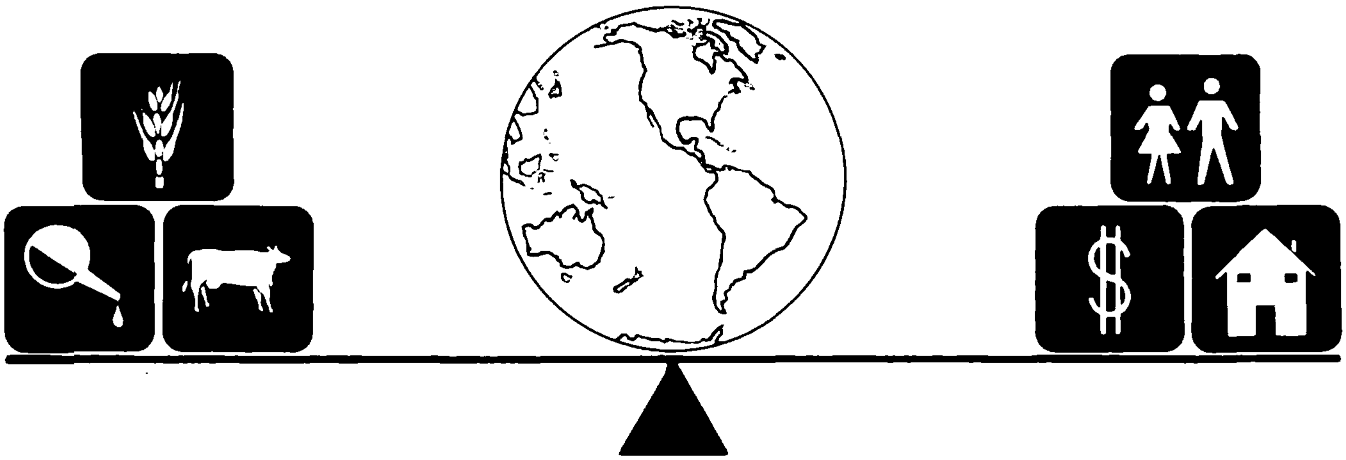
A HUNGRY WORLD:

THE CHALLENGE TO AGRICULTURE



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Abstract

Factors that determine world food needs are (1) population, (2) per capita market demand, and (3) income levels and distribution. Crops furnish the greatest share of the world's human food supply. Crop production projected to 1985 shows increases in wheat, rice, and maize, and limited increases in soybeans and dry beans. The outlook for animal products (meat, milk, eggs), though less predictable, indicates potential increases are possible through improved feed conversion and reproductive efficiency.

Limiting factors in future food output include environmental, economic, and industrial forces such as land, energy, and technological development.

For 1985, worldwide human food production from crops and animals is projected to balance reasonably well with required gross amounts at present levels and patterns of consumption. Calories are projected to be in shorter supply than protein. Imbalances will occur among regions, with critical deficits expected to occur in Asia, Latin America, and Africa. North America and Oceania show projected surpluses of both calories and protein.

Beyond 1985, the food situation is more difficult to assess. Key factors are world population increase and the amount and quality of the world's undeveloped arable land. The more intensive the food system becomes, the more vulnerable it will be to the less controllable parameters such as genetic failures, diseases, global weather disturbances, and sudden crucial input shortages. It behooves both developed and developing countries to provide a margin of safety through technological development and food reserves.

The present world food problem, triggered by a sudden decline in world food output in 1973 and by continuing upsurge in world food demand, has various causes. Some of the causes, such as poor weather, may well be temporary influences; but others, such as rising population and increased energy prices, apparently are longer-range in nature.

A crucial question is: Will the primary factors behind this latest dramatic development in the world food situation be permanently significant, or will they disappear in two or three years? Of course, no unqualified answer is possible at this time. But it is imperative that an attempt be made to assess the available evidence in order to provide an independent, objective judgment of the long-term prospects for the world food situation.

This paper summarizes a University of California Food Task Force report, which had these objectives: (1) to evaluate expected world food supply-demand conditions in 1985 and beyond; (2) to identify the basic factors that may lead to shortfalls in food supply; (3) to identify alternative solutions; and (4) to assess the implications for research and education (See Acknowledgment).

World Food Needs

Three basic factors determine the demand for food by humans: (1) population, (2) per capita market demand, which in turn is influenced by (3) income levels and distribution.

Population. The world population, currently estimated at about 4 billion, is growing at a rate of 2 percent per year. There appears to be little chance of much drop in that overall rate by 1985. In the developed

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world, the problem appears to be manageable; but in Asia, Latin America, and Africa, growth rates remain excessively high (Figure 1). The problem is particularly serious in Asia, where population density is already high.

Income. Worldwide income averages have been climbing faster than population, but this fact mainly reflects affluence in the developed world. The two primary problems are (1) the income gap between the "have" and the "have not" nations, and (2) income gaps among individuals and households within nations.

Demand. It appears that, until 1985 at least, effective per capita demand for almost all crops and animal products will grow even faster than population. Per capita consumption demand trends differ in developed and developing countries, but the overall projected increases, combined with increases in total population, indicate far greater total food needs in 1985 and beyond. For example, world demand for cereals is expected to be 39 percent greater in 1985 than in 1970.

Individual nutritional requirements, of course, may be different than per capita market demand. Actual food consumption usually exceeds nutritional needs in developed countries, while the opposite situation prevails in many less-developed nations. One question is that of protein needs versus energy (calorie) needs. Despite worldwide concern about protein shortages, the evidence indicates that future shortages of calories to satisfy nutritional requirements will be more crucial than shortages of protein.

The extent of the future world food problem will depend upon the balance between (1) gross food demand (allowing not only for food but also for nonfood uses and losses) and (2) effective supply (the amount that actually will be produced and marketed).

World Food Production Potential

Crops, including those fed to animals, furnish nearly all of the world's human food supply — whether the output is measured in terms of tonnage, food energy, or protein. Animal products and fish provide about 35 percent of man's protein.

Cereal grains are the most important crops, accounting for about 75 percent of both the world's cropland area and the total calories produced. Wheat and rice are the two most important single crops.

Crop production has been projected to 1985. Among the cereals, wheat yields should continue to increase as they have since 1950, so that little increased cropland will be required. Rice yields are projected to increase at a somewhat slower rate than wheat. For maize (corn), substantial increases in both yield and cropland are needed and appear achievable. For soybeans and dry beans, potential yield increases are limited, so that substantial increases in area will be needed.

The outlook for future supplies of animal products (meat, milk, eggs) is less predictable because livestock productivity so far is very low in many areas for various reasons — low genetic potential, poor disease control, poor management, and so on. However, there have been dramatic increases in animal product output in the developed countries during the past two decades. And large potentials remain for improving both feed conversion and reproductive efficiencies in both developed and developing countries.

Future gains in aquatic food production will be limited by both biological and institutional factors. Aquaculture is generally believed to have limited potential to increase total food output until large advances in technical production knowledge occur.

Limiting Factors

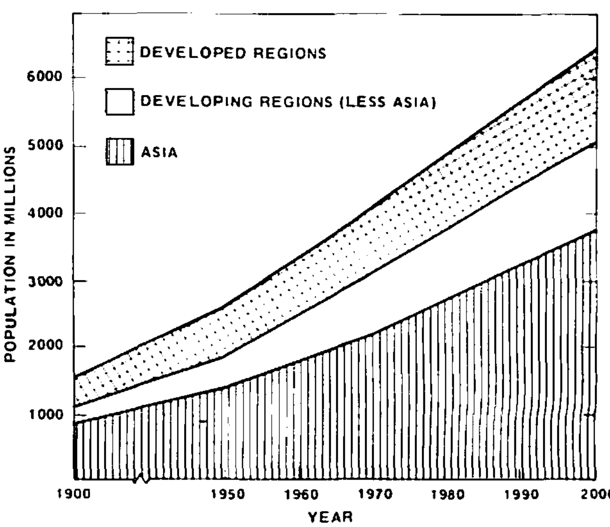
Future food output will be determined by the renewable natural resource base, by development of technology, by energy, and by other environmental, economic and institutional forces.

Some of the more significant factors are arable and irrigable land; climate; inputs of fertilizer, pest and disease control, irrigation, mechanization, and plant improvement; livestock breeding, management, and disease control; environmental quality; fossil fuels and other energy sources; and such human factors as poverty and institutional constraints.

Land

Ultimate limits on food production are set by the quality and availability of arable land, and by irrigation potentials. About one-half of the world's potentially arable land (3.2 million hectares) is now in use as cropland. The rate of new cropland development has been slow during the past 25 years, but is expected to increase during the next decade. However, the land not being cropped is generally less productive than the land in current use. There are additional problems: lands to be developed often are remote from population centers; vast capital investments are needed for development; transport systems and agricultural industries must be developed; and often intensive research and technological development are required.

Figure 1 WORLD POPULATION GROWTH IN MILLIONS 1900–2000



Energy

Energy, like land and water, is an underlying resource crucial to worldwide food production. The energy shortages and price increases of 1973-75 have emphasized the pervasive impact of this resource on all nations and all economic sectors, including the food production-processing-marketing system.

The effects on agriculture of the energy resource base are complicated by at least two factors:

1. **Agriculture must compete with other sectors of the economy for energy more than for other natural resources.**
2. **Agriculture involves diverse forms of energy, interconnected to varying degrees. For instance, food energy and fossil-fuel energy must be considered and balanced against each other in long-range planning for food production.**

Energy use in agriculture is as intensive in many other industrialized nations as in the United States. In fact, per hectare use of fertilizer — which requires large amounts of energy in its manufacture — is higher in Japan and many European countries than in the United States. However, the substitution of mechanical power for human labor has advanced further in the United States than anywhere else.

The developing nations have much smaller inputs of mechanical and chemical energy into agriculture. One result is, paradoxically, more apparent efficiency in total energy use when outputs of food energy are compared with inputs of mechanical and chemical energy. Relatively primitive food production systems yield about 16 calories of digestible energy for each calorie of energy from humans, animals, and fossil fuels. On the other hand, U.S. farmers produce only about a single calorie of food energy for one calorie input of fossil-fuel-based energy. Further, when the entire U.S. food system is considered, the ratio is 6 or 7 calories of fuel energy expended for each calorie of food energy produced.

In the U.S. food production system, the three largest energy-consuming sectors are meat animals (39 percent), poultry and eggs (20 percent), and dairy products (20 percent). However, these products are relatively efficient in converting energy to protein.

In most primitive countries, the yield of digestible energy per hectare is low. Under these circumstances, fossil fuels dramatically increase crop output per hectare, even though there may be a great change in the ratio of food energy produced to fuel energy consumed.

Additional energy applied to agriculture will provide an increase in human productivity and food output that is greater in a developing country than in a developed one. As industrial growth takes place in a developing country, however, agriculture's share of total economic activity declines, and competition for energy resources increases. For this reason, mechanical energy in agriculture is confined at first to the items with the highest potential payoff — fertilizer, tillage, water pumping, and transport.

Energy shortages and higher energy prices probably will be more harmful to countries in intermediate stages of development than to either industrialized nations or those with subsistence agriculture. A critical area of concern is energy to manufacture fertilizer, particularly nitrogen.

Because many developing nations have surplus labor — manifested in unemployment and poverty — labor-displacing technology may be a social disservice. A desirable alternative would be the development of tools and technologies that still use large labor inputs, while crop production per hectare is increased by methods such as machinery for heavy tillage.

Food Balances in 1985

On a worldwide basis—and allowing for various assumptions and unknowns—1985 human food production from crops and animals is projected to balance reasonably well with the gross amounts required at present levels and composition of food ingestion. *There will be* an overall shortage of oilseeds, and possibly some shortfalls in market supply of certain animal products, primarily reflecting affluence in developed countries.

These points are clearly indicated:

1. **Effective demand and production may be about equal on a world basis, but there will be wide imbalances among regions.**
2. **Calories are projected to be in shorter supply than protein.**
3. **Regional shortages will have vastly different implications for areas that can afford to buy on the world market (Europe) and for those that cannot (Asia, Latin America).**

Projected food energy or protein deficits, or both, which appear relatively small on a percentage basis in Asia, Latin America, and Africa, are actually critical because they are expected to occur in areas where population pressures are high and productivity and per capita incomes are low, and the sheer volume of projected deficits is almost overwhelming. Asia will be particularly hard-pressed to meet the food needs of a rapidly growing populace because of its lack of undeveloped land and water resources.

Two regions — North America and Oceania — show projected surpluses of both food energy and protein, not only well above the levels required for their own nutritional needs, but also well above internal effective demand. Combined potential surpluses in these regions could make up all the world's food deficits in 1985 if:

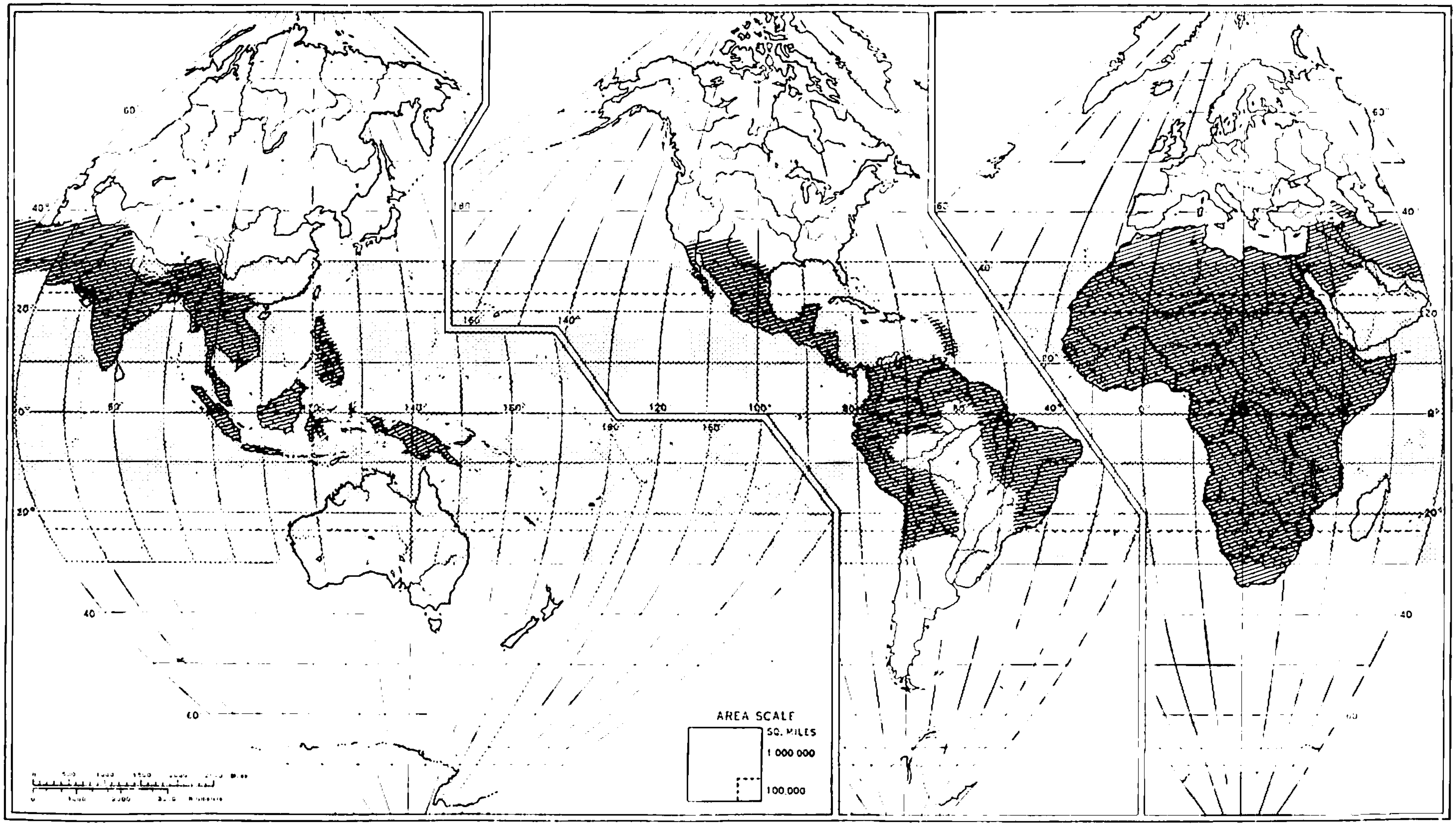
(1) economic incentives to producers are sufficient, and
(2) developed countries are able and willing to assist or subsidize the transfer of food to whatever degree is necessary.

Patterns of international trade — including economic forces, governmental policies, and the effects of the energy shortage — will have a large influence on the outcome.

Worldwide Implications

There are both short-run and long-run aspects of the world food situation as projected to 1985 and beyond. In several regions population growth rates in excess of food production increases, expected to continue at least to 1985, will compound food supply problems over the long run. Meanwhile, short-run market surpluses — that

Figure 2 GEOGRAPHICAL DISTRIBUTION OF WORLD FOOD PROBLEM



CALORIE DEFICIENT AREAS

65% of World Population
60% of World Animals
20% of World Agricultural Production

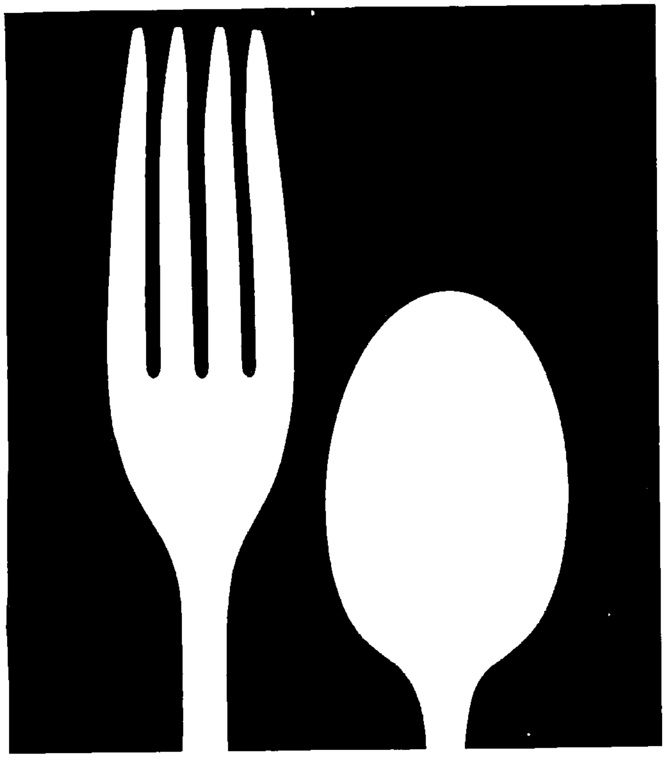
is, actual supplies in excess of effective demand—are likely to recur in countries that are capable of producing food in excess of their consumption requirements. Thus, the distribution of world food supplies will remain a more serious problem than total world crop and animal production. Given the limited purchasing power of many consumers in less developed nations, the world food dilemma will continue: malnutrition and starvation will prevail in some areas, while food surpluses accumulate in other regions. Figure 2 illustrates the geographical distribution of the world food problem.

The world's food shortages will continue to be centered in the developing regions of Asia, Africa, and Latin America, but the problem is worldwide. Effects of human suffering and unrest in the developing regions inevitably will be felt elsewhere. In addition, potential solutions to the world's food problem have their origins in industrialized nations, or at least will require their cooperation.

Outlook Beyond 1985

The food situation beyond 1985 is more uncertain. While no attempt was made in the University of California Task Force study to assess food balances after 1985, certain key issues need emphasis. World population is projected to increase by another 1 or 2 billion from 1985 to 2000. At the upper population variant this means feeding about twice as many people in 2000 as existed in 1968. At the lower variant the world population in 2000 would still be 50 percent greater than it is today.

The amount and quality of the world's undeveloped arable land creates further uncertainty for food production beyond 1985. For obvious reasons the best land and the easiest to develop was developed first. It will be increasingly difficult to mobilize the necessary human, institutional, and economic resources rapidly enough to keep pace with food demand in countries where the need will continue to be most critical.



Technology and research requirements for the years 1985-2000 present even greater challenges. Much of the yield-increasing technology assumed in our projections for the 1970-1985 period is currently available for adoption or is in the advanced stages of development. But meeting food production needs during the last 15 years of the twentieth century will depend upon accelerated adoption of known methods, development of new technology, and, indeed, some real "breakthroughs." Broad planning, basic and adaptive research, and the development of effective vehicles for international cooperation are imperative if food production technology is to be available when and where needed. Improved methods for monitoring world food production and utilization will be required for effective planning.

A final word of caution for 1985-2000 relates to those parameters over which man has the least control. The more intensive the food system becomes, the more vulnerable it is to unexpected adverse dynamics from physical and biological factors. Possibilities of genetic failures, diseases, global weather disturbances, and sudden crucial input shortages make the world food system more precarious. It behooves both developed and developing countries to allow a margin of safety. Technological development and food reserves are two ways to provide that margin.

Implications for Research and Education

Worldwide research and education needs are particularly urgent in these areas:

1. Population growth.
2. Nutrition.
3. Crop production, particularly the use of tropical soils; productivity of water use; pest control; fertilization; and genetic resources.
4. Animal production, particularly the under-utilized range resources and the under-exploited genetic potential of livestock.
5. Energy in food production-consumption systems.
6. The environment, particularly management of pollutants and analysis of trade-offs between environmental and food production goals.
7. Human and economic institutions, particularly the problems of income disparity and research delivery systems.

Acknowledgment

[1]A Hungry World: The Challenge to Agriculture; Summary Report, by University of California Food Task Force, July 1974, pp. 1-68. The task force was headed by agricultural economist Harold O. Carter at Davis. Members were George M. Briggs, professor of nutrition, Berkeley; John R. Goss, professor of agricultural engineering, Davis; Maurice L. Peterson, professor of agronomy, Davis; Davis W. Robinson, professor of animal science, Davis; Seymour D. Van Gundy, professor of nematology and plant pathology, Riverside; Pran Vohra, professor of avian science, Davis; and James G. Youde, extension economist, Davis. George Hellyer, special assistant to the task force, and R. H. Coppock, educational communicator, also contributed to the report.