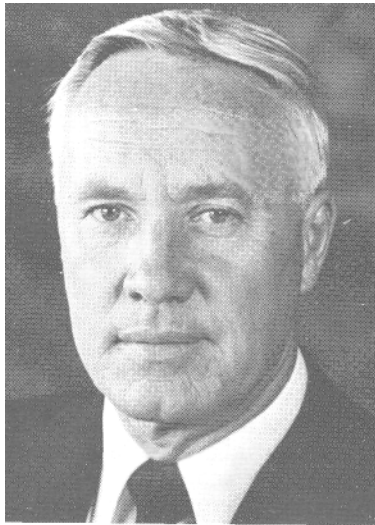


FEEDING A HUNGRY WORLD

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Dr. Daniel G. Aldrich, Jr.— first Chancellor of the University of California, Irvine, since January 19, 1962. Responsible for developing the campus from bare ground to a fully operating institution.

Dr. Aldrich joined the University of California as a junior chemist in the Citrus Experiment Station at Riverside in 1943.

Following three years of service in the armed forces during World War II, he progressed to professor of soils and chemist in the Agricultural Experiment station and chairman of the Department of Soils and Plant Nutrition on the Davis and Berkeley campuses.

In 1958 he was named dean of the University of California's Division of Agricultural Sciences.

INTRODUCTION

Historically, each major inhabited region of the earth has produced its own food supply, and agricultural production generally has kept pace with population growth.

As populations have grown, crop failure from drought, flood, or whatever cause in a given region necessarily affects ever greater numbers of people. It is estimated that under 2 million humans starved to death in the 17th century, 10 million in the 18th century, 25 million in the 19th century, and perhaps 12 million thus far in the 20th century.

Were it not for improved communications, early warnings, the remarkable productivity of

North American agriculture and a worldwide food distribution capability, agriculture in the 20th century could well fail to keep pace with the world population growth of 2 per cent a year and major regional crop failures could now claim more lives than at any time in the past.

This is a period of great international anxiety about the world's ability to feed its growing population. In 1972 the world food situation was transformed from one of food surpluses and low prices to one of relative food scarcity and high prices. This rapid reversal has raised again a wave of widespread food-population pessimism similar to that which has swept over the world several times since Thomas Malthus wrote his influential essay in 1789.

A wide spectrum of opinion exists about the causes of this rapid change in the world food situation and its likely development in the future. One judgment is that we have reached the limit of the world's ability to feed even our present numbers adequately. A second judgment is that the events of the early 1970s signal a fundamental shift in the structure of the world's food economy. In this view we have entered a period of more or less chronic scarcity and high food prices. The soaring demand for food spurred by both continuing population growth and rising affluence, has begun to outrun the productive capacity of the world's farmers and fishermen.

In this view, limits of expanded food production require reduced consumption by the world's rich to feed the world's poor.

A third judgment is that while the situation for the next year or two is precarious, it has resulted from a combination of factors which can be overcome. In this view, to which I subscribe, food production during the next decade will keep a half a step ahead of population growth but that there will be times and places of critical shortage.

This last view is similar to that of a recent United Nations study, of a study by the Economic Research Service of the USDA, just published, and of the Committee of the National Academy of Sciences and National Science Foundation which I chair.

The Committee considers the primary issue in balancing the world food-population equation to be early reduction in the rate of population growth and attainment of population equilibrium as soon as possible.

The limitations that bear on the population-food balance may be grouped into those relating to population, to agricultural resources, and to the more general features of the world food system. The main thrust of my remarks today is to describe briefly some of these limitations and what subsequently I believe we can do about correcting them.

Population, Affluence, and Food

The population of the world is now nearly four billion and increasing at about 200,000 persons per day. The rate of increase in the developed countries is only about 0.8 percent and declining steadily, while in the developing countries the average rate of increase is about 2.5 percent, a record rate that has just begun to decline on a global basis and may not yet have reached its peak in some countries.

Meanwhile, there has been a recent rapid decline in death rates, accounting for a steep

acceleration in the rate of population increase of developing countries.

Substantial population growth continues for a considerable period well after fertility has fallen to a level that would, in the long run, just assure population replacement.

Even if a couple produces just enough children for replacement, the final size of the population will reflect the very large number of young people today rather than the more moderate number of current adults.

If the more developed areas maintain fertility at or below the replacement level, and the developing countries attain that level by the end of the century, the total population of the world might level off in 70 years at about 8 billion, more than 80 per cent of it in the presently "developing" countries.

In the long run, attainment of an average rate of increase very close to zero is inevitable. What is uncertain is what the total population will be when growth does cease, and how the balance will then be maintained; i.e., with a high birthrate and an average duration of life of less than 30 years, or a low birthrate and an average life expectancy of 70 years or more.

In some poor countries, the average person is sustained by the equivalent of about 400 pounds of the locally indigenous cereals per year—just over one pound per day, which is barely sufficient to support life. Nearly all of this is eaten directly; little can be spared for conversion to meat, milk, and eggs. There are many, perhaps 20 percent of the population, whose consumption is significantly below their national average.

Per capita incomes in developing countries have been rising at the rate of 2 percent a year. In these populations, where 70 to 80 percent of personal income is spent on food, increased income results in demand for more and better food. Hence, national food demand has been growing more rapidly than has population, i.e., about 3 percent per year.

In the already richer countries, rising incomes—estimated at more than 3 percent per year—enable people to eat increasing amounts of fat and animal products. For animals that are fed cereal grains, each calorie of meat product requires an input of about 7 to 10 calories, requiring a high per capita utilization of cereals. In the United States and Canada, for example, per capita utilization of cereals approaches 1 ton per year, most of which is fed to livestock.

Per capita consumption of animal products seems to have leveled off in North America, but the upward trend in Europe, Japan, the USSR, and among the higher income groups of the developing nations may be expected to continue for a long time into the future.

Most of these countries are importing increasing amounts of both livestock products and feedgrains and soybeans with which to expand their own livestock production. This rising demand exerts substantial upward pressure on the world price of cereals, in turn rendering difficult the desirable increased consumption of cereals in lower income countries.

Food and Health

Few cereal grains are so constituted as to be nutritionally adequate, of themselves, for

man. It is the populations that lack opportunities for dietary enrichment that exhibit typical signs of protein and vitamin insufficiency.

In many developing countries a majority of the children may be malnourished. The immediate consequences are high mortality rates. When the deficiency is early, prolonged, and severe, there is a lasting effect on mental development and learning capacity. At times of actual famine, young children along with expectant and nursing mothers are the first to suffer.

Agricultural Land

Much has been said about the significance of the frontier in fostering a strong sense of individual freedom; it may now be recognized that the frontier also engendered a relatively casual attitude toward natural resources. Today there are few such geographical frontiers remaining with readily utilizable new agricultural lands.

Some parts of the world actually face a net reduction in agricultural land because of pressure from competing uses. In the United States, much farmland has been diverted to other purposes, often committing highly productive land to housing, roads, or other construction. Certain of the more densely populated countries such as Japan and several Western European nations have used ever-decreasing amounts of crop land in the past few decades.

Worldwide agriculture by traditional methods is approaching a maximum.

It may eventually be possible to farm the hot humid tropics or the deserts effectively, but to accomplish this will take much research, time, effort, and money.

Water

The availability of water is critical. In the United States currently about 370 billion gallons are used per day, approximately 35 percent of it for irrigation. Projected needs are for twice this amount well before the year 2000, yet water tables in several areas of the country already are receding at an alarming rate.

At present less than 4 percent of the total world riverflow is diverted for irrigation. Utilization of most of the remainder is limited by the geographic distribution of river systems that can be made available only through vast engineering projects.

Fertilizers

The major nutrients sustaining the growth of crop plants are nitrogen, phosphorus, and potassium. The high productivity of modern agriculture depends substantially on the application of these nutrients as fertilizer. Nitrogen limits productivity of crops more frequently than does any other nutrient factor.

In 1973, U.S. exports of nitrogen fertilizer dropped to one-third of their 1969 level due to increased domestic demand. Current projections indicate that the U.S. will have to import nitrogen fertilizers in 1975. Due to limitations of the natural gas supply and

perhaps of capital for construction, little expansion of American capability for production of this commodity is expected in the near future. Both domestic and foreign sources will be very restricted in 1975 and for some years to come.

Reserves of potash and phosphate are large but unevenly distributed. North America seems well-endowed with both, whereas South America has but little. Africa as a whole is lacking in known reserves of potash. Asia is not abundantly endowed with either.

The world market for fertilizers now is suffering from rapid cost increases, especially for nitrogen. The limitations on supplies available for world trade, at a time when developing countries are becoming increasingly dependent upon fertilizer applications for achieving the high yields attainable with new genetic lines of maize, rice, and wheat, certainly will limit and perhaps reduce food production.

Pesticides

Losses to agriculture from diseases and insects can be estimated at roughly 25 percent in the field and from 10 to 50 percent to crops in storage.

Crop yields in the developing countries would be increased appreciably if pesticides could be more widely employed. Reliable use estimates are difficult to make, but it is thought to be increasing by about 11 percent per year in the developing countries.

As in the case of fertilizers, however, rising costs will impose restrictions on the extent to which pesticides will be utilized in the developing countries.

Energy

Energy inputs, particularly in the form of fuel, have vastly lowered the manpower requirement for farming and at the same time have been associated with large gains in productivity. The energy investment at the farm level in the United States doubled between 1947 and 1970.

In some cases the energy investment can become very high in proportion to the energy value of the crop—as much as 50 to 70 percent in the United States.

The investment in the farming operation is a relatively small part of the total energy cost of the entire food system, including processing and commercial and home food handling.

As petroleum sources diminish, the problem of energy input into the-entire food-producing and processing system deserves careful scrutiny. Energy-intensive agricultural practices will not be applicable in their entirety to the developing countries that have more restricted supplies of fuels.

As a consequence of the dramatic rise in the price of petroleum in 1973, many developing countries find themselves in serious difficulty regarding fuel supplies.

Marine Food Resources

It seems equally clear that in developed countries there must be serious consideration of a transition to less intensive use of fuels.

The importance of fish in the human diet has risen steadily over the past generation, as man's capacity to exploit the oceans has improved. Between 1950 and 1968 the world fish catch rose by nearly 5 percent each year, but declined in three successive years following the peak catch of 70 million metric tons in 1970.

It is evident that some fisheries may have been over-harvested, and many marine biologists now feel that the global catch of table-grade fish may have reached or even passed its maximum sustainable limit.

Today there is inadequate biological knowledge of the limits of marine production. An acute need exists for studies that will establish the size of the annual catch sustainable by each major fishery and for international agreement concerning the allocation of these resources.

Weather and Climate

Within any given decade there are likely to occur irregularities in rainfall patterns that are capable of inflicting enormous damage to agriculture.

In addition there are long-term climatic trends that may have major significance to agricultural potential.

Some students of climate suggest that these considerations indicate that the last century, characterized by a burgeoning human population, was not "normal" or "typical" but rather, extraordinarily favorable for agricultural production of domesticated crops.

Should a current cooling trend continue, as it has since 1940; should the fertile northernmost plains be taken out of agricultural production by contraction of the growing season, this could be serious indeed.

Food Reserves and Aid Programs

Direct food aid has constituted about 15 percent of total official developmental assistance in recent years. Various difficulties have plagued food aid activities in the past, including the fact that importation of such food stocks can seriously distort trade patterns and undermine the incentives for agricultural production in the recipient nation.

The FAO has formulated a plan for coordinating world food reserves that will be considered at the World Food Conference in November. However it may be designed, such a reserve should take into account market considerations; otherwise it may be counterproductive.

It should be clear that in the long term, no major inhabited geographic region can look indefinitely to food imports for its basic nutrition. Each must strive for nutritional self-sufficiency.

Protein Supplies

Lack of sufficient suitable protein is one of the chief nutritional deficiencies in the world.

Protein production faces constraints from the necessarily limited supplies of meats, legume crops, and fish. One cow still raises only one calf each year, and scientists have been unable to achieve a breakthrough in soybean yields per acre.

The importance of soybeans as a source of protein in the world food economy is indicated by the fact that they have become the single leading export product of the United States—surpassing in dollar value the export sales of wheat, maize, or such technology-intensive items as computers and jet aircraft.

There has been a worldwide drop in the percapita production of other common legumes such as beans and chick peas, with a consequent rise in their prices and decreased consumption by those peoples who most need them to complement predominantly cereal diets. Urgent attention needs to be given to increasing legume production to a point at least comparable to the population increase.

Technology

Unlike engineering technology, agricultural technology must be tailored to the specific conditions of individual farms or farming areas.

Crop varieties, fertilizer placement, disease and insect control, irrigation, feeding and management of animals, and many other variables affected importantly by environment must be developed, or at least tested, in each locality.

AMELIORATIVE MEASURES

Slowing Population Growth

Increasing the world food supply can serve constructively only as it provides additional time in which to achieve the primary goal of slowed population growth.

A reduction in the current high fertility rates in developing countries would afford modest relief in the food-population balance by producing a somewhat smaller population increment each year than would otherwise occur. More important, it would improve nutrition in the many poor families in which malnutrition is aggravated by an excessive number of children and by short inter-birth intervals.

In a number of developing countries there has been a recent sharp and extensive decline of fertility and in some instances an important contributing factor appears to have been government support of family planning programs. Nevertheless, population growth also is proceeding at startling rates in many other parts of the world, most dramatically perhaps in such developing nations as Mexico, Algeria, Ecuador, and Venezuela.

Lowered population growth must be achieved by changes in social mores such that large families are not desired, and through widespread adoption of family planning measures. All governments must participate in this international crusade. None are immune from the effects of population growth at home or elsewhere on the planet. Each

must bring to bear the full array of tools at its disposal: an adequate food supply, education, medical care, access to contraceptive techniques, old age insurance, improved status of women, employment opportunities, tax incentives.

It is highly unlikely that the developing nations can finance this themselves. It is in the self-interest of the developed nations to assist generously in this effort. There are no humane alternatives.

Disease Prevention and Control

There is a negative feed-back among inadequate nutrition, food utilization, infectious disease, and parasitic infestation. Even a slight inadequacy or imbalance in nutrition can increase susceptibility to disease, and the diseased condition can markedly lower the effective utilization of the nutrients that are available.

Programs of preventive immunization, improved sanitation and various measures for the control of such mass diseases as malaria, schistosomiasis, cholera, and tuberculosis will relieve pressures somewhat on food resources and will improve not only the health but the economic productivity of individuals.

Increasing the World Food Supply

Rather than increasing dependence upon food aid, each nation must press toward development of its own productive capacity, including especially the production of crops by techniques that are adapted to the local climate, customs, and demands. In most instances this can best be done through encouragement of small farms and rural development, in which government and public institutions must play a primary role because private industry in general has no way of realizing returns on investments in such activity.

Enhancement of agricultural capability also will depend on adequate capitalization to allow for expanded irrigation, land reclamation, limited mechanization and processing and storage facilities, and the development of market agriculture as well as subsistence agriculture. This will require credit for the individual farmer to permit acquisition of at least minimal machinery and supplies.

Of special importance to the developing countries generally is adaptation of agricultural techniques to tropical and subtropical climates. Much of the world's expertise in this area resides in industrial concerns that represent a unique resource on which interested nations could call for assistance.

Food resources can be significantly supplemented by development and exploitation of various new and at the present time unconventional foods. Single-cell protein derived from yeast or bacteria grown directly on agricultural wastes or petroleum hydrocarbons already are proving practical for animal feed. In time, some of these items may be useful as human dietary supplements when their presently high costs decline sufficiently and their physical and biological properties render them acceptable for this purpose.

Various forms of aquaculture also are being developed. These include a number of

freshwater, brackish, and marine organisms that can be raised under controlled conditions and are expected to contribute to the quality of diets of certain populations.

Increasing U.S. Agricultural Productivity

There is reason for concern about the vigor and growth of the scientific and technological effort underlying agriculture in the United States. For the past two decades, there was an understandable reluctance to invest heavily in agricultural science and technology.

There remains an appreciable capacity for greater production by U.S. farms with the application of current technology. But in the last analysis the extent to which potential capacity will be achieved will depend on the measure and permanence of economic incentives that are perceived by the farmer.

The dramatic changes in cost and availability of fuels and fertilizers must be expected to impose many new constraints on the manner of agricultural production. A vigorous and imaginative research activity will be essential in meeting these changing stringencies.

Establishing an International Food Reserve

The global food outlook requires that serious consideration be given to establishment of an internationally managed food reserve system for use in times of emergency. A system of this kind also would provide a measure of price stability in the world food economy, which would be in the best interests of all.

The need for such reserves is particularly obvious at this juncture, when grain reserves in the United States are so low as to make impossible a major response to shortages elsewhere.

Consideration should be given to plans such as that proposed in 1973 by the director general of the UN Food and Agriculture Organization, which called upon nations, both exporters and importers, to hold agreed-upon minimum levels of food stocks.

Once the mechanisms for building international food reserves are established, a system would then have to be devised for distributing the supplies as needed and for determining criteria for payment by the recipient nation.

Increased Efficiency in Use of Food

Most of the protein malnutrition in the world is attributable to uneven distribution. Unfortunately, this does not mean that if the affluent accept a reduction in intake those who need it will in fact receive it. To some extent, protein malnutrition can be prevented by effective nutrition education, to some extent by pricing and distribution policies established by responsible governments.

Since the diets of affluent populations include amounts of animal products far in excess of those needed for optimum health, it is surely justifiable to encourage the use of more plant proteins, thus easing stress on overall grain supplies.

Energy Conservation

Overall, policies and practices must be developed to slow the exploitation of fossil fuels and to optimize the use of energy. Where, for example, natural gas is now being flared, it seems reasonable that there should be established fertilizer manufacturing plants to utilize these otherwise lost resources.

Trends in natural resource depletion and energy costs suggest that far more attention be devoted to opportunities for recycling. Phosphorus, for example, is the essential component of fertilizers that in the long run is most likely to be limiting—yet techniques are readily available for recovering substantial amounts from sewage. Similarly, large-scale fermentation of cornstalks, wheat chaff, etc., could recover a large fraction of the energy invested in the crop.

NEW RESEARCH PRIORITIES

Health and Fertility Control

Research is required to establish how most readily to provide an adequate balanced diet to the children of each developing area. Available evidence suggests that until there is reasonable assurance that children have a high chance of reaching maturity, their parents are poorly motivated to reduce fertility.

Were the social and economic goals of development attained, fertility would be expected to decline as it has in all other countries that have already achieved development. But since those goals are far from attainment, research is required to identify means for hastening reduction in fertility in the interim. Among the many facets of this problem one may list research in: human fertility and reproductive physiology; social and psychological factors in motivation for fertility control; the best means of producing and distributing contraceptive materials; the linkage between socioeconomic progress and fertility control, and the opportunities to improve the status of women.

Improved Efficiency of Agricultural Production Systems

Specific highly desirable research programs requiring increased emphasis include: genetic improvement of food crops and protection against increasing genetic vulnerability of crops and livestock, including maintenance of gene pools and genetic stocks; intensified research on nonleguminous nitrogen fixation, including possible introduction of nitrogenase by genetic engineering; intensified research on crop and livestock diseases and development of new biological and chemical means of pest control; studies of climatic variations as they may affect food production; development of agricultural practices that would conserve and make optimal use of energy sources and natural resources; improvement of methods for harvest, transport, storage, processing, and marketing; development of agriculture in cleared tropical forests, and improved efficiency of aquacultural production systems.

If these efforts are to be successful, the developed world, through its communications

technology, its research capacity, its substantial pool of trained and public service-oriented experts, and its financial resources, must expand its collaboration with the developing world. Unless this collaboration is effective the chances of avoiding disaster seem slim indeed.

CONCLUSIONS

The outlook for meeting overall food needs for the next 5 or 10 years appears manageable provided there is a major, concerted effort to increase food production globally, and provided there is no serious setback to production in the principal food-producing regions. The outlook for subsequent decades is alarming unless real progress can be made in reducing the rate of population growth.

The quality of life will be determined critically by the actual level of population attained when equilibrium is achieved. If that level be too high, the resultant social and political instabilities may well lead to an entirely different "solution" to these problems.