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2 Environment, Population, and Technology in Primitive Societies

Ester Boserup

WHEN THE RATE OF INCREASE of European populations accelerated in the second half of the eighteenth century, European economists elaborated a theory of interrelationships between environment, population, and technology, which continues to be applied by many social scientists who are dealing with problems of development of primitive societies. The basic characteristic of this theory is that it deals with demographic trends as an adaptive factor: It assumes that a given environment has a certain carrying capacity for human populations, defined as the number of persons who can be accommodated in that region under the prevailing system of subsistence. Population is kept within the limit for subsistence in a particular environment by customary restraint on the number of births or by high rates of mortality, including various forms of infanticide. According to this theory, over the long run primitive societies tend to have a rate of zero population growth. The rate rises above zero if improvements in the technology of food production increase the carrying capacity of the environment, but only until the new limit is reached, after which the rate of population growth again returns to zero.

This reasoning suffers from two main weaknesses: First, the theory focuses exclusively on the technology of food production, ignoring the effects of technological changes in other areas and the effects of the environment; secondly, the theory ignores the effects of demographic change on both environment and technology.

EFFECTS OF TECHNOLOGICAL CHANGES ON POPULATION

Demographic trends in primitive populations are influenced not only by food technology but also by health, transport, and war technologies, and by the system of organization, which could be called "administrative technology." Until recently, health technology was so primitive that many well-fed populations had low birth rates owing to endemic venereal disease and malaria, and high mortality rates, particularly for infants. The main technique of avoiding contamination by epidemic disease was to isolate oneself as much as possible from the source of contamination by such procedures as abandoning the old village and building a new one in another place, fleeing the town, and closing the gates of the town or the frontiers of the country. Some of these measures tended to spread the epidemics more widely rather than to contain them.

Improvements in the means of transport, which open up new regions for human contacts, are likely to raise mortality rates by giving greater sway to the spread of epidemics. It is true that improvements in transport technology might sometimes reduce mortality by facilitating the supply of food to a famine-stricken region, but since such improvements make it easier for a conqueror or an indigenous ruling class to move food away from the region where it is produced, they could also result in reduction of food available for the local population, with negative effects on demographic trends.

Improvements in military technology usually raise mortality rates, particularly when they are of a kind to benefit the aggressor more than the victim. However, the effects of a given type of technological change are often complex. For instance, building walled towns probably reduced losses in warfare but increased mortality by epidemics if sanitary and other health technology was not improved. In other words, this particular improvement in military technology caused deterioration of the (urban) environment, which might have raised mortality by more than it reduced direct war casualties.

Administrative technology is particularly important in affecting mortality rates in cases of military events and food shortages. A breakdown of the organization of society might transform a local war or harvest failure into a demographic catastrophe.

The examples above may suffice to illustrate that improvements in food technology are only one among many types of technological changes that influence demographic trends in primitive societies. Therefore, it seems unwarranted to assume that population growth was rapid in primitive societies in the past whenever the rate of growth was unhampered by an inelastic supply of food. Many primitive peoples who were not underfed and who did not fully use the subsistence capacity of their territory must have been decimated by epidemics and wars repeatedly; and I surmise that such wars were waged rarely in order to conquer empty land for a people suffering from overpopulation, but more often in order to conquer slaves or inhabited land (i.e., people who could be made to pay tribute).

Thus, the most reasonable assumption about past demographic trends seems to be that some unfortunate peoples, decimated by disease and war,

had negative rates of population growth and disappeared, while other more fortunate ones had positive, but fairly low, rates of growth over long periods. There seems to be little reason to assume that zero rates of population growth occurred more frequently in past history than other rates of growth, positive or negative.

In many cases, peoples with positive rates of growth may have migrated to land that became free when the previous inhabitants were reduced in numbers. But in many other cases, the effects of different rates of population growth among neighboring peoples must have been the opposite: Peoples with positive rates of population growth would use their increasing numerical advantage to force neighboring peoples with declining or less rapidly increasing numbers to become slaves or wage workers in the villages and towns of the stronger people, thus further increasing the differences in population densities within a region. I shall return to the effects of such variations in population density later.

Increase of Population and Change in Subsistence Technology in the Early Development of Europe

Until fairly recently, agricultural history dealt mainly with Europe, and European agricultural history was interpreted in the light of the classical theory mentioned above. It was assumed that the primitive nature of agricultural equipment prevented the cultivation of most of the land that is under cultivation today. It was also assumed that the European population was unable to expand, except in periods when better equipment was introduced. In such periods, rates of population growth would have been positive until the new capacity limit for food production was reached, at which time the long-run rate of population growth was assumed to have returned to zero.

This theory fails to take account of the fact that much of the land that was uncultivated in prehistoric times and later, was not land that could not be used with the existing types of equipment, but rather land that was used in certain years but that in other years lay fallow under the prevailing systems of long fallow.[1] Europe's population began – like populations on other continents – as hunting-gathering communities, but as early as 4500 B.C. some populations in temperate Europe seem to have adopted a system of forest fallow similar to that still in use in some contemporary primitive communities on other continents. When this system is used, a plot cleared in the forest is cultivated for a brief period and, when weeds appear, it is left

1 Evidence to this effect is presented by Ester Boserup in *Conditions of Agricultural Growth* (Chicago: Aldine, 1965).

to regrow into forest. The system requires a large area of land to feed a small group of people. The next step in the development of European agriculture was a gradual shortening of the fallow periods and lengthening of the periods of cultivation for any given piece of land, in step with the gradual increase of the European population.

During many centuries, systems of shorter and shorter fallow spread gradually over Europe, until finally annual cropping became widespread in the eighteenth and nineteenth centuries. The change was slow because the increase of population was slow and intermittent, and an increasing labor force was the precondition for a type of change under which the share of land under cultivation at any given time would increase and the share under fallow correspondingly decline. In regions of Europe that remained sparsely populated the land-using systems of long fallow continued to be used for many more centuries than in those regions of Europe where population increased more rapidly, whether by natural increase or by immigration. By ignoring the process of gradual shortening of fallow, the classical economists, and the economic historians who were influenced by their reasoning, failed to notice the link between demographic trends on the one hand and environment and technology on the other.

The gradual transition to shorter fallows changed the environment. Forests were thinned out and eventually disappeared, and natural grazing pastures and man-made fields replaced them. Also soil conditions changed as forest areas were transformed either into grassland or into drained, marled, and manured fields. In step with all these changes, the primitive digging sticks and stone axes used in the food-gathering and forest-fallow stages had to be replaced by other hand tools and later by ploughs.

The gradual shortening of fallow served to feed larger and larger populations in Europe, but the effects of this change on labor productivity in European farming seem not always to have been positive. When fallow was shortened, labor-intensive operations of land preparation, weeding, and fertilization became necessary in order to prevent a decline of crop yields and exhaustion of the soil. The negative effects of this on labor productivity tended to offset the positive effects of improved equipment.

Agricultural historians have described cases in which reduction of population after major epidemics or wars was accompanied by a reversion to systems of longer fallow.[2] This would seem to indicate that, in these cases, the previous expansion of output by shortening of fallow had been obtained at the cost of a decline in output per unit of labor. The point is important in evaluating the effects of these technological changes on the demographic trends, because these changes could be expected to accelerate

2 See, e.g., Marc Bloch, *Les caractères originaux de l'histoire rurale française*, vol. 1 (Paris: Les Belles Lettres, 1931), vol. 2 (Paris: Armand Colin, 1956); and B. H. Slicher van Bath, *The Agrarian History of Western Europe* (London: E. Arnold, 1963).

population growth only if they raised output per unit of labor. If the only positive effect of these changes were to allow a larger population to raise total food production in proportion to the increase in numbers, there would seem to be little reason to expect any acceleration of the rate of population growth as a result of the changes of methods.

Effects of Demographic Trends on Environment

The recent acceleration of rates of population growth in contemporary primitive communities on continents other than Europe provides much new information about the interrelationships between demographic growth, on the one hand, and environment and technology, on the other. Both natural and social scientists have studied the changes in environment and technology that are occurring under population pressure in contemporary primitive societies, and a number of scholars are taking this evidence as a starting point for a reinterpretation of the ancient history of primitive and other preindustrial societies.

In order to provide a framework for discussion the main primitive subsistence systems are listed below according to the difference in periods of cultivation and fallow, beginning with the most primitive systems with the longest periods of fallow and the smallest carrying capacity in terms of human populations. This framework also illuminates the preceding discussion of early European development and underlies the examination of the impact of demographic trends on technology in the sections that follow.

1. Gathering of food – no cultivation, all land "fallow land"
2. Forest fallow – one to two crops, followed by 15–25 years of fallow
3. Bush fallow – four to six crops, followed by 8–10 years of fallow
4. Short fallow – one to two crops, followed by one year of fallow
5. Annual cropping – one crop each year with a few months of fallow
6. Multicropping – two to three crops each year without any fallow

The number of persons who can live in a given area of land is, of course, higher the shorter the period of fallow. It is not possible to use all the subsistence systems in all environments, but most environments are adaptable and allow a choice between several of these systems: A semidesert can be used for herding but also for irrigated crops.

If the population using one of these subsistence systems increases (by natural growth or by immigration) to the point of exceeding the carrying capacity of the land under that system, the environment is likely to deteriorate. If the subsistence system is food gathering, edible plants and animals may gradually disappear. If the subsistence system is forest fallow, the forest may gradually disappear and become replaced by bush or grassland. In other cases, grassland may become overgrazed, and the cultivation of steep hillsides may result in erosion and barrenness. In such cases, the population may have to move to another region, leaving a useless desert behind. This seems to have happened, for instance, in some parts of southwestern Asia during ten millennia of agricultural exploitation of the environment.[3]

But sustained demographic growth among primitive peoples does not always result in deterioration of the environment, because the possibility exists that the population, when it outgrows the carrying capacity of the land with the existing subsistence technology, may change to another subsistence system with a higher carrying capacity. Sometimes this change is even facilitated by the transformation of the environment, for instance, by the replacement of forest by bush or grassland, which forces the population to shift to bush fallow or grass fallow instead of forest fallow and to introduce types of tools that can cope with grassy weeds.

Changes in Subsistence Systems under Population Pressure

Studies of changes in subsistence systems in contemporary primitive societies have been undertaken by many anthropologists, geographers, and agricultural experts. These studies are usually limited to a single change within a particular community or region, for instance, from food gathering to agriculture, or from forest to bush fallow, or from short fallow to annual cropping. Likewise, economic historians and archaeologists have taken an interest in changes in primitive subsistence systems that have occurred in the history of the peoples they are studying. Most of these studies are also limited to a single change, but by linking a number of studies made by different scholars, it is sometimes possible to follow the whole process of gradual change from land-using to land-saving systems in step with demographic growth within a major region. I mentioned above the changes that have taken place in the course of European history; similar changes from land-using to land-saving systems have taken place in other parts of the world. For ancient Mesopotamia, evidence from many studies has been combined to show a gradual change from the food gathering on mountain slopes before 8000 B.C. to intensive agriculture based on large-scale irrigation and plough cultivation in the southern plains four thousand to five thousand years later.[4]

3 Frank Hole, "Evidence of Social Organization from Western Iran 8000–4000 B.C.," in *New Perspectives in Archeology,* Lewis R. Binford and Sally R. Binford, ed. (Chicago: Aldine, 1968).

4 A more detailed discussion of agricultural growth in Mesopotamia is provided in Philip E. L. Smith and T. Cuyler Young, Jr., "The Evolution of Early Agriculture and Culture in

It is apparent from the few examples mentioned above that the change from the food-gathering stage to intensive preindustrial agriculture has been a very slow process. It apparently took ancient Mesopotamia over four thousand years to pass from the beginning of food production to intensive, irrigated agriculture, and it took Europe still longer to pass from the introduction of forest fallow to the beginning of annual cropping a few hundred years ago. Moreover, the geographic diffusion of land-saving systems was also very slow and, in some cases, it failed altogether to take place. Even today, some food-gathering peoples are left, and primitive long-fallow systems continue to be the basic subsistence system in large areas of Africa and Latin America and in parts of south and Southeast Asia.[5]

The subsistence systems mentioned above are distinguished not only by differences in periods of cultivation and fallow but also by differences in types of equipment used. Food-gathering peoples use little or no equipment – they may use sticks to dig up edible roots and fire to enlarge hunting or grazing areas. Forest fallow cultivators also use digging sticks and fire, but bush fallow cultivators usually use hoes or machetes. Most short-fallow cultivators, annual croppers, and multicroppers use ploughs and keep draught animals, and many annual croppers and most multicroppers use various types of irrigation equipment. Thus, the equipment used for the more land-saving systems of subsistence is much more complicated than that used for the more land-using systems.

It is pertinent, therefore, to ask whether primitive peoples are likely to invent new tools and new subsistence systems when their population size comes to exceed the carrying capacity of their environment with the existing system. The answer is, of course, that it is not necessary to "invent" either a new system or the tools needed for operating it in order to change the subsistence system and to introduce new types of equipment. Both in contemporary and in past primitive communities, technological innovation

Greater Mesopotamia," in *Population Growth: Anthropological Implications,* ed. Brian J. Spooner (Cambridge, Mass.: MIT Press, 1972).

5 There are studies of people on all continents who apply land-using subsistence systems and do not utilize the full subsistence capacity of their territory with the prevailing system. See, e.g., W. Allan, *The African Husbandman* (London: Oliver and Boyd, 1965); Robert L. Carneiro, "Slash-and-burn Agriculture: A Closer Look at Its Implications for Settlement Patterns," in *Men and Cultures* (Papers of the Fifth International Congress of Anthropological and Ethnological Sciences, 1956); Robert B. Ekvall, "Demographic Aspects of Tibetan Nomadic Pastoralism," in Spooner, *Population Growth;* M. B. Gleave and H. P. White, "Population Density and Agricultural Systems in West Africa," in *Environment and Land Use in Africa,* ed. Michael F. Thomas and G. W. Whittington (London: Methuen, 1969); and Richard B. Lee, "Work Effort, Group Structure and Land Use in Contemporary Hunter-gatherers" (Paper for research seminar on archeology and related subjects, University of London, 1970).

was rarely the result of invention but rather the result of diffusion of technology from one community to another. A growing population that is beginning to outgrow the carrying capacity of its subsistence system is likely to be receptive to the idea of borrowing technology from other communities with higher population densities and with less land-using subsistence systems.[6]

When we observe that even today some peoples use primitive land-using subsistence systems and primitive transport systems that were abandoned by other peoples many millennia ago, we should not ask why these peoples never invented the plough and the wheel, but why the diffusion of these technologies seems to have happened fairly rapidly in some cases and not at all in other cases. In other words, why did small groups of people who live in regions of very low population density and use primitive land-using subsistence systems never adopt the better technologies that were used by other peoples with whom they have been in contact?

Labor Productivity of Land-Using and Land-Saving Subsistence Systems

The main answer to the question posed above seems to be that the primitive land-using subsistence systems, that is, food-gathering and long-fallow agriculture, have a higher output per unit of labor input than usually assumed and, therefore, the primitive peoples who use them have little incentive to change to more land-saving subsistence systems, as long as they are few enough to obtain the necessary food by use of the land-using systems. But the advantage of the land-using systems has been overlooked, partly because of lack of proper information about labor input and partly because many of the peasants who use land-saving systems produce large surpluses that they deliver to landlords or sell to merchants, while the primitive peoples who employ land-using systems rarely produce any surpluses beyond the immediate needs of their families. It seems, however, that the surpluses produced in preindustrial peasant communities, which have been taken as proof of the relatively high labor productivity of the land-saving agricultural systems used in such communities, are partly yields on labor investments and partly the result of a larger input of labor in the cultivation of crops than that customary in primitive communities where land-using systems are used.[7] In other words, it seems that the peoples who employ land-using systems would also be able to produce surpluses if they were to make labor investments and work longer hours. We shall see below why such peoples usually fail to produce any surpluses.

A number of anthropological studies show that present-day hunting-and-food-gathering communities obtain the necessary food without working very hard, even when they live in inhospitable environments. A study by Lee of the Bushmen living in the Kalahari Desert reveals that the women who do the food gathering use only two to three days a week to provide the necessary food. Lee's studies of the Bushmen show the alternatives available to a food-gathering people when their group size increases and the ways in which they adapt to increasing group size.[8] He measured the distances that the women must walk in search of food and the burden they have to carry under varying assumptions about group size and the average number of young children per woman. With increasing group size, a woman must walk longer and longer distances in search of the necessary food, and the choice is between spacing the children more (children born alive and allowed to live) and splitting into separate smaller groups. The latter solution would of course be excluded if the number of Bushmen in the whole territory were to become so large that there would be no free space for new groups. In that case, women would have a strong incentive to produce some crops instead of gathering all the food. It is tempting to ask if the connection found by Lee between the need to carry children around and the increasing burden of food gathering with increasing group size can help to explain the fact that it is the women who usually cultivate crops in the most primitive systems of long-fallow agriculture that follow the stage of food gathering.

Many hunting-gathering peoples produce some crops as a supplement to their diet, and it seems that when their territory becomes more densely populated and their hunting-and-food-gathering activities therefore become less productive, they come to rely increasingly on their crops and on domestic birds and animals. In other words, as population pressure in groups of food gatherers and hunters gradually makes the environment in which they live less productive, they may react by adopting an alternative technology, which was already known but had hitherto been little used. This new technology will increase the carrying capacity of the environment but will probably lower labor productivity. Therefore, the new technology is unlikely to be transferred from one people to another as long as the population size permits the

6 The relationship between population growth and the diffusion of technology is discussed in D. E. Dumond, "Population Growth and Cultural Change," *Southwestern Journal of Anthropology* 21 (1965).

7 Boserup, *Conditions of Agricultural Growth;* "Present and Potential Food Production in Developing Countries," in *Geography and a Crowding World,* ed. Wilbur Zelinski, Leszek Kosinski, and R. Mansell Prothero (London: Oxford University Press, 1970); and *Women's Role in Economic Development* (London: St. Martin, 1970).

8 For a fuller discussion of this topic, see Lee, "Work Effort, Group Structure and Land Use." See also Lee, "Population Growth and the Beginning of Sedentary Life," in Spooner, *Population Growth.*

continued use of the old technology.[9] The neolithic revolution – the change from food gathering to agriculture – is not a sweeping revolutionary change but a process of gradual evolution.[10]

Turning from anthropological to archaeological evidence, we have an example of gradual change from food gathering to food production in Flannery's diggings in Mesopotamian village sites from the period 7500–5500 B.C. In a site that contained remnants from this very long period, he found striking changes in the composition of vegetable foods, with a gradual decline in the use of wild legumes, the major staple food at the beginning of the period, and a gradual increase in grains of cultivated cereals, weeds, and plants typical of fallowed agricultural land. Flannery rejects the idea that early agriculture caused any drastic improvement in people's diet or provided a more stable food supply. He assumes that the slow change from wild food to produced food was a means to increase the carrying capacity of the environment in response to population growth, and he points out that the anthropological studies by Lee and others also suggest that population pressure was the factor that made prehistoric hunting-gathering peoples turn to agriculture.[11]

The sequence of gradual change from more land-using to increasingly land-saving types of agriculture in step with population growth in ancient Mesopotamia has been traced by Smith and Young by means of the archaeological finds of equipment. The plough was in use in the southern plains from the fourth millennium B.C., but hoes for short-fallow cultivation were found in much older sites in mountain villages in the area. It is more difficult to trace digging sticks by archaeological excavation because they are made of wood, but Smith and Young have suggested that holed stones found in the oldest of village sites may be weights for digging sticks and that the lack of hoes in other very old sites may be "evidence from silence" for the use of wooden digging sticks for long-fallow cultivation. The excavations seem also to indicate that a considerable increase of population took place during the period when primitive tools were gradually replaced by better equipment.[12]

Sanders has traced the development of subsistence systems in the Mesoamerican region from ancient times to the Spanish conquest and compared them to the apparent demographic trends in various parts of the region, taking account of the special environmental and other factors. He concluded that the most productive direction for research in the evolution of civilization is to study the history of population growth and its relationship to increasingly intensive agriculture.[13]

The low labor input needed for subsistence under long-fallow agriculture has been brought out by a large number of studies from many parts of the world. Carneiro concluded from a study in the Amazon Basin that the easiness of the long-fallow system was one of the factors that induced primitive cultivators to split up their local communities and disperse over the territory when their numbers were growing, instead of changing to more land-saving systems. He suggested that because of the centrifugal effects of land-using systems with growing populations, old civilizations based on land-saving, labor-intensive agricultural systems are found in what he calls "circumscribed areas," that is, regions where growing populations were confined in a restricted area surrounded by inhospitable mountains, deserts, or oceans and thus had no other choice than to adopt the land-saving systems in spite of the lower labor productivity.[14]

In comparing the labor needed to obtain food for a family by means of either land-using or land-saving systems, it is necessary to take account not only of the labor needed for actual food gathering or crop growing but also of inputs of labor that are in the nature of investments and that are prerequisites for the use of more land-saving systems of production. While no such labor investment is needed for food gathering and very little for forest fallow if the clearing of land is done mainly by fire, the land-saving systems usually cannot be applied without some preliminary labor-intensive land improvements. These labor investments range from clearing roots and stones from land before it can be ploughed for the first time to building wells, ponds, dams, terraces, bunds, and so on, for irrigation. Once such labor investments have been made, it may be possible to obtain higher output per man-hour from the cultivation of permanent fields than from long-fallow agriculture on similar land, but for a primitive population that must choose between undertaking the labor investments and starting long-fallow cultivation in a new place, it is a labor-saving operation to split up the group and continue with long-fallow agriculture in two different places. The yields of the labor investments – if properly maintained – may last forever, but the planning horizon of peoples who subsist by food gathering or long-fallow agriculture is a few years at most.

9 Lewis R. Binford, "Post Pleistocene Adaptations," in Binford and Binford, *New Perspectives in Archeology.*

10 G. R. Galy, "Pour une géographie de la France préhistorique," *Annales* 24 (1969).

11 Kent V. Flannery, "Origins and Ecological Effects of Early Domestication in Iran and the Near East," in *The Domestication and Exploitation of Plants and Animals,* ed. Peter J. Ucko and G. W. Dimbleby (Chicago: Aldine, 1969).

12 See Smith and Young in Spooner, *Population Growth.*

13 William T. Sanders, "Population, Agricultural History and Societal Evolution in Mesoamerica," in Spooner, *Population Growth.*

14 Robert I. Carneiro, "Slash-and-burn Cultivation among the Kuikuru and Its Implications for Cultural Development in the Amazon Basin," in *The Evolution of Horticultural Systems in Native South America,* ed. Johannes Wilbert (Caracas, 1961).

Demographic Trends and Nonagricultural Technology

For obvious reasons, the more land-using subsistence systems can be pursued only as long as the population in the region remains below a certain size. There are many other types of technology, however, that require the density of population to be above a minimum level.

It is well known, since Adam Smith's famous dictum, that the division of labor is limited by the extent of the market. This applies not only to modern industrial technology but equally to specialized products of traditional crafts and provision of services. Full-time specialized craftsmen could not possibly exist in villages of long-fallow producers in the Amazon region with populations of 50–150 persons. Craftsmen and other specialists can find enough customers for full-time specialization only in large villages or in small villages in regions that are so densely populated that the distances between villages are small enough to allow one craftsman or other specialist to serve several villages. Thus, very small, isolated groups of persons who practice the land-using primitive subsistence systems cannot afford such specialized activities. Their inhabitants must remain jacks-of-all-trades, which means that their relatively high labor productivity in the provision of food is partly offset by a low labor productivity in the provision of other necessities of life. Such communities are caught in a trap because the maximum density consistent with their subsistence system is below the minimum density needed for development in fields other than food supply. They are not likely to escape from the trap until population density in the region becomes so high (by natural growth or by immigration) that they are forced to adopt a land-saving system of subsistence.

Also much transport technology – modern as well as primitive – can only be applied where there is a certain minimum population. Even a footpath through tropical forest can exist only if used regularly by a certain number of people (or animals). Transport by cart or wagon can develop only where the local population is large enough to build and maintain a network of roads, and the canalization of rivers also requires a large labor force. Thus, small groups living in regions without naturally navigable waterways cannot develop urban centers because the necessary transport of food to such centers cannot be organized. Most ancient civilizations were situated on navigable rivers, and until fairly recently the towns in the interior of Africa were in fact large villages drawing their food supplies from surrounding fields.

With growing population density in a region, it becomes possible to construct and maintain a good network of roads linking the town or towns to food-producing areas or it becomes possible to dig canals or to canalize rivers for transport purposes. At this stage of development, it is no longer

necessary that specialized craftsmen and persons performing specialized services for society at large live scattered in villages or move frequently from place to place living off the land, as did the European kings and their courts until population density in their kingdoms increased and the transport system improved. When population density increases, and the land-using subsistence systems are replaced by land-saving systems, both rulers and craftsmen can settle permanently in towns with the additional advantages of still more specialization, better organization, and more specialized equipment.

We may define a town as a major population center, the inhabitants of which do not themselves produce the food they consume. This definition brings into focus the fact that urbanization in primitive societies requires either a high density of rural population or particularly favorable opportunities for the transport of food, for instance, by boat.

It is thus inaccurate to say that the appearance of towns depends upon a high level of labor productivity in agriculture or upon a high degree of exploitation of peasants by a social hierarchy. What is needed is a large food surplus in an absolute sense but not necessarily a large food surplus per agricultural producer. Urbanization in Europe made rapid strides in the eleventh and twelfth centuries; we know that population was increasing considerably in this period, but we have no reliable information about any major improvements in agricultural equipment and in the productivity of agricultural labor at that time.[15] However, a large town may be supplied by small marketable surpluses produced by a large number of producers, if settlement patterns and the available means of transport permit the transportation of food surpluses.

Thus, as far as production is concerned, there may be nothing to prevent long-fallow agriculture from making available the surpluses needed for the supply of towns, but the producers fail to do so because transport to towns is uneconomical with this type of agriculture and because the dispersion of populations using long-fallow systems usually prevents them from reaching the stage of specialization and social organization needed for the development of urban centers. Orans has stressed that long-fallow producers have potential surpluses of food that are not actually produced because there is no need for more than what is customarily consumed in their local communities.[16] But food is not the only article of consumption, and it could as well be said that such peoples have potential surpluses of specialized crafts and services that do not materialize because the local market is too small to permit specialization of labor.

Many of the ancient urban centers obtained their food supply from

15 Bernard Wailes, "Plough and Population in Temperate Europe," in Spooner, *Population Growth*.

16 Martin Orans, "Surplus," *Human Organization* 25 (1966).

intensive irrigated agriculture in the region where they were located, and it is usually suggested that this is because labor productivity is particularly high with irrigated agriculture. It seems more relevant to point out that this type of primitive subsistence system has a particularly high output per unit of land, since crop yields are high and more than one crop may be obtained per year. The high demand for labor per unit of land and the high output per unit of land make it necessary and possible for a large number of families to live within a small area. Therefore, even if the surplus per family is small, the total surplus available within a fairly small distance from the town will be large. In addition, the irrigation canals, or the river used for irrigation, can be used for boat transport of food to the town.

It takes a large labor force, however, to construct and maintain a major irrigation system and to cultivate irrigated crops with primitive technology. Therefore, a major town can be provided with food from this type of agriculture only if the region where it is situated is densely populated or if the military strength of the town forces the outlying population to settle around the town and construct and operate the irrigation system. In any case, it is the total labor force at the disposal of the society that matters and not the size of the surplus that can be extracted per agricultural family. As long as the ancient civilizations had small populations, they used small-scale irrigation; the systems of major irrigation seem to have been created after these societies had grown populous by natural population growth and by immigration of either slaves or free labor from other areas.[17]

Effects of Unequal Demographic Growth on Social Organization

There seems to be a fairly close correlation between population size and density, on one hand, and the degree of stratification and complexity of the social system, on the other.[18] Hunting-gathering groups are usually small and scattered, and they have a simple social organization. Long-fallow cultivators usually live in somewhat larger groups and in regions of somewhat higher population density, and they may reach the stage of tribal organization and chiefdoms. But only larger groups, with higher population densities and more land-saving agricultural systems, are likely to reach the next stage, that of preindustrial peasant community with a certain degree of urbanization. Thus when the size and density of population are increasing

17 Robert M. Adams, "Early Civilizations, Subsistence and Environment," in *Man in Adaptation*, ed. Yehudi A. Cohen (Chicago: Aldine, 1968).

18 Relevant studies of this correlation have been made by William T. Sanders and Barbara J. Price, *Mesoamerica: The Evolution of a Civilization* (New York: Random House, 1968); and Michel J. Harner, "Population Pressure and the Social Evolution of Agriculturalists," *Southeastern Journal of Anthropology* 26 (1970).

in a primitive society, the social organization of this society becomes increasingly complex through the interplay of several factors, all of which seem to be related to population density. One of these factors is the gradual development of hierarchical systems of land tenure, in step with the change to more land-saving systems of subsistence. Another is an increasing tendency toward tension and hostility both within each local group and between neighboring groups, when the numbers in each group become larger and the distances between the local groups smaller. This may create or enhance social differentiation and a more centralized organization of society either through warfare or through the appearance of a ritually sanctified social ranking.[19]

Egypt and some "circumscribed areas" in Asia reached fairly high population densities many centuries before the Western Hemisphere or Africa (as far as we know), and this may help to explain why we have found the oldest urban civilizations in the Near East and Asia. Robert Adams has shown that ancient Mesopotamia and Mesoamerica at the time of the Spanish conquest reached strikingly similar stages of civilization. But both the Old World during the height of Mesopotamian culture and America before Columbus seem to have had such small populations that only a few peoples in each continent reached the minimum population density required for urban civilization. The few existing urban civilizations were like small islands in a sea of "barbarian" communities, primitive tribes practicing one of the land-using subsistence systems.

To build an urban civilization with the technology available to the population in such a center required a large labor force occupied in labor-intensive investment work, and, as a rule, the peoples who managed to build such civilizations seem to have used all the means at their disposal to obtain foreign labor from the surrounding barbarian groups. But if the urban civilizations skimmed off the population increase of the surrounding barbarian peoples or even decimated their numbers, the remaining barbarian population was prevented from reaching the minimum density for urbanization. The barbarians continued their land-using subsistence systems, caught in the trap of low population density described above. More recently, the American slave raids in Africa seem to have had similar effects.

Such developments entailed a growing technological and cultural gap

19 A number of writers have reviewed specific factors in the relationship of complexity of society to density. Thus, Boserup in *Conditions of Agricultural Growth* reviews changing patterns of land ownership. Carneiro, in Wilbert, *Evolution of Horticultural Systems*, and in "A Theory of the Origin of the State," *Science* 169 (1970), relates inter- and intra-group hostility to group density. Robert McC. Netting in "Sacred Power and Centralization: Some Notes on Political Adaptation in Africa," in Spooner, *Population Growth*, discusses ritualistic stratification of society. And Robert M. Adams, in *The Evolution of Urban Society: Early Mesopotamia and Prehispanic Mexico* (Chicago: Aldine, 1965), discusses such stratification as it is brought about by warfare.

between the centers and the surrounding peoples. The high-level technology used in the centers was inapplicable in the sparsely populated regions that separated the centers from each other, and this also hindered the diffusion of technology from one center to another.

Environment and Population Growth

While war casualties and forced migration no doubt helped to keep rates of population growth below or close to zero in many primitive societies, environmental differences also are often important in explaining divergent demographic trends. However, we should avoid the common fallacy of thinking of environment exclusively in terms of potential for gathering and producing food. We must also take account of other factors, especially the different incidence of disease in different environments.

It is well known that most contemporary primitive peoples live in the wet tropics – an environment in which both temperature and humidity allow abundant plant growth in all seasons, but one that also provides particularly good conditions for the growth of bacteria and other parasites that decimate primitive populations. As a consequence, mortality due to disease is likely to be much lower in dry and temperate climates. This positive environmental factor in the latter climates may be more important for rates of population growth than the negative environmental factor: the greater difficulty of providing food because of the interruption of plant growth in the dry or cold seasons. In view of the foregoing discussion of the far-reaching impact of population growth on technological change, the implied demographic differential may help to explain why it was the dry and temperate climates that gave rise to most of the early civilizations.

3 Climatic Fluctuations and Population Problems in Early Modern History

Gustaf Utterström

I

Ever since Malthus and Ricardo, all discussions of the pressure on food supplies have started from the assumption that population is the active factor and nature the fixed. This interpretation, however, can hardly be reconciled with modern scientific thought, especially if the problem is viewed in the long term. It is not necessary to go to other geological periods in order to discover great changes in nature. Two changes have occurred in Sweden in the course of the last few thousand years which have radically altered the living conditions of human beings: the great land-elevation which followed the melting of the inland ice, and the climatic fluctuations which have occurred continually. The former was a gradual change and is still proceeding; the latter have made themselves felt at irregular intervals and with varying intensity.

I have suggested in an earlier article that the development of population in Scandinavia and the Baltic regions during the first half of the eighteenth century, far from supporting the Malthusian theory of population, can only be explained by exogenous factors, in particular by the fact that a period of unusually mild climate occurred in the early decades of the century until it was brought to a close about 1740 by a return to more extreme conditions. Even the later surges of population growth seem to have been made possible above all by a mild climate.[1] This prompts the question whether earlier climatic fluctuations might not also have played a decisive part in the development of population – perhaps not only in Scandinavia but in central and western Europe as well. For example, is a partial explanation of the great advance in European economic life from the ninth century to the end of the thirteenth, as well as of the subsequent secular depression during the fourteenth and early fifteenth centuries, to be found in changes in the

1 G. Utterström, 'Some Population Problems in Pre-Industrial Sweden', *Scandinavian Economic History Review* 2 (1954):108ff.