Population Trends and Food Production Potential

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Abstract

Highlights of a program to increase world food supplies have been given. Potential results are promising because there is nothing radically new in the program with the exception of a major revision in the method of using scarce resources. Agriculture will be the prime recipient of these resources at the expense of alternative opportunities. Even agriculture will be budgeted strictly to avoid waste and low response per unit of input. Transferral of the program to other nations will be a major challenge as substantial adaptation to local resource availability and quality will be imperative.

A program to reduce the demand for food must be developed concurrently. Reducing the growth rate of the human population can be achieved through a variety of programs based upon changes in knowledge, attitude, and practice toward family planning. A variety of government programs will be needed to accomplish this objective.

Success in both programs is imperative and demands the highest endeavors of man; failure, in either or both, dooms mankind to the greatest castastrophy of his life on earth.

The current rapid expansion of the human population in the world is one of the most significant problems of our time. Many other problems — the rapid depletion of nonrenewable resources, pollution of the environment, malnutrition among a vast number of people, degradation of human life quality, even war or peace — all are linked inexorably to the ever-increasing number of human beings on our spaceship earth.

This explosive growth in human numbers is a unique experience in man's history. But this development, together with historical trends, conforms to fundamental relationships regarding the growth trends of any specie, including man. One such relationship concerns the hypothetical potential of any specie to reproduce. Briefly stated, the numbers of any specie increase in a geometric ratio — 1, 2, 4, 8, 16 and so on — if there are no external forces to act as checks. Thus, if there are sufficient resources, especially food, for maintenance, growth, and reproduction, the numbers of the specie can achieve astronomical levels in a relatively few generations. This relationship can be illustrated by an exponential curve which, after a slow rise, suddenly rises almost vertically. A second relationship indicates that available resources, especially food, will not increase as rapidly and external checks will be exerted in the forms of starvation, disease, conflict over territory, and similar events. In these ways, the explosive growth will be halted and eventually a balance will be established between the specie and ecological restrictions (1).

Demographic measures can be used to evaluate the interplay between these two concepts. A common measure is the "growth rate" which summarizes in percentage terms the difference between the "crude birth rate" and the "crude death rate" (number of births or deaths per year per 1,000 people). Once the growth rate is available, one can calculate the doubling time in years for any given level. These are most useful measures when one attempts to make future predictions and interpretations. Although other more appropriate measures are available to predict population trends for a specific nation or group, the measures given above underline important relationships in the historical and future trends of the total human population on earth.

Using indirect evidence and inferential methods, elaborate studies have been made by a spectrum of qualified scientists to estimate vital statistics and the total number of humans at various historic periods. The results must be considered as approximations for all past periods. Even data for recent periods qualify as best estimates, given our imperfect information. However, exact numbers are not as significant as the trends and relative changes in total numbers through the time span under consideration.

Using these estimates, one can trace human population trends from the distant past. Early man's continued existence was tenuous indeed. The crude birth rate has been estimated at 45 and the crude death rate was nearly as great, perhaps 44.8. Thus the growth rate was extremely low and several thousand years were required to double any population. Under these conditions one can imagine that entire groups or a large part of such groups of early man succumbed to external forces which checked any potential for explosive growth.

The agricultural revolution, related to the domestication of plants and animals about 8000 B.C., may have relaxed food restrictions to some extent, but additional deaths apparently occurred because of diseases associated with concurrent village living. Estimates for this period indicate a growth rate double that of early man but still requiring about 2,000 years to double the base number.

After thousands of years, when external forces held human population growth under tight control, it is estimated that there were 250 million people on the earth at 0 A.D. From that date, the trend in population numbers and associated forces can be traced with greater accuracy (Figure 1). It required over 1,600 years to double population to achieve one-half billion. The next doubling was achieved in 250 years, or in 1850, and the first billion people were aboard the spaceship. Two, three, and four billion followed in ever-narrowing time periods. The last level was achieved in April 1975 and required only 45 years to double from 2 to 4 billion. The dramatic expansion phase of the curve began to unfold (2).

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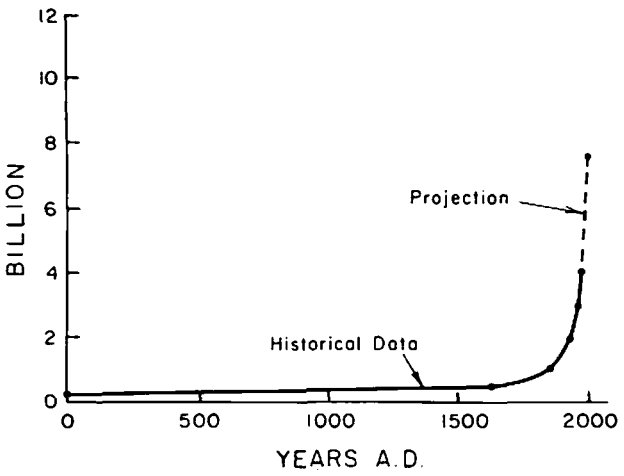
Figure 1 World Population Trend, 0 to 2000 A.D.



Such doubling rates are possible only when there is wide divergence between the crude birth rate and crude death rate. This is the case. Data on the world population for 1970 provide the following (3):

Crude birth rate (number)	33
Crude death rate (number)	13
Growth rate (percent)	2
Doubling time (years)	35

Herein lies the basis for the unique expansion of the human population now underway. The birth rate has declined approximately 25 percent from the historical period when man lived close to the brink of extinction. But the death rate has decreased by nearly 70 percent! Currently, the external checks are not as restrictive as in past periods.

The forces behind this phenomenon are many and complex. All are interrelated and operate simultaneously. Frequently, three outstanding events have been recognized. Most fundamental is the scientific revolution or knowledge explosion which led to greater understanding of relationships in nature and greater control by man of future events. The industrial, agricultural, and medical revolutions in recent decades stem directly from such knowledge. A second factor was the opening of vast land areas in the "new worlds" to settlement by peoples of the "old worlds." A third was the tapping of energy sources in the form of fossil fuels to support the industrial revolution by exploiting energy from prehistoric periods. The cumulative effects of these forces was to increase man's health, longevity, and productivity. Under the impetus of these developments the crude death rate fell precipitously, even in the underdeveloped countries, as technology, especially simple medical techniques, spread rapidly into all societies. Although the crude birth rate also fell, the decline was not comparable. Temporarily the external checks were mitigated and growth rates achieved levels never known before.

Predicting Future Trends

If the development of past trends in human populations is a difficult task, the prediction of future trends seems equally difficult. In the near term, some confidence can be attached to the estimates because precursive factors are already established. But for the longer term, only the broadest generalizations are possible. Such generalizations must be made, however, if only to indicate that the present exponential expansion is a temporary and self-correcting deviation in the history of man. This conclusion can be drawn with certainty simply from mathematical implications. But the determination of the peak level, the rates of future increases and decreases, the extent of over-corrections, and the eventful time and level of stability can only be conjecture.

Some insights may be gleaned from observing demographic changes that have occurred in the developed countries. These populations constitute about one-fourth of the current world population. Many of these societies are approaching a stable population in which the crude birth and death rates are in approximate balance and the growth rate is nearing zero. Major social, ethical, technological, economic, and political changes were necessary in these nations to encourage the existing people to take steps to limit the birth rate without overt coercion.

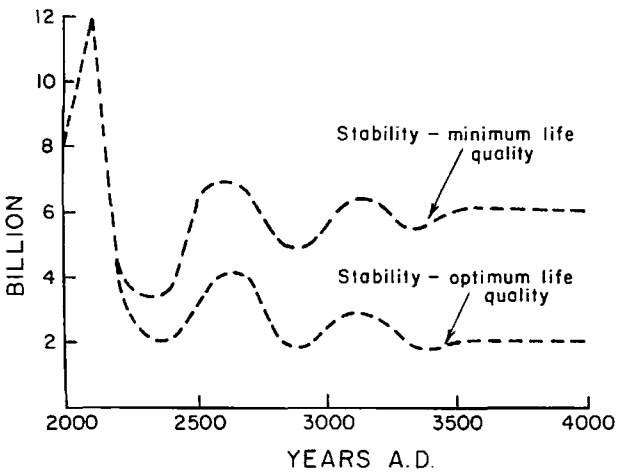
Can similar steps be taken in the underdeveloped countries? How long will it take to achieve results now that the model and basic knowledge are known? From past experiences it has been shown that an integrated program embracing core aspects of social systems must be used to achieve this reduction. It is not enough that the technology of birth control be available. There must be education and motivation to change attitudes, understanding, and productivity; there must be protection for the extended family members of the traditional societies.

Without such steps only the most coercive *techniques* by the political system can lower the birth rate. Also, timing becomes of critical importance. The suggested program involves a slow evolutionary process. Yet the doubling time is becoming ever shorter. Currently there is a crucial race between expansion of the number of humans on the spaceship and expansion of the food to feed this number. And, currently, the race is being lost! Should present birth rates continue at approximately the current level, correction will be inevitable and drastic. The crude death rate will rise sharply to bring about a negative growth rate, and populations will experience a dieback of major magnitude (4).

In the race there is another significant variable. The simplified model is based upon a situation in which the food problem has been solved by an agricultural revolution that has been sufficiently dynamic to meet nutritional needs of the local population. By the application of advanced production technology in agriculture, and the extensive use of minerals, chemicals, and energy, a small part of the population working in agriculture can feed the remaining large part. This latter group can work in the sciences and arts to pour forth a continuing knowledge mass to meet the various problems of the society.

To a considerable extent the developed countries have followed the brief outline of the model. But, in

Figure 2 Alternative Predictions of World Population Trends, 2000 to 4000 A.D.



doing so, they have consumed a disproportionate amount of nonrenewable resources and have contributed critically to the pollution and degradation of the environment. With recognized restrictions upon the future availability of specific resources and the increasing dangers of environmental deterioration, it would be irresponsible to extrapolate potentialities of the model to the remaining three-fourths of the world population in the underdeveloped countries.

Forces that Affect Population

Predictions of future growth trends must evaluate and reconcile the forces that tend to expand or to limit *human* numbers. All demographic estimates give a continuing expansion well into the next century. The next doubling to 8 billion may occur in 30 years. This is due to the high proportion of individuals in the world populations who are currently 15 years old and under. For example, in the underdeveloped countries over 40 percent are in this group. They will be the parents of the near future. Therefore, birth rates can rise in most nations, not because people may have more children in a lifetime, but because more individuals will be in the family formation and child-bearing ages during this period.

A possible doubling to 16 billion is doubtful. Scientists believe that voluntary checks will reduce the crude birth rate and that external checks will increase the crude death rate. There is evidence that both forces are already having an impact. Further, unless some major new technologies are achieved in the discovery and use of basic resources and in pollution control, a sharp cutback in the number of humans on earth may occur through the external checks that limited growth rates throughout most of man's existence (5).

Figure 2 shows hypothetical trends for the human population during the next 2,000 years. Using a level of 4 billion people as a base in 1975, rapid expansion continues until a level of 12 billion is reached at the end of the twenty-first century. The cumulative effects of limiting forces will bring about a sharp correction which could reduce numbers to the 1975 level or below. During the following centuries, attempts will be made to achieve a stable population number that is consistent with the carrying capacity of the earth. In this adjustment there will be periods of over-correction in both directions before stability is achieved. Two levels are shown as possible extremes of the stable situation. These levels will reflect a conscious decision on the part of future man relative to life quality. The choice will be between alternative combinations of quantity and quality — fewer people on the spaceship with favorable life characteristics versus more people with less favorable life characteristics.

How Many People Can the Earth Sustain?

Important steps can be taken to alter the carrying capacity of the earth. And special efforts will be made to use effectively those scarce nonrenewable resources needed in food production and distribution for all peoples. Again, the steps to achieve increased food production are many and complex. They are interrelated and should be applied simultaneously. Recent achievements give promise for future accomplishments. In the last two decades the total world output of food increased by 69 percent (Table 1). Population growth for the same period was 44 percent. Average per capita production was 17 percent greater by the end of the period. However, the sharp divergence of average per capita food production between the developed and developing countries shows that a favorable average situation is coming to an end for most of the people of the world (6).

Table 1 Total and Annual Increase in Food Production, Population, and Per Capita Food Production, 1954-1973

	Total increase 1954-1973	Annual rate of increase
	(percent)	
Food production		
World	69	2.8
Developed countries	65	2.7
Developing countries	75	3.0
Population		
World	44	2.0
Developed countries	22	1.0
Developing countries	61	2.5
Per capita food production		
World	17	0.8
Developed countries	33	1.5
Developing countries	8	0.4

Source: *The World Food Situation and Prospects to 1985*. Economic Research Service, U.S. Department of Agriculture, Foreign Agr. Econ. Rpt. 98, p. 12.

During the same decades programs to increase food production for all people have been outlined by many individuals and groups. The most recent statement came from the World Food Conference held in November 1974 under the sponsorship of the United Nations. The program is summarized best by considering the nineteen resolutions that were passed and made explicit various procedures to reduce food demand and increase food supplies and availability.

Rather than prepare a similar list of steps, some basic concepts that must be a part of any successful policy to increase food supplies and availability are given below. No attempt is made to describe programs through which these policies could be carried out. The goal here is to discuss relationships that should be of prime importance in a comprehensive policy toward achieving a stable population level with a given life quality.

Basic Concept Relationships

1. One-World Earthship Philosophy

For decades man has followed an exploitive posture toward his world. Use and abuse were guidelines. When his numbers were small, little permanent damage was done. With his numbers increasing alarmingly and his life style generating additional demands, the human impact upon a fragile system with finite resources results in an accelerating deterioration. A revised set of guidelines is imperative. Exploitation must give way to a recognition of the limited carrying capacity of the spaceship and to those practices that will maintain or possibly enhance this capacity.

The production of food will rank near the top in an array of activities that will have need for critical resources. Balancing the availability and use of resources among alternatives will alter greatly the lifestyle of many people, especially in the developed world. The new lifestyle need not be of a lower quality, but human values will be altered significantly. As all nations are not equally endowed with critical resources, this adjustment will require a recognition of these differences and will require procedures to minimize international differences.

2. Rationalization of Food Sources

Where feasible, man should enter the food chain as early as possible (second trophic level). Currently, this is done throughout much of the world's populations. Important exceptions give substantial possiblity for feeding a given number at a full nutrient level. Several developments which will be discussed will solve the protein requirements for that number.

3. Adjustments in Land Use

Under present food demands, the land area of the world is used approximately as follows:

	percentage
Arable cropland	10
Permanent pastures and mountain meadows	20
Forests and brushland	30
Other (deserts, mountains, tundra, marsh)	40

With increased needs for food, it is feasible to consider that 20 percent could be arable. Areas could be taken from the other categories at considerable expense by clearing vegetation, removing rocks, draining, irrigating, and using adaptive techniques. As one uses soil of ever lower productive potential the cost-benefit ratio of such actions will require careful appraisal.

A greater opportunity lies in the land beneath one's feet. Improved land use which would include the preservation of high-quality arable land from development, the use of soil conservation techniques, soil-building crops, crop rotations, and the addition of green manures, animal manures, and wastes of industry and urban areas, could increase by a significant factor the production possibilities of cropland now in use. At the same time, an important recycling of critical chemicals and a diminution of pollution problems could be achieved.

4. Adjustments in Crops

High crop yields can be anticipated through a four-pronged program of fertilization, genetic manipulation, pest control, and cultural management. Greater knowledge of specific plant nutrient requirements, timing of these needs, cost and returns of fertilizer programs, and the impact upon the environment would be necessary for optimum fertilizer use. Genetic procedures already used to increase yields per acre could also be employed to enhance the quality of crops, especially the essential amino acids content. An array of chemical, biological, and genetic techniques could be used to control various crop pests. A host of changes in various aspects of production, harvesting, and distribution, could lead to greater efficiency in the use of critical resources.

Plant proteins, especially those from legumes and pulses, can provide a substantial part of the daily protein requirement per person. By improving the balance of various protein carriers in the diet, essential amino acids would be used more effectively to meet nutrient needs and help eliminate malnutrition.

5. Rationalization of Animal Usage

Animals play a strategic role in the transfer of the sun's energy into human food. As shown above, much of the land area is in pastures and mountain meadows, and other nonarable categories. Converting certain plant growth on these areas into human food is accomplished by various animals. The resulting meat and milk products provide desirable food that is high in the essential amino acids commonly low or lacking in plant food of today. Desirable land use also necessitates soil-building forage crops in rotation with grains. All of these forages, plus waste products from grains and many other sources, must continue to be converted into human food by animals.

Some feed grains and supplements are fed to animals to meet nutritional requirements. This must continue. But feeding grains to fatten animals could be largely eliminated. Technological programs similar to those used with plants could also be used to increase productive efficiency of animals as has been accomplished in the past. Through the rational use of animals, more effective human food production could be achieved throughout the world, both directly through animal products and indirectly through improved plant production.

6. Other Food Sources

Plants and animals not commonly used as sources of human food could be used to a greater extent. Rational use of the seas and inland waters could contribute substantially to nutritional needs. Fortified and synthetic food will play an ever-increasing role in meeting the food demands.

7. Continued Research and Education

The great expansion in total world food production in the last two decades built upon the basic and applied research of many decades. It is essential that a continuous program be carried out to add to the store of human knowledge and that it be applied to the problems of the demand and supply of food. Once this information is available the difficult problem of transfer in an operational format to the food procedures and consumers throughout the world must be solved.

8. Changes in Infrastructure

Although food demand and supply problems will rank as fundamental considerations of future human populations, their lives will be structured by a series of institutions that are necessary for societies to exist at all. Systems of government, law, education, transportation, communication, and property ownership, all are examples of elements of an infrastructure that evolves in a complex society. Adaptations must and will occur in these institutions. The primary goals of such institutional changes should be to stabilize human population numbers and to enhance the quality of human life within limitations imposed by the physical phenomena of our earthship.

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World Food Situation

Perspectives for Students in Agriculture

R. G. Arnold and T. E. Hartung

Abstract

This paper presents some facts regarding the world food situation, discusses the implication of food shortages, identifies factors contributing to the present world food situation, and reviews proposed solutions. A high priority on enhanced production of food, combined with population control and improved utilization of existing commodities in by-products can result in a world where people are better fed than at present. Although these approaches may be feasible from a technological standpoint, they are complicated by the social, religious, political, and economic factors that influence food production capabilities and food consumption patterns. Obviously agriculture students will find themselves confronted in their careers with unparalleled world food problems and must have some comprehension of what lies ahead.

Food and People — Some Current Facts

Critical food shortages currently exist in several regions of the world. Dr. John Hannah, administrator of the World Food Council, recently reported that 10 percent of the world's population is facing chronic hunger (2). Because of unequal distribution of the world's food supply, this translates to 25 to 30 percent of the population who are facing severe food shortages in some regions of the world.

It is generally acknowledged that we are now in the tightest food supply situation since World War II. World grain reserves, which were as high as 95 days' supply in 1961, fell to 22 days' supply in the fall of 1974, and were projected to be approximately at an 8-day supply by late spring of 1975. This is the equivalent of "pipeline levels" of grain (5).

To illustrate the unequal distribution of food, consider the fact that U.S. citizens consume on the average the equivalent of one ton of grain per person per year in the form of cereal grains and feed grains in the form of livestock products. Annual per capita consumption of grains in the developing countries is approximately 400 pounds, or about one-fifth of the per capita consumption in the United States. The unequal distribution of food is most critically seen in the area of quantity and quality of protein available to people of the developing nations.

In projecting future demands for food, increased population pressure must also be considered. World population is now approximately 3.8 billion persons. Figures from the World Food Conference indicate that this figure will be approximately 8 billion persons in the year 2000. This means that, in order to stay even, we

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