1 PEOPLE AND LAND

1.0 INTRODUCTION

Be fruitful, and multiply. – *Genesis 1:22*

People who count people count a lot of us, and more all the time. The world now holds about 5.5 billion people, adding approximately 100 million each year. Are there too many of us, using up the earth's resources and polluting its surface? Are there not enough, leaving work undone that could make the world's people more prosperous? Are there too many in some places and not enough in others, or too many that we don't like and not enough that we do? We address these issues in this chapter and throughout this book.

This chapter discusses the size of the world's population, its distribution, and the types of land available to people (1.1); the history of population growth (1.2); variation in such characteristics as age distributions and growth rates in different parts of the world (1.3); the relationship between population and wealth (1.4); and three sections that explore the question of whether the world has too many people – a comparison of lesser-developed countries with industrial ones (1.5), a discussion of the U.S. population (1.6), and finally an exploration of the thorny issue of population control (1.7).

FURTHER READING: This chapter depends on an abundance of statistics from the following sources: Population Reference Bureau (1994); World Resources Institute (1992, 1994); United Nations (annual a, annual b); and United States (annual).

1.1 POPULATION DENSITIES AND LAND USE

Most national governments pay lip service to the idea of conservation of natural resources, but in practice soil conservation is not a vote-winning issue with the electorate. – *N. Hudson,* Land Husbandry, *p. 32*

The earth currently (mid 1990s) holds about 5.5 billion people. If they were spread evenly over the entire inhabitable land area of the earth, we could calculate a population density as follows:

- The surface area of the earth is 197 million (197×10^6) square miles.
- Assume that 75% of the earth is uninhabitable. This figure includes the 71% that is ocean and 4% in Antarctica and the Greenland icecap, but it leaves large areas that are only marginally inhabitable, such as the Sahara Desert, in the 25% of the earth that we can live on. Thus, the inhabitable land surface is $0.25 \times 197 \times 10^6$ square miles.
- The population density is the population divided by the area, or $5.5 \times 10^9/0.25 \times 197 \times 10^6 = 111.7$ people per square mile.

Instead of 111.7, we cite the population density as 110 people per square mile. The reason for the approximation is that we have made two prior approximations in the data. One is the population of the earth as 5.5 billion, and the other is the 25% of the earth that is inhabitable. Both of these figures are meaningful only to two "significant

Cambridge University Press
978-0-521-56872-2 - People and the Earth: Basic Issues in the Sustainability of Resources and Environment
John J. W. Rogers and P. Geoffrey Feiss
Excerpt
More information


(a)

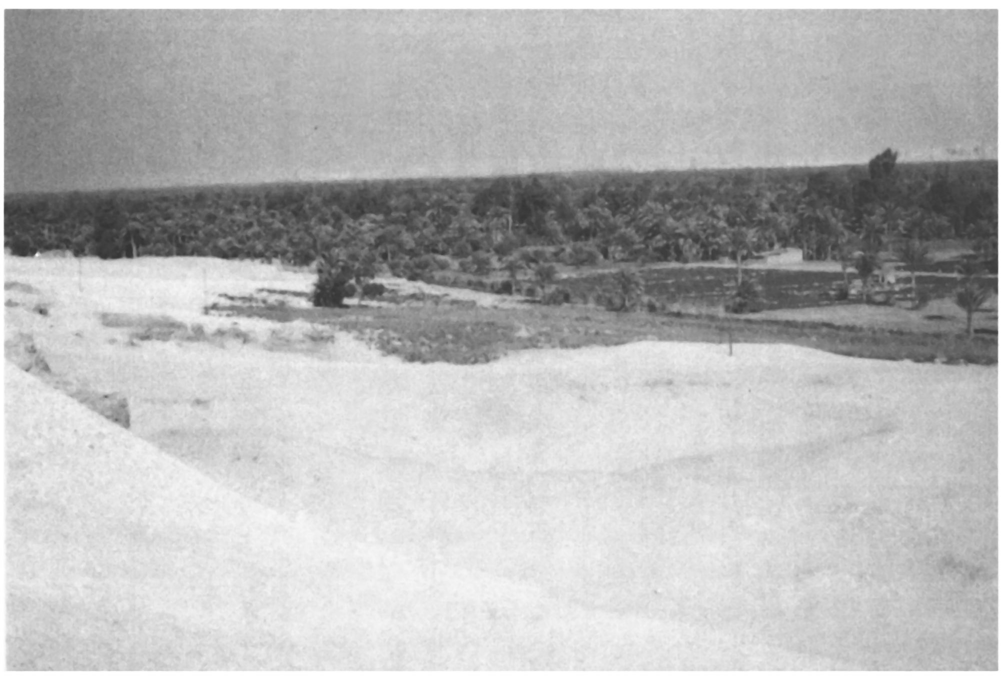

(b)

Figure 1.1 Population along the valley of the Nile River in Egypt: (a) river meandering through a valley that is three to four miles wide and ranges from a few 10s to more than 100 feet below the surrounding desert. It contains farms, date orchards (large dark areas), small villages, and a few areas of high ground that are white because they are not irrigated by the river. Only a few irrigated areas (dark areas toward the left of the photograph) have been established in the surrounding desert. Because the desert is nearly uninhabitable, virtually all of Egypt's 60 million people, increasing by nearly 1 million each year, are crowded into the valley and delta formed where the river enters the Mediterranean. These areas contain only 4% of Egypt's total land area and have a population density of nearly 5,000 people per square mile; (b) date palms in the valley as seen from the surrounding desert. It is possible to stand with one foot in irrigated land of the valley and one in the desert that supports no vegetation.

figures," so we report the density as 110 people per square mile, showing only two significant figures (1 and 1). To put a population density of 110 per square mile in perspective, each person would have about 6 acres of space as a private preserve – a square mile contains 640 acres, and an acre is about the size of a football field (American football field, which is about 20% smaller than a soccer field, known as a football field in the rest of the world).

Calculation of the population density of the entire earth masks important variations in densities from place to place (Fig. 1.1). Many of these variations are controlled by variability in the types of land available for hu-

Table 1.1 *Land use and population densities in selected countries*

	Percentage of area in				Density in people per square mile as population divided by	
Countries	Cropland	Pasture	Forest	Other	Total area	Inhabitable area
World	11	26	31	32	110	310
United States	21	26	32	21	74	157
Canada	5	4	39	52	8	89
Netherlands	27	32	9	32	1174	1190
United Kingdom	29	46	10	16	626	835
Germany	35	16	30	19	602	1180
France	35	21	27	17	273	569
Russia	8	5	44	44	22	169
Malta	41	0	0	59	2954	7205
Nigeria	34	44	14	8	279	358
Saudi Arabia	0.5	40	0.5	59	22	48
India	57	4	22	17	794	1302
China	10	34	14	42	331	762
Japan	12	2	67	19	586	4186
Brazil	9	20	66	5	48	166
Trinidad and Tobago	23	2	43	31	650	2600
Australia	6	56	14	24	6	10

Notes: Because of lack of information, the areas of forest and other in Russia are arbitrarily assigned as one-half of the area not used for crops or pasture.
Sources: Population Reference Bureau (1994); World Resources Institute (1994).

man use. We discuss population densities first and then their relationship to land use.

Variations in population densities

A herder on the steppes of Mongolia, where the population density averages 4 people per square mile, may look for miles across the countryside without seeing anyone. Conversely, inhabitants of major cities can live only by building apartments on top of each other and thus achieving a level of crowding up to the population density of Tokyo (the world's most crowded city), with a population of nearly 8 million squeezed into slightly more than 200 square miles for a population density of 34,000 per square mile. We show two different measures of the population densities of selected countries in Table 1.1. One measure, which we used for the population density of the whole earth, is the population divided by the total land area. Another, perhaps more meaningful, number is the population divided by the land area on which people can be reasonably expected to live. Because wasteland generally cannot be inhabited and forests should not be cut down for habitation, we define this inhabitable area as the sum of the areas of cropland and pasture.

The countries with the largest populations are China (1.2 billion) and India (900 million). China is still growing, although stringent birth control programs have reduced the rate (Section 1.5), and India is predicted to surpass China as the world's most populous country sometime during the next century. Large populations raise images of great crowding, well past the burden borne by the rest of the world. These images are false. The population densities (total area) are 300 people per square mile in China, well below the average in many wealthy European countries, and 800 in India, not much more than the European average. The perception of crowding in a country such as India comes from the cities, deluged with an influx of people from the countryside at a rate faster than services can expand. Bombay, for example, has grown from a city of 1 million in 1948 to more than 10 million today largely by absorbing young people pushed out of rural India by a birthrate that overwhelmed the supply of sufficient land or

Table 1.2 *Estimated populations of megacities in early 21st century*

City	Population (in millions)
Bangkok	11
Beijing	12
Bombay	16
Buenos Aires	13
Cairo	13
Calcutta	17
Delhi	13
Jakarta	15
Karachi	9
Los Angeles	11
Manila	12
Mexico City	25
Moscow	10
New York	17
Rio de Janeiro	14
São Paulo	23
Seoul	14
Shanghai	15
Tokyo	22

Notes: Some estimates include populations of metropolitan areas, but some cities would be much larger if their metropolitan areas were included.
Sources: Data are from various sources, mostly publications of the United Nations.

jobs to make a living. This influx is predicted to continue well into the 21st century, creating megacities with populations greater than 25 million people (Table 1.2).

Europe and Japan demonstrate that high population densities do not necessarily cause poverty. The Netherlands is one of the world's most crowded countries, and all of Europe exceeds the average world population density by a factor of 3 to 4. Europe is rich, however, because it has a climate and geography that permit about half of its land to be used for crop and animal production and a level of political and social organization that enables Europeans to use these resources. The overall population density of Japan is about twice that of Europe, but most of Japan is a land of steep-sided mountains, and only about 15% of the area can be farmed or even used for cities and towns. Thus, several thousand Japanese must fit into each square mile of arable and inhabitable land (see the difference between the two measures of population density in Table 1.1). Paradoxically, some of the world's most crowded countries are also its smallest and some of its major vacation spots. The islands of Barbados, Maldives, and Malta must pack their populations of a few hundred thousand people into very small areas circumscribed by the ocean.

Land use

Land can be classified in various ways. We use four categories here – cropland, pasture, forest, and other land. As well as discussing the four categories, we list their distribution in selected countries in Table 1.1 and illustrate them in Figure 1.2.

Cropland is land used for standard production of grains, vegetables, and other plants consumed by people or fed to animals for human consumption. Land that can be used naturally must have adequate soil and rainfall, and most food crops have a limited range of temperatures to which they can be exposed (Section 2.2). Cropland also includes land that is not naturally fertile but can be used agriculturally through application of fertilizer and/or irrigation water (Sections 2.2 and 4.3).

The area covered by cropland can either expand or contract from year to year. Expansion is caused by conversion of other land to agriculture by application of fertilizer and water. It occurs when governments or private individuals attempt to increase agricultural productivity, either to provide more subsistence for the local population or to produce wealth through trade (Section 2.5). Most of the converted land was formerly used for pasture, and because animals can generally be raised more efficiently on hay grown domestically than on natural pasture (Section 2.3), this conversion temporarily increases total productivity. Some expansion of cropland is also accomplished by clearcutting of forests, generally accompanied by burning. Because most forested land, particularly in the tropics, does not have adequate soil for crops, this expansion usually requires addition of massive amounts of fertilizer; we discuss the disastrous consequences of clearing tropical forests in Section 8.3.

Area classified as cropland can shrink for two reasons. One is the deliberate decision, now being made in many European countries, to reduce overproduction of food and allow some land to return to a natural state. A second, and very unfortunate, reason is environmental degradation caused by soil erosion, leaching of nutrients out of the soil, or contamination of soil and water by human activity. This reduction is particularly serious in lesser-developed countries, but the industrialization of agriculture may have long-term effects in all countries, as we discuss in Section 2.5.

Pasture comprises areas that domestic animals graze on. Much of it is natural grassland, which is particularly useful for cattle and sheep, but goats can also browse on bushes and other vegetation. Some grasslands, especially in northern temperate climates, are very productive and support large populations of animals. In semiarid regions such as southern North America, much of Africa, and Australia, however, pasture may offer so little edible vegetation that animals can survive only if they can roam over large areas (more than 1 square mile per cow in some regions). Although some pasture is being converted to cropland, the principal change in the area devoted to pasture is a reduction caused by excessive animal populations. We discuss this problem further in Section 2.3

Forest and woodland include area covered by trees. This category includes vast stretches of conifers (pines and related varieties) in subarctic areas, mixed hardwood and conifer forests that cover the temperate regions of much of North America and some parts of Europe, and the environmentally fragile rainforests of the tropics. Tree-covered areas may expand because of abandonment of cropland or may contract by conversion to cropland (see earlier discussion and Section 8.3).

Other land constitutes the final category. Just when you thought the classification was going to be simple, we must now introduce this nebulous term. It results from the difficulty of further subdivision and generally means places without usable vegetation. Most of this other land could be called wasteland. It includes Arctic tundra, treeless and covered by small plants; steep mountain sides with large exposures of bare rock; and deserts so arid that they contain virtually no vegetation. It also includes areas covered by human habitations, industry, malls and their vast parking lots, roads, and airports – in short, places where nothing grows because people have covered them with asphalt, concrete, bricks, wood, and other construction materials.

Although the area that people have covered seems to be large, it actually is a very small percentage of total land area. It appears large because, when we are in the center of a city, we see only streets, sidewalks, and buildings and think that the entire city and its surrounding suburbs have demolished every living thing. But cities contain parks, and houses have gardens and lawns. A large city (megacity) like London, for example, seems to sprawl interminably over the countryside, but examination of a map showing a 30-mile radius around London reveals that more than half of one of the most urbanized places on earth consists of forests, parks, and agricultural land. A few cities, like Cairo, are compressed and lack these amenities, but generally they cover only a few tens of square miles. The only country in which people have built on most of the land is Singapore, which consists essentially of the city of Singapore and a small outlying region. In short, an exact calculation of the amount of "other" land covered by constructed areas is difficult to make, but it is less than 1% in most countries and not more than a few percent even in densely populated Europe.

FURTHER READING: Hudson (1992).

1.2 HISTORY OF WORLD POPULATION AND GROWTH RATES

If the population of the world were to continue to grow at the present rate for six hundred years, there would then be only one square yard per person. It is inconceivable that this should happen, but the important question is: Why will it not happen? – *P. Appleman*, The Silent Explosion, *p. 137*

How has the earth reached its population of 5.5 billion people? The consequences of having children are illustrated in Figure 1.3, which shows a constantly increasing population that follows an "exponential" growth curve (the mathematics of exponential curves is explained in the caption for Fig. 1.3). This exponential curve demonstrates an excess of births over deaths that causes the population to increase at a "constant rate" through time. For example, if 1,000 people show an increase of 0.5% per year, to 1,005, then an 0.5% increase of 10,000 people will add 50 to population to increase to 10,050, and so on to larger populations. A constancy of growth rate signifies a constant period of time in which a population doubles its size. We refer to this period as the "doubling time" (t_{doub}). Starting from any arbitrary time, the population is twice as large after 1 t_{doub}, four times as large after $2t_{doub}$, 8 times after $3t_{doub}$, and so on. Inevitably, as the absolute number of people increases, the number of people added each year will increase also, yielding the concave upward curve of Figure 1.3, and populations with short doubling times become very large very quickly.

Having already used the figure of 5.5 billion for the present population of the world, we now investigate the population at different stages of earth history. We must start by recognizing that the world's population is not easy to count. A modern census suffers from the problems that births and deaths change the population while the counting is in progress; that people move, particularly nomads who may cross national borders; that some peo-

(a)

(b)

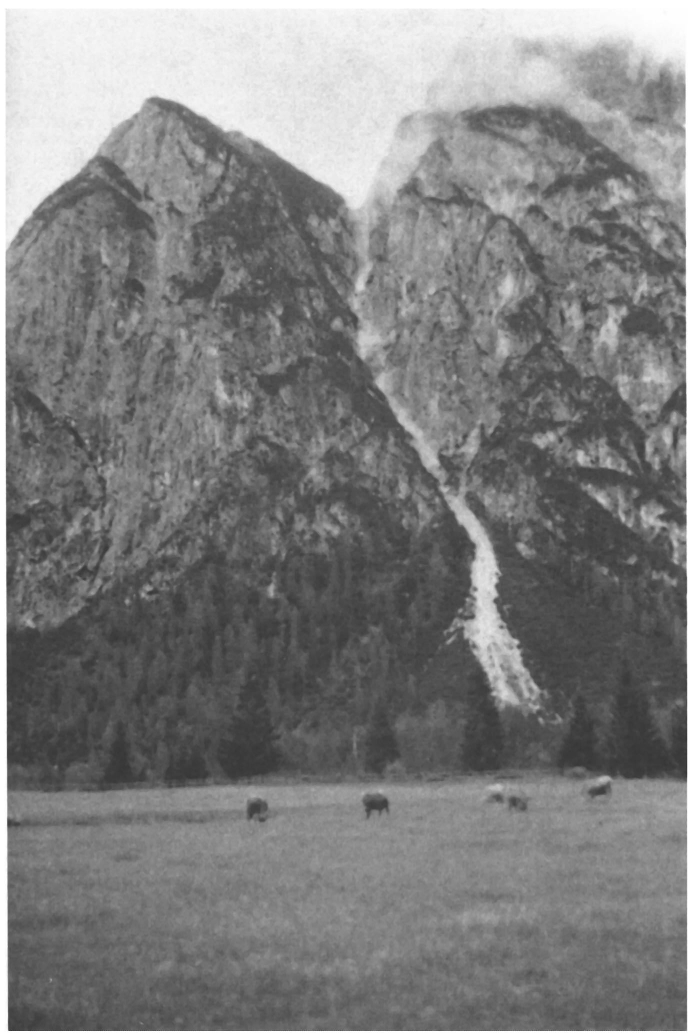
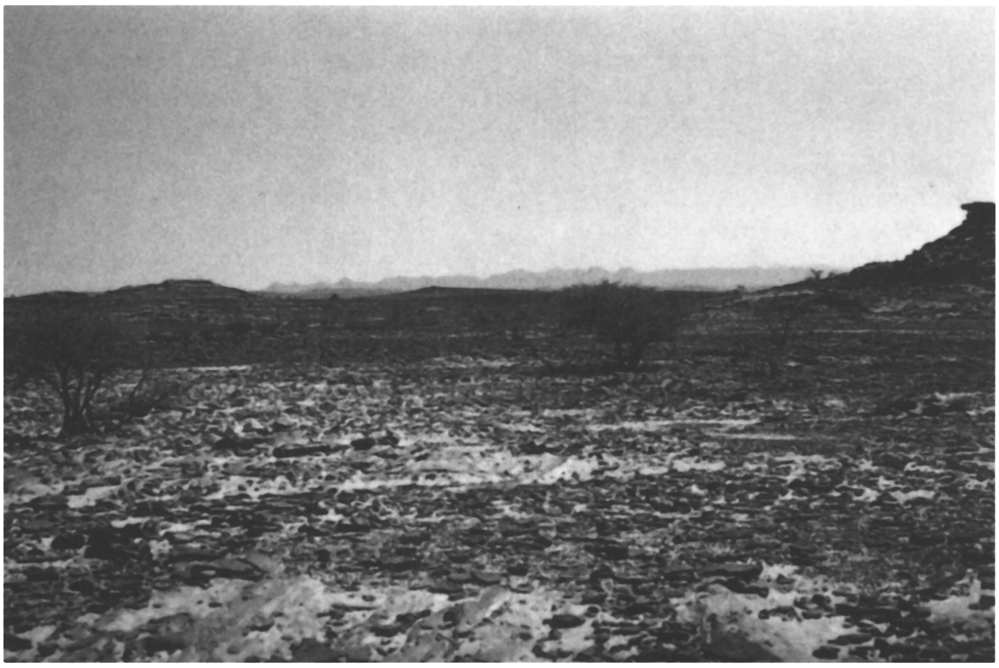


Figure 1.2 Examples of the four types of land use discussed in the text: (a) cropland in central Sweden; (b) pasture in the Dolomite Mountains of northern Italy; (c) forest in the Karelian region of western Russia; (d) wasteland along the border between Saudi Arabia and Yemen.

Cambridge University Press
978-0-521-56872-2 - People and the Earth: Basic Issues in the Sustainability of Resources and Environment
John J. W. Rogers and P. Geoffrey Feiss
Excerpt
More information

(c)

(d)



ple avoid being counted, especially if they are living in a country illegally, or aren't paying their taxes. Some people just do not like government officials who ask questions and refuse to cooperate. Census figures become shakier as we go further into the past. We know the population of England in 1085 because in that year William the Conqueror ordered the preparation of the Domesday Book in order to control his new kingdom more effectively. Few other areas of the world were that organized in the 11th century or kept any records at all. Furthermore, the idea that every square inch of the world belongs to one country or another is a modern invention (see discussion of Afghan nomads in Box 1.1). Most of human history was a time of massive migrations, ephemeral kingdoms, borderless open lands, and no written records. Using the best estimates that we can find for past

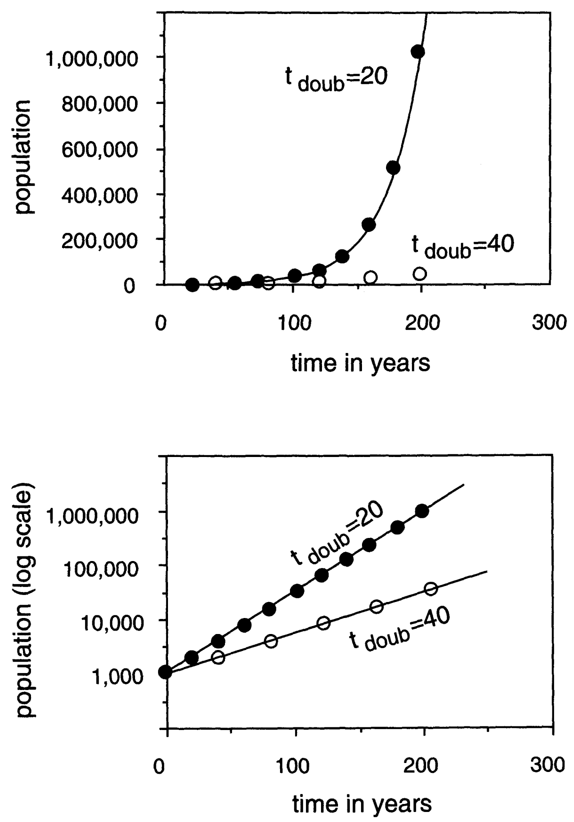


Figure 1.3 Exponential curves. Two graphs demonstrate the effects of growth at "constant" rates and different "doubling times" (see text for definition). The graphs show the sizes of two different populations, each starting with 1,000 people, after the doubling period for each population (40 years for one and 20 years for the other).

The top graph shows the growth of both populations with time plotted on the horizontal axis and population on the vertical axis. On this scale, the growth of the population with a 20-year doubling time is so fast that the population with a 40-year doubling time seems barely to change.

A curve drawn through plotted points for the population with the 20-year doubling time shows the typical shape for a "constant" rate of growth (see text) that leads to larger and larger increments as time passes. This curve is described by the equation

$$P_t = P_0 e^{kt},$$

where P_t = the population at any time t; P_0 = the population at any starting time designated as $t = 0$; t = the time of growth from the arbitrary starting time; k = a constant characteristic of the population; e = the base of natural logarithms (2.718). The value of k (the rate constant) varies among different populations. Where k is high, the population grows rapidly; a low k signifies slow growth. The position of kt as a "power" of e makes the equation and curve "exponential."

The constancy of growth shown by the exponential relationship can be demonstrated further using calculus. If we say

rate of increase = constant X population at any time,

the calculus expression is

$$dP = kPdt$$

or

$$dP/P = kdt$$

which, on integration from a starting time $t_0 = 0$ to a finishing time of t, yields

$$P_t = P_0 e^{kt}$$

The curvature of the exponential graph in the top graph shows the effect of constant growth but makes the graph more difficult to interpret than a straight line. Linearity is accomplished by expressing the relationship logarithmically as

$$\ln P_t / P_0 = kt,$$

where ln is a natural logarithm (to the base e). The logarithmic relationship enables us to plot the logarithm of P_t / P_0 on an arithmetic axis versus t, yielding the straight line shown in part B.

Rates of growth of various populations can be described by the rate constant k. As discussed in the text, however, they are more easily understood by the "doubling time" (t_{doub}). The value of t_{doub} can be determined both graphically and from the logarithmic form of the growth equation. When $P_t / P_0 = 2$, the t in the growth equation is t_{doub}. Then

$$\ln 2 = 0.693 = kt_{doub}, \text{ or}$$

$$t_{doub} = 0.693/k.$$

populations, we obtain the curve shown in Figure 1.5 for the change in world population through time. This figure shows three basic stages in human history.

The period prior to about 10,000 B.C. was a time of hunter–gatherer societies. People lived on the animals they could kill and the fruit and other edible vegetation they could find. Although the diet was varied and probably nutritious, these societies were limited by the primary productivity of the land (see Box 1.2 for the life of a modern hunter–gatherer society). Thus, the family/tribal groups were small and widely scattered and had to move frequently as they exhausted the resources of one area. Several factors kept growth rates low. Life expectancy was short, perhaps about 20 years, with most children dying in infancy. The food gathered would not have been edible by infants, causing mothers to breast-feed their children for 2 to 3 years, thus reducing their periods of fertility. Also, very young children are hard to travel with, a fact confirmed by any modern parents who have packed a car to take a baby on a family outing. The total

BOX 1.1 SQUEEZING THE AFGHAN NOMADS

The collision of the Indian subcontinent with Asia that began about 40 million years ago, and still continues, lifted the Himalayas and adjacent lands to the highest elevations on the earth. Where the western edge of the Indian plate pushed against Asia, the crushing was so intense that it created what geologists call a "syntaxis," or in rare moments of clarity, a "knot" in the Pamir region of central Asia. Various mountain ranges radiate from this knot, and the southwesterly one occupies most of central and northern Afghanistan (Fig. 1.4).

For many centuries, the mountains and valleys of the Pamir and neighboring areas have been the home of nomads. They lived in tents and pastured their herds, mostly sheep and goats, in sparse mountain meadows up to 10,000 feet high during the summer. When winter closed in on them they moved to the valleys, where they continued to tend the herds and where some of the wealthier families had permanent houses and agricultural plots. The spring and autumn migrations commonly lasted 2 months and covered several hundred miles.

The migrations did much more than provide feed for the herds. The nomads needed grains and vegetables to eat, clothing that could not be produced solely from wool, and some very limited consumer items. For these goods, they needed money, and they made it in several ways. One was transporting the merchandise (grain, etc.) for a fee. More common was the pur-

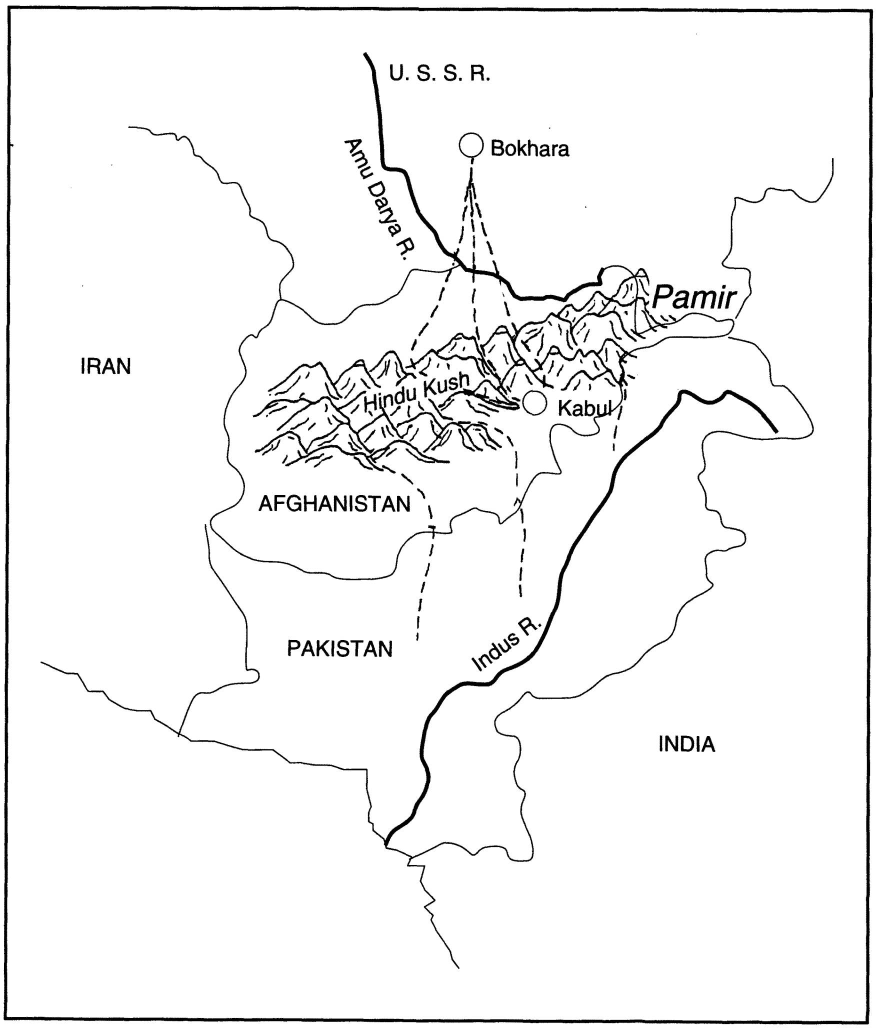


Figure 1.4 Nomad trails in the Afghanistan area. Modern Afghanistan extends from the northern border along the Amu Darya River, closed by Russia in 1920, to the southeastern border that Pakistan closed in 1960.

BOX 1.1 SQUEEZING THE AFGHAN NOMADS *(continued)*

chase of grain, clothing, and other goods in one area and its sale at a profit elsewhere. The nomads also sold the produce of their flocks as milk, wool, and occasionally as meat.

Many of the major trading routes crossed the present Afghanistan, although individual groups generally traveled over only part of the distance (Fig. 1.4). The low valleys of the Indus plain were fertile regions in which to spend the winter. The high reaches of the Hindu Kush Range provided summer pasture. Trading was good in Bokhara and other cities of central Asia made rich by the east–west traffic between Europe and China (the Silk Road). This migratory life suited the terrain of Afghanistan. Rain falls only in the mountains, and agriculture in the valleys depends on irrigation from streams or wells. Even with irrigation, only 12% of the country is arable, and much of the rest is too rocky or too dry even for grazing.

Wealthy countries have now eliminated most of this nomadic life. Three events are most important in this elimination. The first was in the 1800s, when the British colonial government in India, which included Pakistan, reached an agreement with the tsarist government of Russia on territorial borders between them. Russia would have control over areas north of the Amu Darya River, including Bokhara and other major cities. British India would have control of areas south and east of the present western border of Pakistan. Between Russia and India would be a buffer state, known as Afghanistan, where the local inhabitants would be free to live their own lives just as long as they didn't annoy the two major powers on either side.

The subdivision of the 1800s had little effect on the nomads, who were still able to cross borders with little trouble. The Bolshevik Revolution in Russia, however, led the new Soviet empire to close its border along the Amu Darya in 1920, effectively sealing off access to the northern part of the nomadic routes. Independence of India from Britain in 1947 was accomplished only by splitting mostly Hindu India and mostly Moslem Pakistan into two separate countries. Then in 1960, Pakistan closed its border to nomads and virtually all other Afghans. Not only did this closing keep the nomads away from the fertile Indus valley, but it also prevented visits between family groups, who had lived on both sides of the original British border and who had not been affected as long as cross-border movement was permitted.

Even with these restrictions, some nomadic movement still occurred within Afghanistan. Further modernization, however, terminated most of what remained. Instead of camels and oxcarts to haul goods, the Afghans bought trucks. The trucks were much more efficient, covered longer distance, even on poor Afghanistan roads, and permitted the opening of markets in settled locations instead of the traveling bazaars operated by the nomads. Herders who could afford to buy trucks hauled their sheep and goats between pastures in the back.

So civilization "won," and the Afghanistan nomadic life-style became extinct.

FURTHER READING: Pedersen (1994).

world population in 10,000 B.C. is estimated at approximately 6 million.

The date of 10,000 B.C. approximately marks the beginning of agriculture, the deliberate growing of grain and vegetables and raising of animals for meat (see Sections 2.2 and 2.3). Although some societies remained, and still remain, mixed hunting–gathering and agricultural, other areas favorable to crop growing became completely reliant on domestic plant and animal production. The benefits of agriculture over hunting and gathering are an increase in the amount of food produced and the ability to remain in one place, at least until the soil is depleted. Thus, population densities could increase, particularly in those parts of the world with rich soils (largely areas of abundant rainfall or river water). This growth averaged approximately 0.1% per year and brought estimated world populations from 250 million in A.D. 0 to 750 million at the end of the dominantly agrarian period in 1750 (t_{doub} varying from ~2,000 years early in the agrarian period to ~1,000 years later). The growth resulted both from an increase in life expectancy, to a worldwide average of about 25 years, and an increase in the number of children produced per woman. Population growth would have been higher except for the bubonic plague ("black death") that scourged most of Europe and parts of Africa and Asia toward the latter part of the agricultural period. In 1750, the population density of Europe, the world's highest, was about 25 people per square mile.

The industrial revolution in 1750 ushered in an age of rapidly increasing populations in those parts of the world that it affected. In 100 years, the combined populations