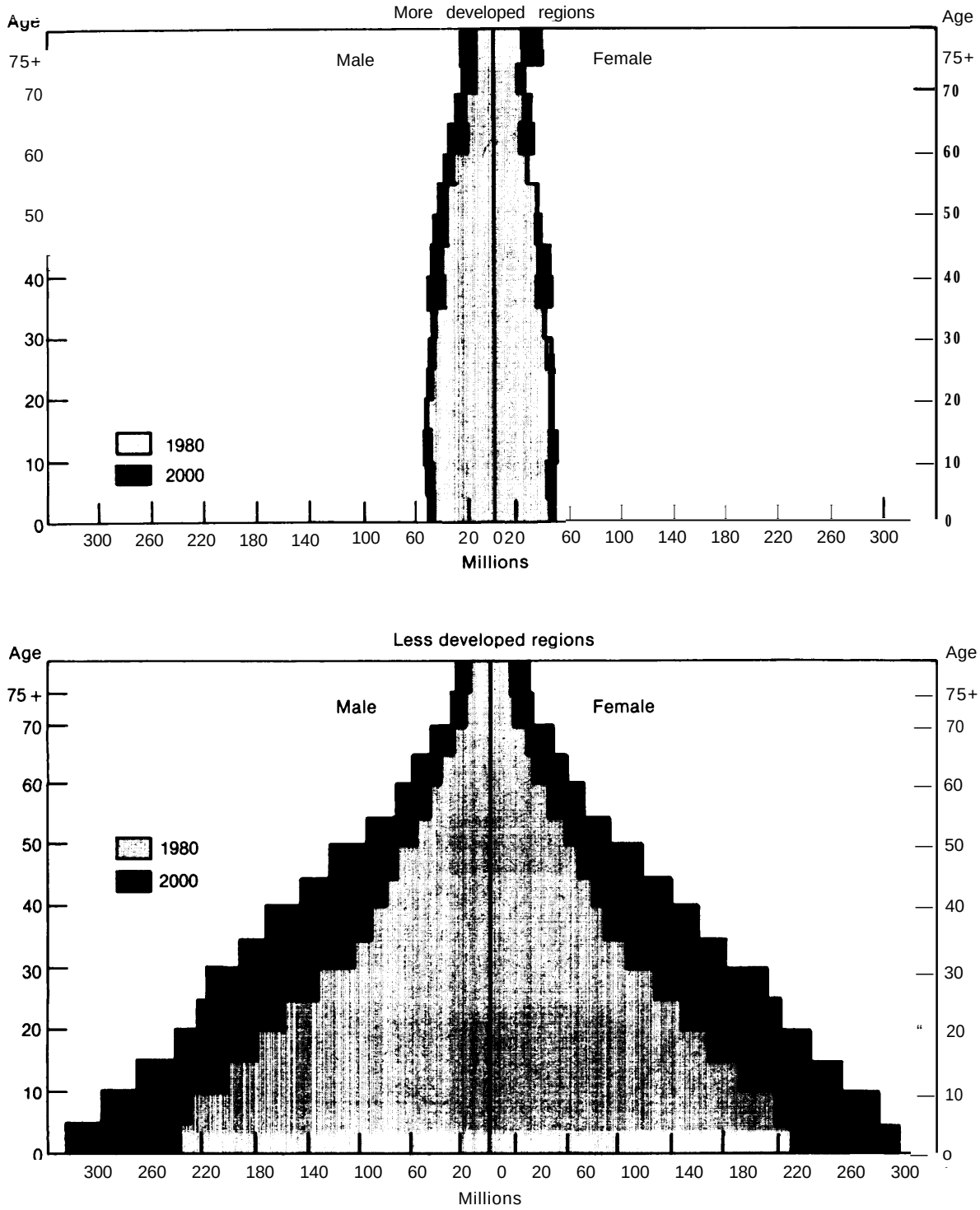
The built-in momentum of population growth

Population growth in the next 20 years has enormous momentum that will affect later population size. This momentum comes from the combination of high fertility and rapidly declining infant mortality in LDCs that followed World War II. The result is a subtle, very powerful built-in inertia, resulting from the age structure of LDC populations (fig. 6A).

In LDCs, far more people are in the younger age groups than in the older ones. Because the number of people entering the reproductive ages each year will be more than 150-percent greater that the number leaving them, the *number of births will be greater each year, even if fertility rates fall dramatically.* Because the younger age groups will be so much larger than the older age groups, the number of people being born each year will be much greater than the number of people dying. Even when fertility approaches replacement levels, the number of deaths will not equal births until the largest cohort of births reaches old age, some 60 years later.

In contrast to the LDCs, by 2000 the MDCs will have a very even distribution of population by age (fig. 6A). The number of people in each 5-year age group between birth and 50 years will be between 87 and 93 million. Each year just as many people will move out of their reproductive years as will enter them. With births at

Figure 6A.—Aae.Sex Composition of More Developed and Less Developed Regions, 1980 and 2000: Medium Series Projections



SOURCE: U.S. Bureau of the Census, Illustrative Projections of World Populations to the 21st Century, Special Study Series, table 2, pt. B, p. 23, No. 79, January 1979.

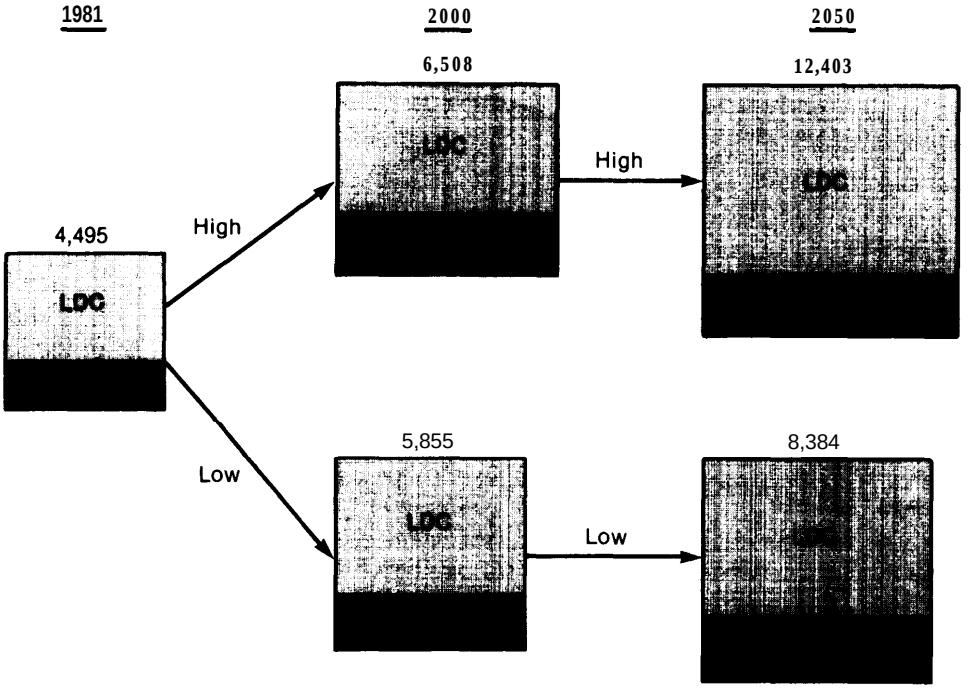
replacement level, approximately the same number of children will be born each year. Furthermore, because the size of the older age groups will be about the same as the younger age groups, the number of children born each year will be about the same as the number of persons dying each year. By 2000, many MDCs are expected to have achieved population stabilization—or zero population growth—with low birth rates equal to low death rates, if their immigration is in balance with their emigration,

One effect of the population momentum in LDCs is to foreclose future options if actions are not taken in time. Frejka and Mauldin (2) conclude that the range between the high and low variants, and thus the range for plausible government options for the eventual size of world population toward the end of the next century, was narrowed by 3 billion people in a single decade. Taking certain actions to reduce birth rates lowered the plausible upper level; not taking other actions raised the plausible lower limit, because by 1980 population momentum had become a part of the built-in growth projection.

How actions taken now can affect the future size of world population is shown in figure 6B. Despite all feasible efforts to reduce birth rates, the world's population will almost certainly double from 4.4 billion to well over 8 billion persons in the next 70 years. But if the world instead chooses a path of high growth by doing nothing further to change trends, an *additional* population roughly *equivalent to that of the entire world in 1981* will be on Earth in 2050. Most of these people would be born in the LDCs, where the initial direct impact of their numbers would be most keenly felt.

The United States is expected to grow from 226 million in 1980 to about 260 million in 2000, and to about 290 million in 2050, while at the same time dropping from 4.9 to 4.0 to 3.5 percent of the world's population. The impact of global population growth on the United States will thus be greatest from beyond its borders.

Figure 6B.–Estimated World Population Growth, 1981-2000-2050 (in billions)



SOURCE: United Nations, 1979, *World Population Trends and Prospects by Country, 1950-2000;* **Summary Report of the 1978 Assessment for 1981 and 2000 population figures,**

The magnitude of growth in many LDCs will almost certainly be disruptive within those countries but the challenge to the carrying capacity and stability of the entire world will be felt everywhere. What some of those impacts are likely to be is examined next.

Technical Note A: Projections of population growth

In general, population projections for countries and regions are relatively accurate in the short term (10 to 15 years), and fairly inaccurate in the long term (over 20 years). Because migration is rarely a major factor in population growth, and death rates have historically declined slowly, the projection of births becomes the crucial element. For example, in the United States, the birth rate fell from 30 (30 births per 1,000 population) in 1915 to 19 in 1935, rose sharply to 25 during the "Baby Boom" year of 1955, and dropped to 15 in 1975. The causes of these changes, which are partially understood after the fact, could not have been predicted.

Even when a birth rate projection misses the actual number by a significant margin, the projection of the total size of the population may still be reasonably accurate over the short term. In a slowly growing population, the proportion of those under age 15 is about 25 percent; in a rapidly growing population this proportion can reach 50 percent (see fig. 2A, ch. 1). In the slowly growing population, a 20 to 30 percent error in estimating births would result in a 5 to 6 percent error in the total size of the population after 15 years. In the rapidly growing population, a projection with this error would be about twice as inaccurate. Errors in projecting birth rates begin to have a much greater effect after 15 years, when children born during the early years of the projection begin to reach reproductive age. Thus any over- or under-estimation of their birth rates will cause errors in the projection to accumulate rapidly.

A second crucial factor in making population projections is the accuracy of the data on population size and on birth and death rates for the base year. If the size estimate is in error, the projection will be inaccurate by the amount of error from the beginning. Inaccuracies will be compounded to the extent that birth and death rate data are inaccurate. This factor is the most serious problem in projecting population growth rates in LDCs, where data are often of poor quality.

Projections made in prior decades for the year 1980 illustrate this problem of poor quality baseline data. The U.N.'S most recent projection estimates world population at 4.43 billion in 1980. In 1973 this projection was 4.37 billion (1.3 percent less than the 1980 estimate); in 1963 it was 4.33 billion (2.2 percent less); and in 1957 it was 4.22 billion (4.7 percent less). The major factor affecting these projections was the inaccuracy of base data on death rates. The death rate for 1960-65 was estimated in 1963 to be 15.9 per 1,000 for the world and 19.2 for LDCs. Today the respective rates for 1960-65 are estimated to have been 14.4 (10 percent less) and 16.8 (12.5 percent less). The decline in death rates was projected fairly accurately, but the higher base figures led to low overall growth rates. Birth rates were estimated more accurately for the base years but were projected to decline more slowly than they actually did, which compensated to some extent for the high death rate projections. Based on calculations of error and estimates of quality of current baseline data, projections for 2000 have an uncertainty range of 10 to 20 percent.

Technical Note B: Exponential growth

The concept of exponential growth can be illustrated by observing, during a certain length of time, a theoretical population in which the rate of reproduction per individual remains constant. Each female on average leaves two females in the next generation. (Population grolvth is measured by the number of females each woman has since women bear children and the ratio of males to females is usually close to 1:1). The two females leave four females in the next generation, the four leave eight, the eight leave sixteen, and so forth. If this were a population with an age at marriage (generation length) of 20, the popula-

tion would double every 20 years. Because individuals in this population are reproducing at a constant rate, the rate at which the population increases depends on the number of people at the beginning. A population with 10 females at the beginning increases faster than a population with two females at the beginning even though each is reproducing at the same rate. This kind of population increase, known as exponential growth, is also referred to as geometric or logarithmic growth. If exponential growth were to continue unchecked, the world would soon contain more living organisms than atoms in the universe. The factors that keep this growth in check are the number of deaths in a population (growth rates slow if death rates rise), the time between generations (age at marriage in human populations), and the number of offspring each couple has (fertility). (Migration is a factor only for individual countries.)

Chapter 2 References

1. Chen, P., contractor's report to OTA, 1980.
2. Frejka, T., "World Population Projections: A Concise History," Population Council Center for Policy Studies, Working Paper No. 66, New York, 1981.
3. Futures Group, "The Impacts of Population Growth on Less Developed Countries," OTA working paper, 1980.
4. Independent Commission on International Development Issues (Winy Brandt, Chairman), *North-South: A Program for Survival* (Cambridge, Mass.: M.I.T. Press, 1980).
5. Littman, G., and Key fitz, N., *The Next 100 Years*, Center for Population Studies Working Paper NO. 101 (Cambridge, Mass.: Harvard University, 1980).
6. Tsui, A. ()., and Bogue, D. J., *Population Projections for the World, 1975-2000: Summary Report of the 1978 Assessment, New* York, 1979.
7. United Nations, *World Population Trends and Prospects by Country, 1950-2000: Summary Report of the 1978 Assessment*, New York, 1979.
8. U.S. Commission on Population Growth and the American Future, "Population Growth and the American *Future"* (Washington, D. C.: Government Printing Office, 1972).
9. U.S. Council on Environmental Quality and Department of State (G. O. Barney, Study Director), *The Global 2000 Report to the President* (Washington, D. C.: Government Printing office, 1980).
10. U. S. Department of Commerce, Bureau of the Census, *illustrative Projections of World Population in the 21st Century,* Current Population Report, Special Study Series P-23, No. 79 (Washington, D.C.: Government Printing Office, 1979).
11. _____, 1980. Revised table to above.
12. World Bank Development Economics Department, prepared by K. C. Zachariah and My Thi Vu, Population Projections, 1975-2000 and Long Term (Stationary Population) (Washington, D. C.: World Bank, 1979).