FEATURES

Three articles from special issue of "SCIENTIFIC AMERICAN," September 1976, on the world food problem.

Through the 1950's and 1960's worldwide food consumption rose somewhat faster than the population growth rate and nutritional levels therefore improved. In contrast to that period, recent evidence suggests that in some parts of the world, especially in South Asia and Africa, population growth rates are down because death rates are up, largely because of food shortages. Furthermore, other areas of the world, including North America, no longer have the vast reserves of grain from which aid was supplied in the years preceding the 1970's. The bumper wheat and corn crops which were expected in the U.S. for 1977 are now in question because of the severe winter drought, thus diminishing the opportunity to accumulate a substantial food reserve.

The first of the attached articles provides considerable background information on the nature of world food shortages and the primary solution to this problem, which is to increase production of basic food crops throughout the world. There follows an analysis of the scope of human hunger, involving an estimated 500 million people who suffer from malnutrition and another one billion who would benefit from a more varied diet. The third article examines the need for poorer countries to modernize their agricultural techniques and to revise their rural economies if they are to raise food production, income and living standards.

Although the subject of food aid programs has become controversial, there is little controversy over helping others to grow more food. These articles substantiate the widely held view that self-help is in fact crucial to alleviating food shortages, in spite of the complex problems involved, since the alternative -- continued hunger and increasing starvation -- is worse.

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ARTICLES

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JEAN MAYER ("The Dimensions of Human Hunger") is the new president of Tufts University. Before taking office in July he was professor of nutrition at Harvard University. Born and educated in Paris, Mayer served with distinction in both the French Army and the Free French forces during World War II. After the war he resumed his studies at Yale University, where in 1948 he received a Ph.D. in physiological chemistry. Two years later he was awarded his second doctorate (in physiology) by the Sorbonne. He joined the Harvard faculty soon afterward. An expert on the problem of human obesity and the mechanism by which the body regulates its food intake, he has published some 650 papers and several books (the latest of which, *A Diet for Living*, appeared in 1975). Over the years he has served as a consultant to several United Nations agencies, including the Food and Agriculture Organization and the World Health Organization; at present he heads the UN Task Force on Child Nutrition. As chairman of the National Council on Hunger and Malnutrition in the U.S., he played a major role in calling the nation's attention to the nutritional problems of the poor in America. In 1969, as a special consultant to the President, he directed the First White House Conference on Food, Nutrition and Health. He has since served as chairman of the nutrition division of the White House Conference on the Aging, and he currently heads the health committee of the President's Consumer Advisory Council.

W. DAVID HOPPER ("The Development of Agriculture in Developing Countries") is president of the International Development Research Centre in Ottawa. Before returning to his native country of Canada to take up his present job in 1970 he had lived for most of the previous decade in New Delhi, where he served first as the director of evaluation of the Ford Foundation's Intensive Agricultural Districts Program and later as associate field director of the Rockefeller Foundation's Indian Agricultural Program and as visiting professor of agricultural economics at the Indian Agricultural Research Institute. A graduate of McGill University, he first went to India for an extended stay in 1953, when he received a Social Science Research Council fellowship to study the economic organization of a village on the Gangetic Plain in north-central India. He left India two years later to continue his graduate studies at Cornell University, where he obtained a Ph.D. in agricultural economics and cultural anthropology in 1957. After teaching for a time in Canada and the U.S. he went back to India in 1962 under the auspices of the Ford Foundation. During the latter half of the 1960's he was an important figure in the green revolution in Asian food production, working with the World Bank, the Asian Development Bank, the Food and Agriculture Organization, the major bilateral donor agencies and Asian governments to match the needs of programs to expand food production with internal and external sources of investment and assistance. He is currently chairman of the subcommittee of the Consultative Group for International Agricultural Research for the establishment of an International Centre for Agricultural Research in Dry Areas.

Food and Agriculture

Introducing an issue about the world food problem. The situation is hopeful, with one proviso: that the development efforts of agrarian countries be concentrated less on industry and more on agriculture

by Sterling Wortman

The world food situation is serious, even precarious. It is also true that the world may have, for the first time in history, the ability to deal effectively with the interacting problems of food production, rapid population growth and poverty. What, then, is the moral of this issue of *Scientific American* dealing with food and agriculture?

Certain facts are indisputable. The world population was two billion in 1930, reached three billion in 1960, stands today at four billion and is headed for six billion by the end of the century. On the other hand, the annual rate of increase appears now to be reaching a peak. The worldwide rate of food production has recently been increasing along with population. The "green revolution" of the late 1960's represented a significant improvement in grain-crop productivity, primarily in parts of Asia and Latin America; China now feeds its vast population; India has just reported a bumper crop of grain. Yet year in and year out much of the world cannot feed itself and has been making ends meet with food from diminishing surplus stocks in a few countries. Hundreds of millions of people in scores of countries live in abject poverty, suffering from chronic malnutrition that reinforces their poverty and subject to calamitous famines when their precarious food supplies are reduced by drought or floods or wars [see "The Dimensions of Human Hunger," by Jean Mayer, page 40].

Faced with these facts, there are serious scholars who forecast impending starvation of major international proportions. Some, pointing out that more than enough food is being produced in many parts of the world, advocate a radical redistribution of that food from the rich countries to the poor ones. Others propose a different solution: they would abandon the populations of the countries whose prospects for survival they consider virtually nil by withholding from them food and technical and economic aid, sending selective help instead only to those countries they give a reasonable chance of survival. On the other hand, many students of the problem are optimistic that food supplies will improve gradually as scientific knowledge and technology are widely applied to improve agricultural productivity, as population growth rates decline under the impact of mass education and family planning and also as an implicit accompaniment of economic advances.

The evidence assembled in this issue, to my mind, justifies the second of the two broad attitudes I have described, but with an important proviso: The improvement will come about only if it is actively engendered by radically new public policies both in the rich nations and in the poor nations themselves. It is important to realize that the mutual relations among the problems of low agricultural productivity, high population growth rates and poverty offer opportunity as well as difficulty. An all-out effort to increase food production in the poor, food-deficit countries may be the best means of raising incomes and accumulating the capital for economic development, and thus for moving the poor countries through the demographic transition to moderate rates of population growth.

Since 1798, when Thomas Malthus published *An Essay on the Principle of Population*, there have been repeated warnings that man's numbers, which are subject to exponential increase, could—or at some time surely would—overtake food supplies, which Malthus assumed could only increase arithmetically. Over the years there have been localized famines and some food shortages of wider extent: there were major shortages in the early 1920's following World War I, in the late 1940's and early 1950's after World War II, in the mid-1960's after two years of drought on the Indian subcontinent and most recently in 1972, when world grain production fell 35

million tons and the U.S.S.R. bought heavily on the international market. Yet it was not until less than 15 years ago that people began to appreciate the serious and chronic nature of the world food problem.

It was in 1963 that Lester R. Brown, who was then working in the U.S. Department of Agriculture, published a paper in which he presented projections to the year 2000 of changes in grain production and net trade. The projections (not predictions but extrapolations of the trends then current) suggested that even though the developing countries could be tripling their grain output by 2000, exports from developed countries to less developed ones would need to be more than quadrupled to meet the ever rising demand. In a 1965 paper Brown noted that before 1940 the less developed areas of Asia, Africa and Latin America had all been net exporters of wheat, rice, corn and other grains to the more industrial nations. By the end of World War II, however, the less developed countries had lost their surplus and the net flow was reversed. The export of grain from the developed world to the less developed one rose from an average of four million tons a year in 1948 to some 25 million tons in 1964. Brown concluded: "The less developed world is losing the capacity to feed itself." Since then the flow of grain from a few developed countries to the developing regions has continued to rise; indeed, in the recently ended crop year it appears that almost all the interregional grain exports came from the U.S., Canada and Australia [*see illustration on page 37*].

If the grain-production trends of the past 15 years continue, according to the International Food Policy Research Institute, the food-grain deficit of developing countries with market economies will be about 100 million tons a year by 1985–1986. If the rather lower rate of increase in production characteristic of the past seven years prevails instead, their annual deficit could reach a staggering 200 million tons.

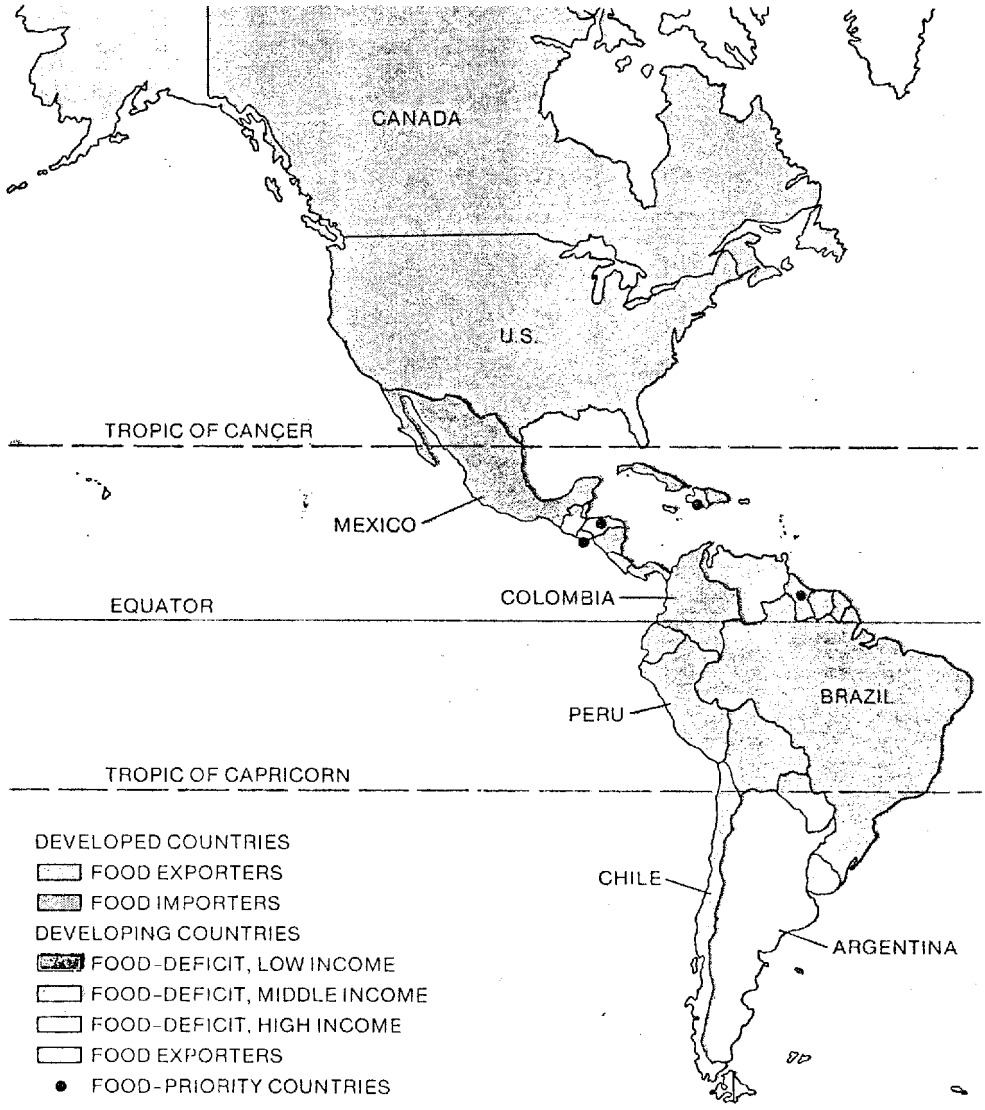
Those projections are specifically for the poor countries that cannot produce enough food to feed themselves. There are developing countries (Thailand and Argentina) that export food and a few, such as China, that are virtually self-sufficient in food. And there are many developed countries that need to import food and are able to pay for it; there is nothing about a localized food deficit that foreign exchange cannot cure. The problem, then, is centered in the developing countries with food deficits. The complexity of the task of improving the situation of those countries derives from their particular characteristics.

Whereas in 1974 the per capita gross national product was $6,720 in Sweden, $6,640 in the U.S., $2,770 in Italy and $2,500 in the U.S.S.R., some 90 countries had a per capita product below $500; about 40 of these had one of less than $200. These are statistical averages: in most market-economy developing countries there are sharp income disparities, and income levels among the masses of rural people are far below any average. As a group these countries have inadequate foreign-exchange reserves; many of them depend on one raw-material export or at most a few; their balance of trade is usually negative and they are heavily in debt.

Developing countries are agrarian, with from 50 to 80 percent of their people in rural areas, often far from centers of government. For most of them the source of livelihood is the production of food or fiber crops or the husbanding of animals that are adapted to local soil and climatic conditions. The productivity of their crops and their animals is in most cases abysmally low. The ratio of land to population is dwindling; in a number of countries the amount of cultivated land per person is less than an acre. Even a few decades ago food production could be increased in most countries by bringing additional land under cultivation or extending grazing areas; now that option is disappearing in many regions. Moreover, as land has been divided repeatedly among generations of heirs, most family holdings have become extremely small.

The rural people have little access to education or health care. Housing is substandard. Life expectancy is low, and large families have traditionally provided a source of labor and of security for parents in their later years. Often out of sight and out of mind of urban-based governments, these rural populations are the poorest of the poor.

Another handicap for many of these countries is their small size: in almost 80 the population is less than five million, and in more than 30 of these it is less



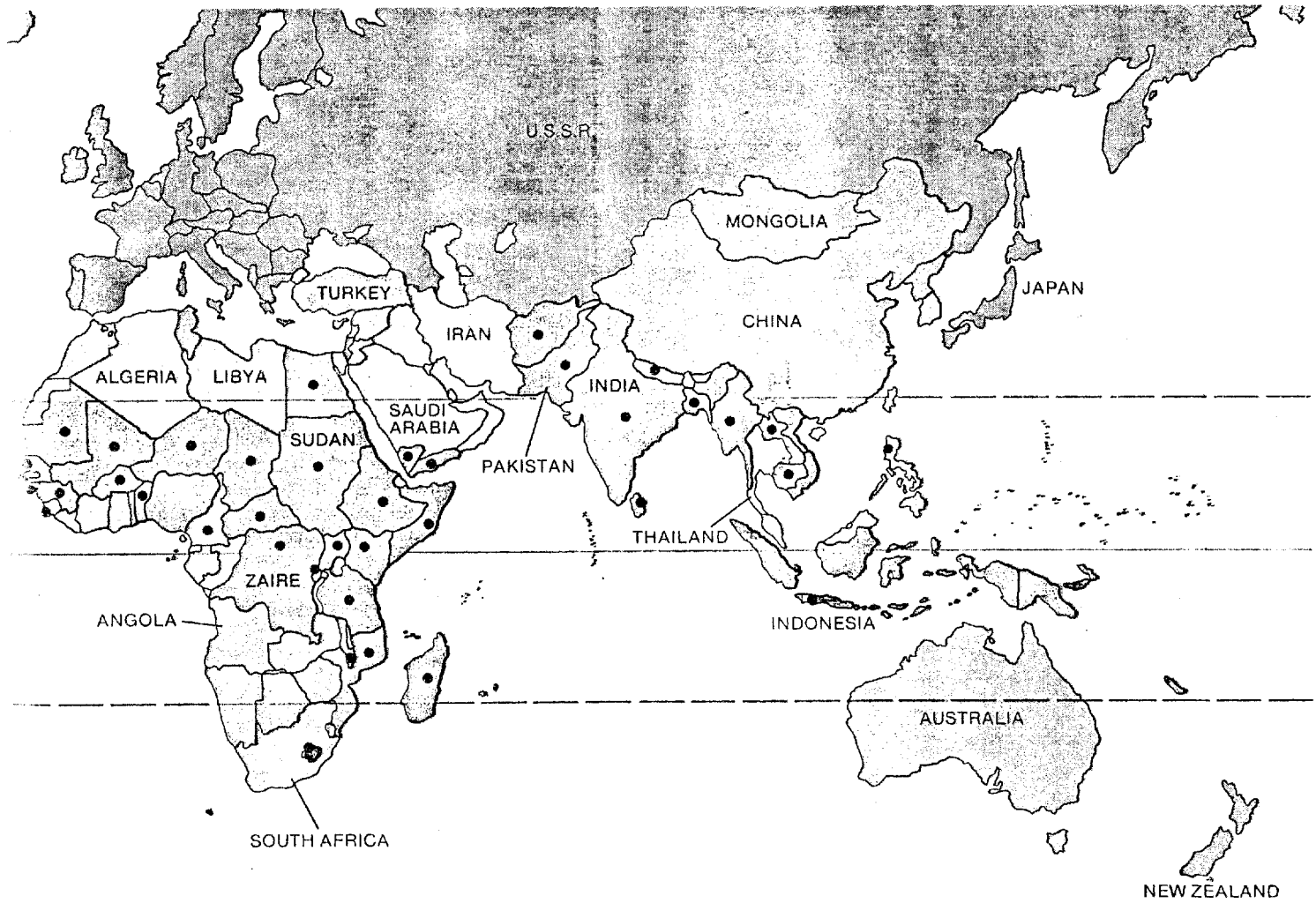
IMPACT OF FOOD DEFICITS AND POVERTY is concentrated in the broad band of developing nations, as is shown in this map based on categories established by the International Food Policy Research Institute (IFPRI). A few developed countries are major exporters of

than a million. Such nations cannot expect to develop for themselves the full range of scientific and other professional services required in fields that are important to development; they must rely on external resources. The developing countries' lack of institutions and trained personnel is exacerbated by the fact that many of them are newly independent. Of the countries listed by the United Nations as being least developed or as being "most seriously affected" by recent economic stresses, 36 have become independent since 1945, 29 of them only since 1960. The departure of the colonial powers left many of them without the skills needed to improve food-crop production, with weak institutions and in many cases without the reliable market outlets or sources of supply that had existed when they were part of a colonial system.

Moreover, as colonies their basic food crops and food animals had been neglected. Many developing countries have numerous centers for research on coffee, cacao, oil palm, rubber and jute and other cash export crops, but until a few years ago there were few such centers for wheat, rice, corn, food legumes, root crops, vegetables and other crops essential for feeding rural and urban populations. Even since independence the attention of governments and industry has tended to remain centered on estate and industrial crops that can generate foreign exchange. There has been little concern for providing the research and training and for establishing the market systems that characterized formerly successful efforts in connection with export crops. In many of these essentially agrarian countries the people in power are military officers, lawyers, businessmen, engineers or others who know little about agriculture or the science that underlies it.

Now increasing numbers of people, most of them in the countryside, are becoming restless. With advances in mass communication and in transportation these long-neglected people are becoming aware that only a small fraction of the citizenry are enjoying the comforts of life. Seeing no hope for themselves or their children, they are receptive to any ideology that offers them what they hold most important: food, clothing, housing, health care, education, security—and hope.

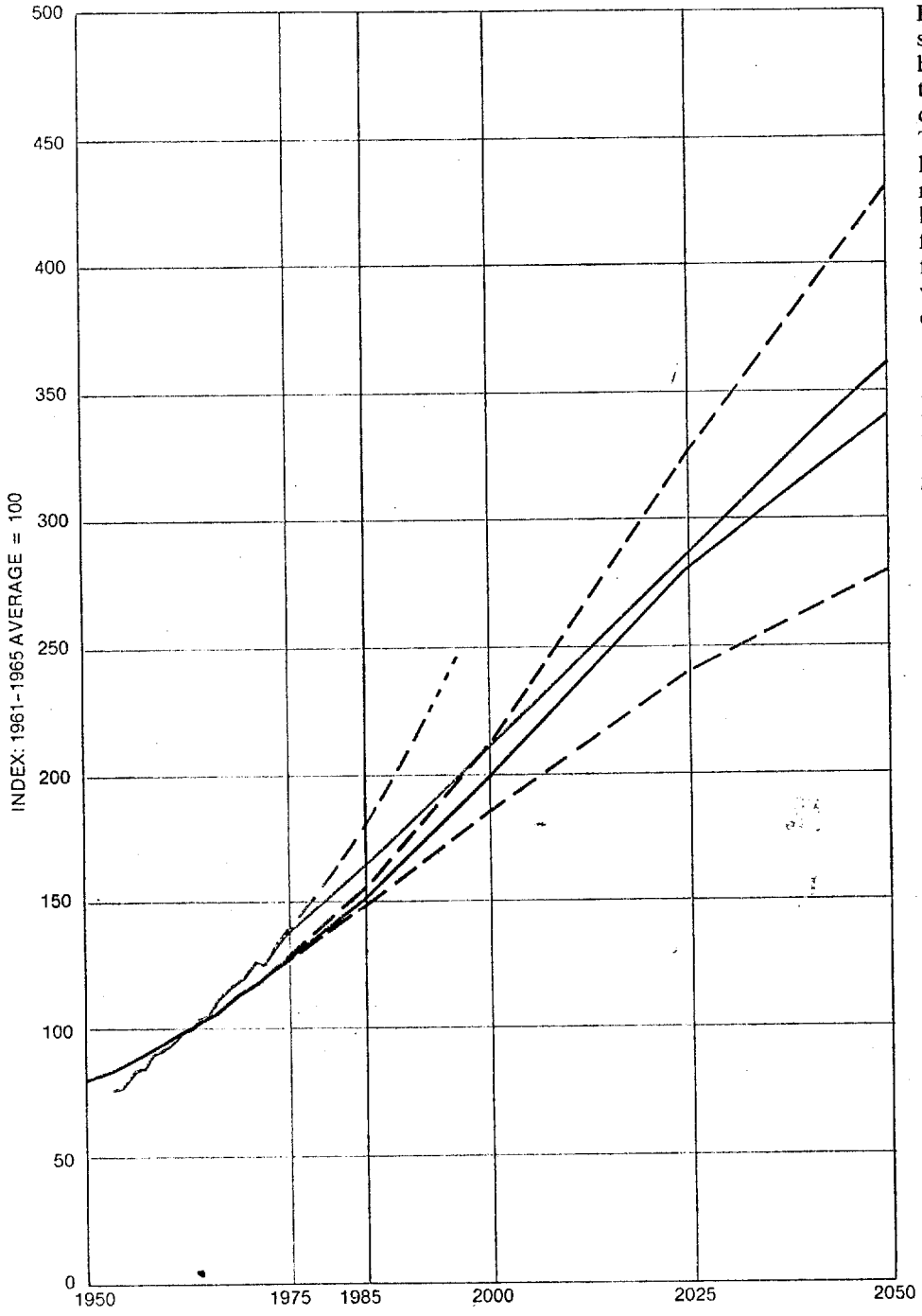
Accordingly government leaders are being made increasingly aware that unless they take steps to develop their rural areas they may well be faced with continuing unrest and violence and even revolution. A new political will to deal with agriculture is emerging. Trends in world food supplies have contributed to the new sense of emergency. With the dwindling of reserves of grain in the U.S. and some other food-surplus countries, many leaders of developing countries can no longer count on continuing access to the cheap (or even free) supplies that have enabled them to keep



food; the rest have net food deficits but can pay to import food. Almost all developing countries have a food deficit and only those in the Approved For Release 1999/09/02 : CIA-RDP79-01194A000100040001-1 which to buy food without constraint. The United Nations has identified 43 "food-priority countries" (*black disks*) with especially low incomes, inadequate foreign exchange and large projected cereal-grain deficits.

food costs low in their urban areas while continuing to neglect their agricultural areas. With the high cost of food on international markets requiring large outlays of scarce foreign exchange, some governments are for the first time being compelled, for political reasons, to worry about their farm populations. The reduction of the surpluses could ironically be one of the more favorable events of recent times—if it galvanizes governments into action.

To understand the kind of action that is required it is helpful to consider the stages through which agricultural systems move and the transformations of the current century. For thousands of years men have practiced traditional subsistence agriculture. Ever since hunters and gatherers took up sedentary farming there has been a long and slow evolution of countless systems of crop and animal production, many of which persist today [see "The Plants and Animals That Nourish Man," by Jack R. Harlan, page 88]. Traditional farming systems involve only man, his animals, his seed and his land, with little need for the involvement of governments or industry or for cooperation with others. The productivity of such systems is largely limited by soil fertility and climate, and family income in cash or in kind depends in part on the size of the farm operation that can be handled with family labor. The great bulk of the world's farmers still practice some form of subsistence farming.

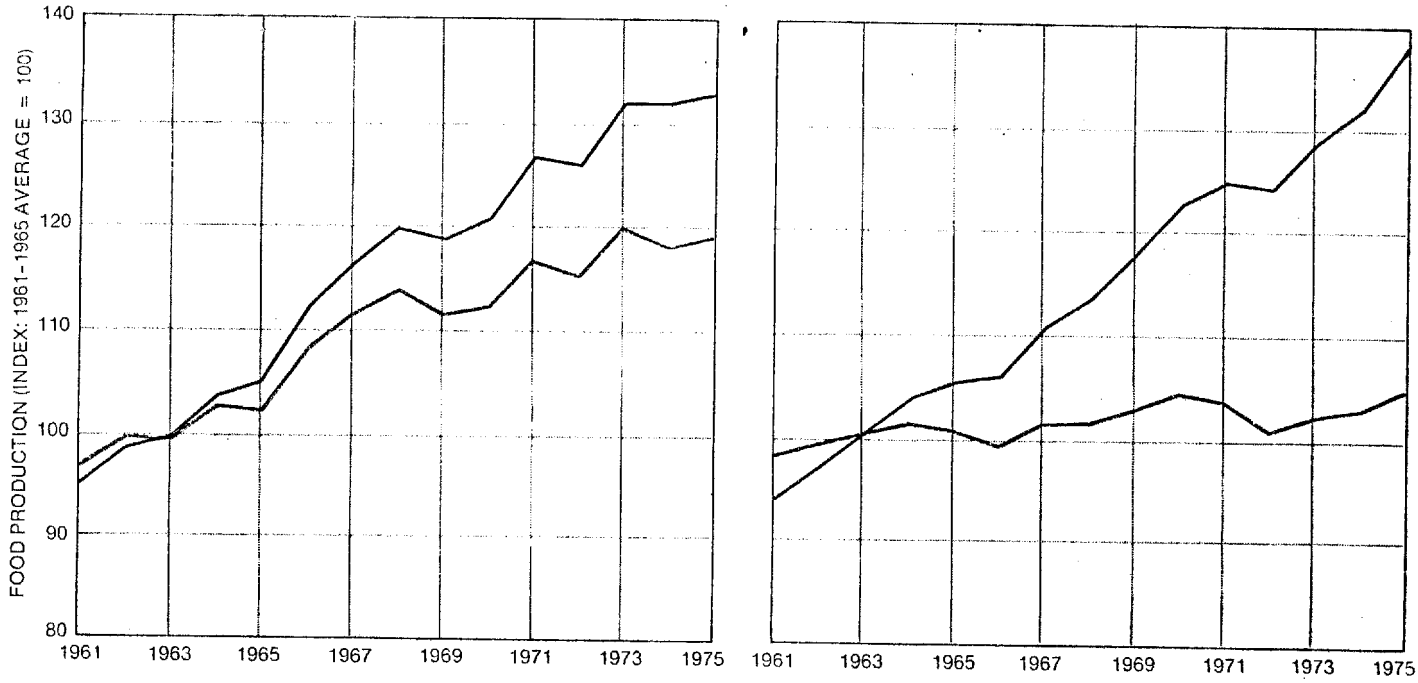


WORLDWIDE FOOD PRODUCTION seems likely to keep up with population in the near future. Here world population (*black*) and food production (*color*) are plotted as index numbers, taking the 1961–1965 averages as 100. Actual data are plotted to 1975. Thereafter three population curves are shown: the UN high, medium (*solid black*) and low projections. Two food-production projections are shown. One (*solid color*) assumes a linear rate of increase (as Malthus assumed must be the case for food production); it is based on the rate of increase (an average of three index points per year) between 1961 and 1973. Such an increase in food production lies above the medium population projection. The other food-production curve (*broken colored line*) illustrates a UN Food and Agriculture Organization projection to 1985 of the 1961–1973 rate of increase, assuming an exponential rate of growth. These curves do not imply that world food production will [illegible] worldwide [illegible] "demand."

A significantly different kind of agricultural development has been introduced largely within this century, based on science and technology and generated mainly by consumer demand. This agricultural revolution, in which the Western nations have pioneered and excelled, has been fostered by research and educational institutions, industry and public agencies, and by the efforts of increasingly sophisticated and innovative farm populations [see "The Agriculture of the U.S.," by Earl O. Heady, page 106]. The past 75 years have seen the introduction of more efficient crop varieties and animal strains; the development, improvement and widening application of chemical fertilizers and means for controlling disease and insect pests; the introduction of ever more farm machinery and the trend toward industrialized farming and other "agribusiness," all underlain by more extensive networks of roads, electric power and communications.

What we begin to see now, and what needs to be promoted, is not simply the spread of this scientific-technical way of life to the developing countries but a new stage of deliberate, forced-pace agricultural and rural-development campaigns driven by several new forces more insistent than rising consumer demand [see "The Development of Agriculture in Developing Countries," by W. David Hopper, page 196]. Literally scores of countries are looking for ways to raise food production, incomes and living standards among the rural masses, not in the 50 or 75 years such changes required in the Western countries but in 10 or 15 years. They have no time to lose.

The first objective must be to increase food production, but more food is not enough. After all, people can get food in only three acceptable ways (if one excludes theft and violence). First, people



FOOD PRODUCTION has increased in developed (*left*) and developing (*right*) countries at similar rates (*black curves*). As FAO data show, however, the rise is largely nullified in developing countries, where rapid population growth reduces production per capita (*color*).

who have land may be able to grow their own food, or at least some of it for part of the year; ways must be sought to enable them to increase their output. Second, people can receive food as a gift, but that only buys important living time and is not a continuing solution to their basic poverty. Third, people can buy food if they have money, but hungry people do not have money—in the developing countries or in the U.S. or wherever else people are hungry.

Thus there are two components to the solution of the food problem: increased production of food, primarily in the developing countries, and widespread increases in family incomes, particularly among the poor. The higher incomes will have to come primarily from the increased productivity and profitability of agriculture, from the development of industry (primarily labor-intensive industries and particularly in the rural areas where most people live), from employment in construction and public works and from the generation of the diverse services that will be in demand as rural areas become more prosperous.

The bulk of the food supply of most agrarian countries is produced by individual farmers with tiny family-operated holdings. Improvement of the productivity and income of these people will require the introduction of new high-yielding, science-based crop and animal production systems tailored to the unique combination of soil, climate, biological and economic conditions of individual localities in every nation [see "Agricultural Systems," by Robert S. Loomis, page 98]. Needed now are concerted campaigns to move into the countryside not only with knowledge of new techniques and new varieties of crops and animals but also with roads and power systems, with inputs such as fertilizers, pesticides and vaccines for animal diseases and with arrangements for credit and for marketing agricultural products.

All of this is aimed at generating the main ingredient for rural development: increased income for large numbers of farm families. Until their purchasing power is increased through on-farm or off-farm employment there can be no solution to the world food problem. Extending science-based, market-oriented production systems to the rural masses can enable the developing countries to substantially expand their domestic markets for urban industry. As farm families attain larger disposable incomes through increased agricultural profits they can become buyers of goods and services, providing more jobs and higher incomes not only on farms but also in rural trading centers and in the cities. What I am suggesting, in other words, is that the improvement of agricultural productivity is the best route to economic advancement for the agrarian developing countries.

Let me mention three nonsolutions to the problems of food and hunger that are often proposed. Larger harvests in the few remaining surplus-production countries, notably the U.S., Canada and Australia, are not a solution. Those countries do need to improve their productivity to create surpluses for export, to maintain their balance of payments [illegible] as the highly gency needs for food caused by calamities anywhere in the world. To continue to allocate free or low-cost food to governments that neglect their own rural areas, however, is counterproductive. It simply allows governments to put off the tedious and unglamorous task of helping their own people to help themselves.

The introduction into developing countries of Western-style, large-scale mechanized farming is also not a solution. Such methods may be appropriate for thinly populated areas in some countries and may help governments to get food supplies under national control quickly, but there remains the problem of getting food from large farms even to nearby individual families that have no money to pay for it. Even if the product of such farms were destined solely for urban consumers, it would deprive the smaller farmers of such markets for their own produce. Perhaps more important, most large-scale mechanized agriculture is less productive per unit area than small-scale farming can be. The farmer on a small holding can engage in intensive, high-yield "gardening" systems such as intercropping (planting more than one crop in the same field, perhaps in alternate rows), multiple cropping (planting several crops in succession, up to four a year in some places), relay planting (sowing a second crop between the rows of an earlier, maturing crop) or other techniques that require attention to individual plants. The point is that mechanized agriculture is very productive in terms of output per man-year, but it is not as pro-

intensive systems are. And it is arable land that is scarce for most farmers in many countries.

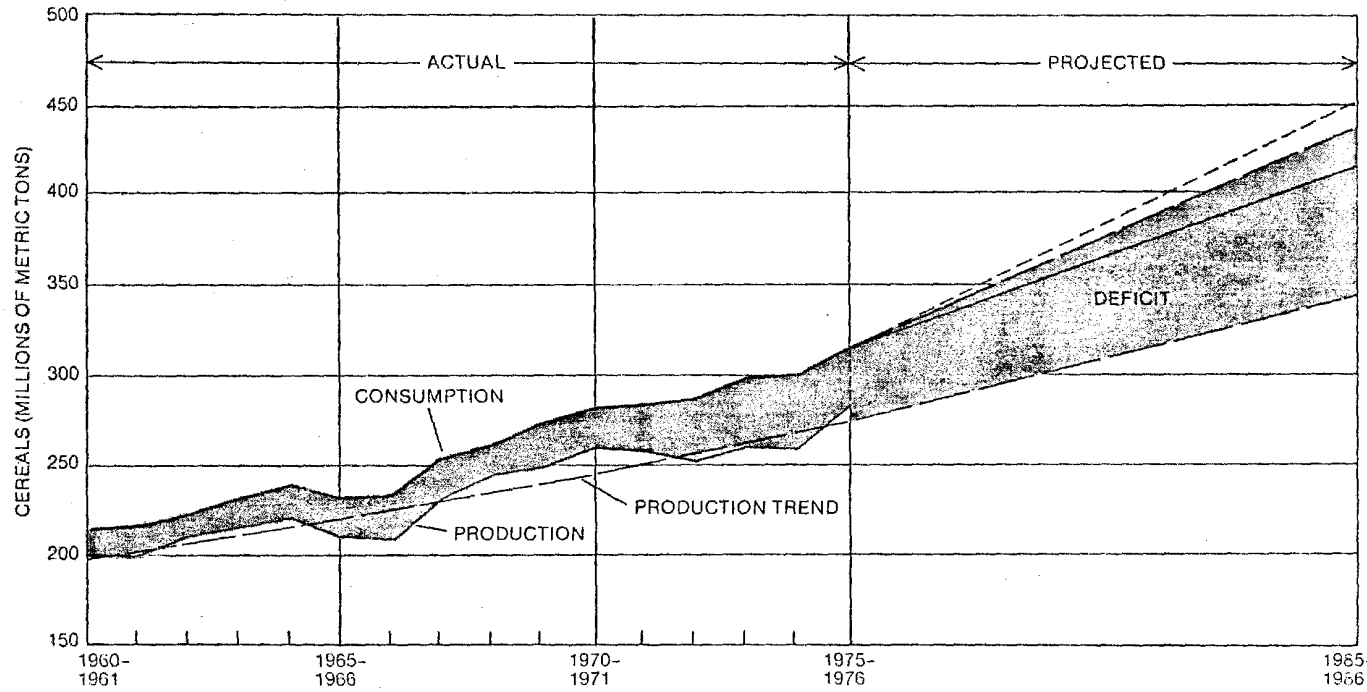
Finally, the advent of synthetic foods, single-cell proteins and so on will not be a solution. These products may prove to be valuable additives, but they have to be bought before they can be eaten. The hungry have no money, and the manufacture of novel foods does not provide any increase in income for the poor. The only real solution to the world food problem is for poor countries to quickly increase the production of crops and animals—and incomes—on millions of small farms, thus stimulating economic activity.

Is there any hope that this can be done? The assertion that this is the right time for "a bold new program" is not, after all, new. It was in 1949 that President Truman proposed his Point Four technical-aid program, arguing that "for the first time in history, humanity possesses the knowledge and the skill to relieve the suffering" of the world's poor. Is it any more reasonable to call for a new initiative today than it was a quarter of a century ago? The fact is that since then there have been a number of significant and hopeful developments.

First of all, the nature of the problem has become understood only during the past dozen years or so. I remarked above that the first projections of food requirements and deficits to the end of the century appear to have been made by Lester Brown in 1963 and 1965. The first comprehensive appraisal was undertaken in 1966 by some 125 American scientists and other specialists under the auspices of the President's Science Advisory Committee; their report titled "The World Food Problem" appeared in 1967. There have been many other reviews since then, the most recent major one being that of the World Food Conference in 1974. In the past 10 years the world has begun to mobilize to deal with technical and organizational requirements. The increased production of basic food crops on all farms everywhere has at last been accepted as the primary solution to the world food problem.

The transfer of technology in agriculture is not a simple process, however, and the second hopeful development is that its complexity is now reasonably well understood. Whereas most types of technology are widely applicable, the biological components of agricultural technology are not. They need to be tailored for each locality and developed in it.

For example, when Norman E. Borlaug of the Rockefeller Foundation began to work on wheat production in Mexico in the 1940's, he first tried to raise the yields of local varieties by means of good management practices and the application of chemical fertilizers. The local plants simply grew very tall and leafy and were heavily attacked by rusts. He then brought in from elsewhere all the varieties he thought might possibly work in Mexico, but none of them performed under the length-of-day and climatic conditions and in the face of the locally prevalent disease organisms. Borlaug had no alternative to the slow process of breeding new wheat varieties specifically for conditions in Mexico. As he undertook the research he began to train young Mexican technicians and scientists in wheat improvement and management and to establish reliable sources of quality seed. When he had developed shorter, stiff-strawed wheat varieties resistant to disease strains prevalent in Mexico, it became possible to apply increasing amounts of fertilizers and to harvest more grain instead of more straw. The enhanced profitability of wheat production in turn induced the government and farm organizations to improve irrigation systems and the supply of necessary fertilizers and to strengthen agricultural institutions [see "The Agriculture of Mexico," by Edwin J. Wellhausen, page 128]. The point is that it was basic biological technology that was holding back advances in Mexico with wheat, as it had held



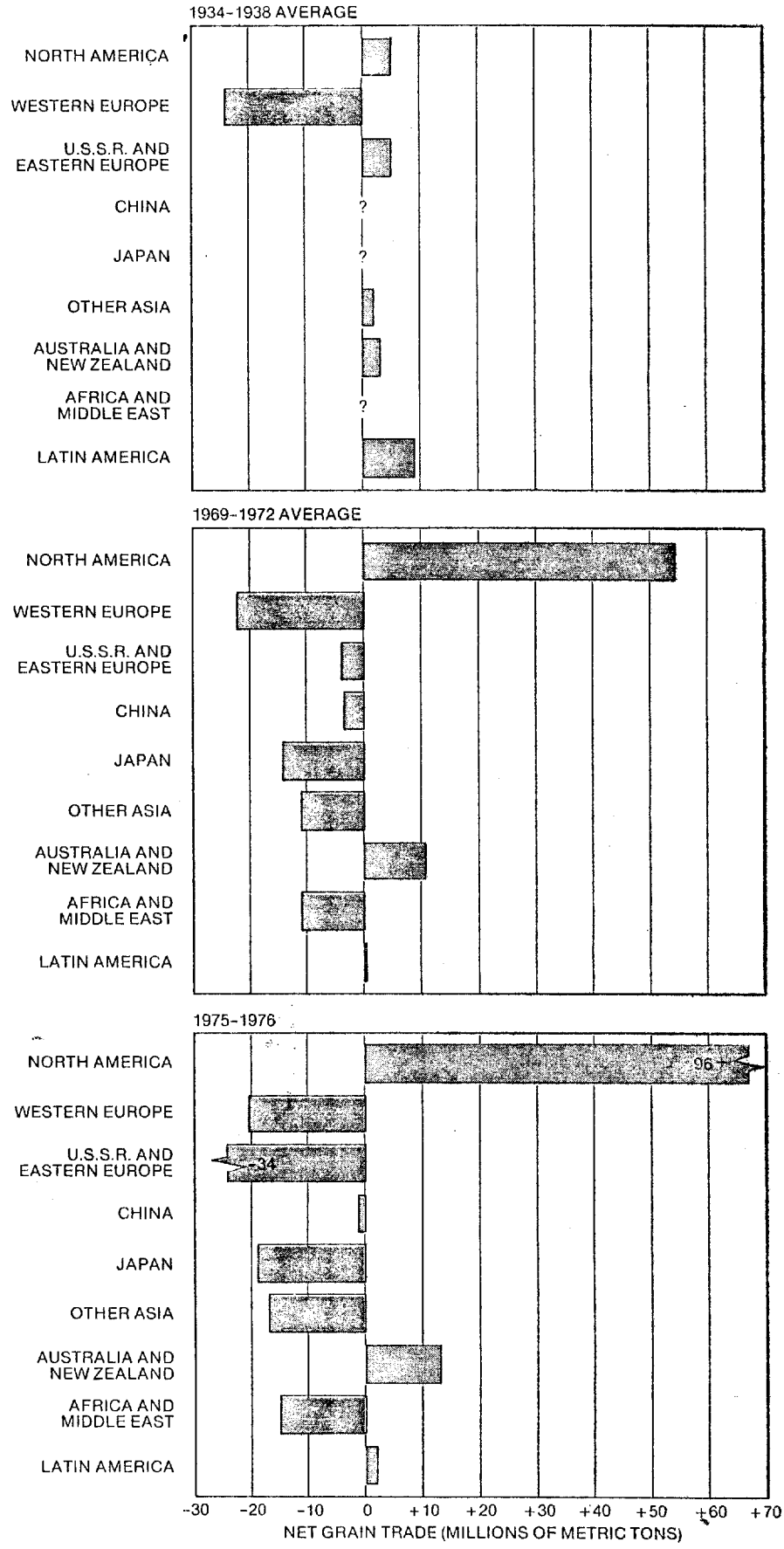
FUTURE FOOD DEFICIT in the developing countries is foreseen by IFPRI. Actual data are given, for cereal production and consumption in the market-economy developing nations that have food deficits, up to 1975–1976 (the crop year just ended). The trend of production since 1960–1961 was calculated and the trend line projected to 1985–1986. Future demand was projected from current human consumption on the basis of population growth and alternative assumptions about growth of per capita income (modified by "income elasticity" data reflecting the extent to which incremental income would be committed to cereal consumption); to this human demand, grain consumed as animal feed is added for countries rich enough to convert much grain into meat. Three demand projections are shown (*color*). One assumes no improvement in per capita consumption over the 1969–1971 level (*solid line*), one assumes low growth of income (*broken line*) and one assumes high income growth (*dotted line*). The curves measure economic demand, not actual need.

them back in Southeast Asia with rice and as it still is today in many areas of the world with many crops and animals.

The great void of food-crop and animal research in tropical and subtropical areas has now been partly filled by the establishment of 10 agricultural research and training centers in Asia, Africa and Latin America, six of them since 1970. Their work is now financed by a consortium of international agencies, national governments and a few foundations, whose support has grown from $15 million in 1972 to $65 million in 1976. Meanwhile several national governments, including those of Brazil, India, the Philippines and Pakistan, are greatly intensifying their own research efforts. For the first time in history the generation of the needed biological components of highly productive tropical agricultural systems is underway.

A third hopeful factor is that the potential for raising yields is great. As of 1971–1973 there were 135 nations in which corn was produced in significant amounts. The highest national average yield in the world was 7.2 metric tons per hectare in New Zealand; in the U.S. it was about 5.8 tons. Yet there were 112 countries with national-average yields of less than three tons, 81 of them with less than 1.5 tons! Yields of other basic food crops and animals are similarly low, reflecting the impoverishment of soils from decades if not centuries of continuous use, the failure to control diseases and pests, the low production potentials of native crop varieties and animal strains, the lack of needed nutrients in fertilizers or feed supplements and other factors.

In many of the poorer countries the application of chemical fertilizers (a good indicator of the degree of intensification of agriculture) is only beginning to spread to the basic food crops. When fertilization is combined with high-yielding varieties and improved cropping practices, yields can climb quickly and substantially, as was demonstrated beginning in the mid-1960's with wheat in India [see "The Agriculture of India," by John W. Mellor, page 154]. Of particular importance has been the creation of short, stiff-straw varieties of wheat and rice, called semidwarfs. Such varieties can utilize higher applications of nitrogen and other nutrients for the production of grain more efficiently than typical native varieties, which tend to grow excessively tall when they are heavily fertilized and to "lodge," or fall over, well before harvesting, reducing yields. For similar reasons plant height has been shortened and stalks stiffened in other grains, including corn, sorghum and barley. When high-yielding varieties are grown as dense populations, with an adequate supply of nutrients



WORLD'S INCREASING DEPENDENCE on grain exports of a few countries is shown by this comparison of the trade pattern before World War II with the situation more recently and estimated figures for the past year. Data are from Lester R. Brown, the Department of Agriculture and IFPRI. Before the war most regions exported grain (*gray bars*); Western Europe imported it (*color*). Now U.S. and Canada supply most of the grain to make up deficits.

and moisture, expenditures to control diseases and insect pests often pay off handsomely, whereas at the lower-yield levels of traditional agriculture they would not. These new varieties have been the catalysts of the agricultural revolution [see "The Amplification of Agricultural Production," by Peter R. Jennings, page 180]. Higher yields result, however, when such varieties are grown in combination with fertilization, disease and pest control, higher-density planting and other measures.

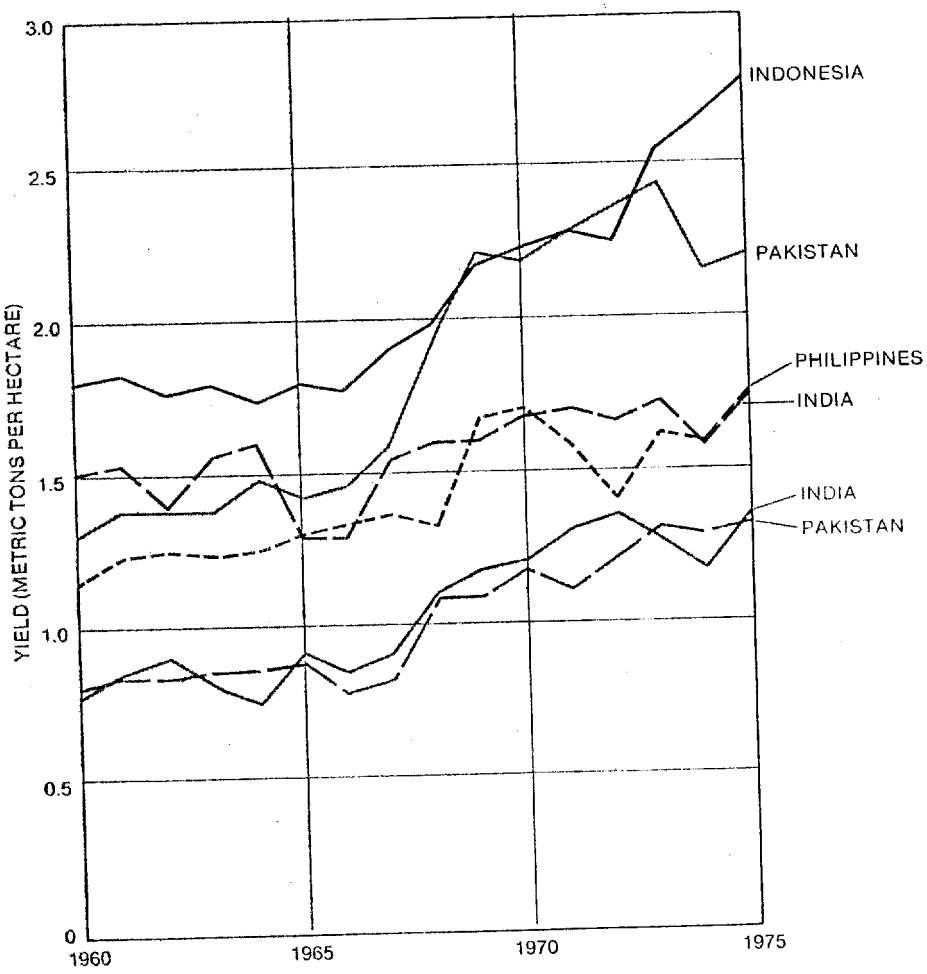
A fourth new element is the availability for the first time of chemical fertilizers in sufficient quantity for widespread basic food-crop production in the developing countries. At the turn of the century the total world output of chemical nutrients was only about two million tons per year. It crept up to about 7.5 million tons by the end of World War II. Then, from 1945 to 1955, production tripled to 22 million tons. In the next decade it doubled again, and now it is appoaching 80 million tons per year. Chemical fertilizers generally can be utilized only in market-oriented systems in which a portion of the harvest is sold to cover the cost of the purchased inputs. Once limited to the production of luxury, high-value cash crops, the application of fertilizers was extended first to grain crops in the U.S. and Europe. We now understand that the green revolution was simply a significant extension of the agricultural revolution that had begun in the industrialized countries.

Fifth, it has been demonstrated that governments can take effective action if the will exists, and that many farmers will adopt new technology given reasonable opportunities to do so. When India in the 1960's successfully introduced high-yielding crop varieties, fertilizers and management practices on some 13 million hectares in five years, it demonstrated that given the availability of technology a government can increase agricultural productivity rapidly if it wants to, and that farmers will accept more productive and profitable systems if they can. There have been subsequent, less dramatic successes in Pakistan, Algeria, the Philippines, Malaysia and elsewhere. It is only in recent years that there has been evidence that small farmers as well as those with larger landholdings can be benefited if scientific and organizational efforts are genuinely directed to their particular needs. Such efforts did not begin on a substantial scale until the late 1960's.

Sixth, there is now in operation a functioning network of financial institutions, including the World Bank, the Inter-American Development Bank, the Asian Development Bank, the African Development Bank and a number of Common Market banks, as well as national agricultural banks in many of the poorer countries. During the past three or four years most major financial institutions have substantially increased their emphasis on agricultural and rural development. The world now has in operation most of the institutions needed to finance major agricultural efforts. Most of these institutions did not exist in President Truman's time; the few that were established then had limited funds and their early emphasis generally was on industrial development rather than agricultural.

Seventh, an impressive (but still inadequate) array of institutions has emerged to assist developing countries with the technical and managerial development of national programs, in some cases also offering financial aid for worthy projects and programs. Among them, in addition to the UN Food and Agriculture Organization, are agencies for bilateral aid in 16 or more industrialized nations and the staffs of the World Bank and regional banks. The Ford, Kellogg and Rockefeller foundations have active programs. Canada's International Development Research Centre has become a leading force. A new, private professional-assistance organization, the International Agricultural Development Service, began operations in 1975. Additional sources of assistance are supported by industry.

Of particular importance is the freedom, only recently gained, of some national agencies to support work aimed directly at increasing the production of basic food crops. The U.S. Agency for International Development, for example, was constrained politically until 1969 (as was Canada's comparable agency) by reluctance to become involved in direct, visible efforts abroad to increase productivity of the basic food crops, particularly the cereal grains. There was a general belief both in and out of government that other nations should not be encouraged to increase production of those crops for fear of competition with U.S. efforts to sell its surplus stocks or even give them away! For example, it was not until the last week of President Johnson's administration that the AID undertook to provide financial support for the International Rice Research Institute in the Philippines and the International Maize and Wheat Improvement Center in Mexico.



UPWARD TREND of yields of rice (*black*) and wheat (*color*) in several Asian "green revolution" countries is due primarily to introduction of high-yielding varieties, more fertilization and better farming practices. [illegible]

By that time it had become apparent that mounting deficits in the developing countries would soon exceed the production capacity of the U.S. and the few remaining surplus producers, and it was becoming clear that much of the hope for expanding international markets of all types rested on improving the economic position of many agrarian countries. That the U.S. and Canadian agencies were not able directly and openly to help other nations increase their basic food-crop production gave them a late start on the problem—a mere seven years ago. The handicap has since been overcome, and the agencies have responded with improved effectiveness.

Another important handicap remains. Most European and North American institutions and individuals have had little opportunity to gain experience in organizing deliberate campaigns for agricultural development. That is understandable. For many of the past 20 or 30 years the U.S. and Canada have had problems of surplus production; there has been no need for public agencies or universities to become involved in campaigns at home to raise agricultural production. Moreover, these countries have an abundance of farm entrepreneurs who are researchers and innovators in their own right, who seek out the products of research laboratories and experiment stations and put them together into highly productive systems at the individual farm level. Such well-educated and exceptionally skilled farm entrepreneurs are scarce in most of the developing countries. Those who provide technical assistance will need to devise agricultural and rural-development systems for large numbers of people who are intelligent but uneducated, and who are therefore unable to undertake on their own the innovation required at the farm level.

Eighth, some governments of low-income countries are showing a new determination to develop their rural areas, with emphasis on the increased production of basic food commodities, the promotion of labor-intensive industry in rural areas and the extension of input supplies and marketing channels into areas where none have existed before.

Finally, there still remain considerable amounts of arable but currently uncultivated land that can be brought into production, except perhaps in Europe and parts of Asia [see "The Resources Available for Agriculture," by Roger Revelle, page 164].

Well-organized campaigns are needed now to force the pace of agricultural development at a rate with which few nations anywhere have had any experience. The key elements in such campaigns are inputs of biological technology and of capital for building the infrastructure to support rural development. I have emphasized that the poor countries must do much for themselves, but they need massive help from the affluent world. For us in the U.S. that calls for a much more serious effort to direct scientific knowledge and technical skills, as well as money, specifically toward foreign rural-assistance programs.

Clearly more is at stake than the alleviation of world hunger, crucial as that is. Improving productivity in developing countries can provide millions of people not only with food but also with housing, clothing, health care, education—and hope. Enhanced agricultural productivity is the best lever for economic development and social progress in the developing world, and it is clear enough that without such development and progress there can be no long-term assurance of increased well-being or of peace anywhere in the world. The existence of new technological, financial and organizational capabilities offers a magnificent opportunity, although perhaps a fleeting one, to take effective action. The crucial question is whether or not governments will have the wisdom to act.

The Dimensions of Human Hunger

The number of people who are poorly nourished or undernourished can only be roughly estimated, but they probably represent an eighth of the human population. Most of them are found in Asia and Africa

by Jean Mayer

Famine, fearsome and devastating though it is, can at least be attacked straightforwardly. A famine occurs in a definable area and has a finite duration; as long as food is available somewhere, relief agencies can undertake to deal with the crisis. Malnutrition, on the other hand, afflicts a far larger proportion of mankind than any famine but is harder to define and attack. Only someone professionally familiar with nutritional disease can accurately diagnose malnutrition and assess its severity. Malnutrition is a chronic condition that seems to many observers to be getting worse in certain areas. In one form or another it affects human populations all over the world, and its treatment involves not mobilization to combat a crisis but long-term actions taken to prevent a crisis—actions that affect economic and social policies as well as nutritional and agricultural ones. In the background always is the concern that too rapid an increase in population, combined with failure to keep pace in food production, will give rise to massive famines that cannot be combated.

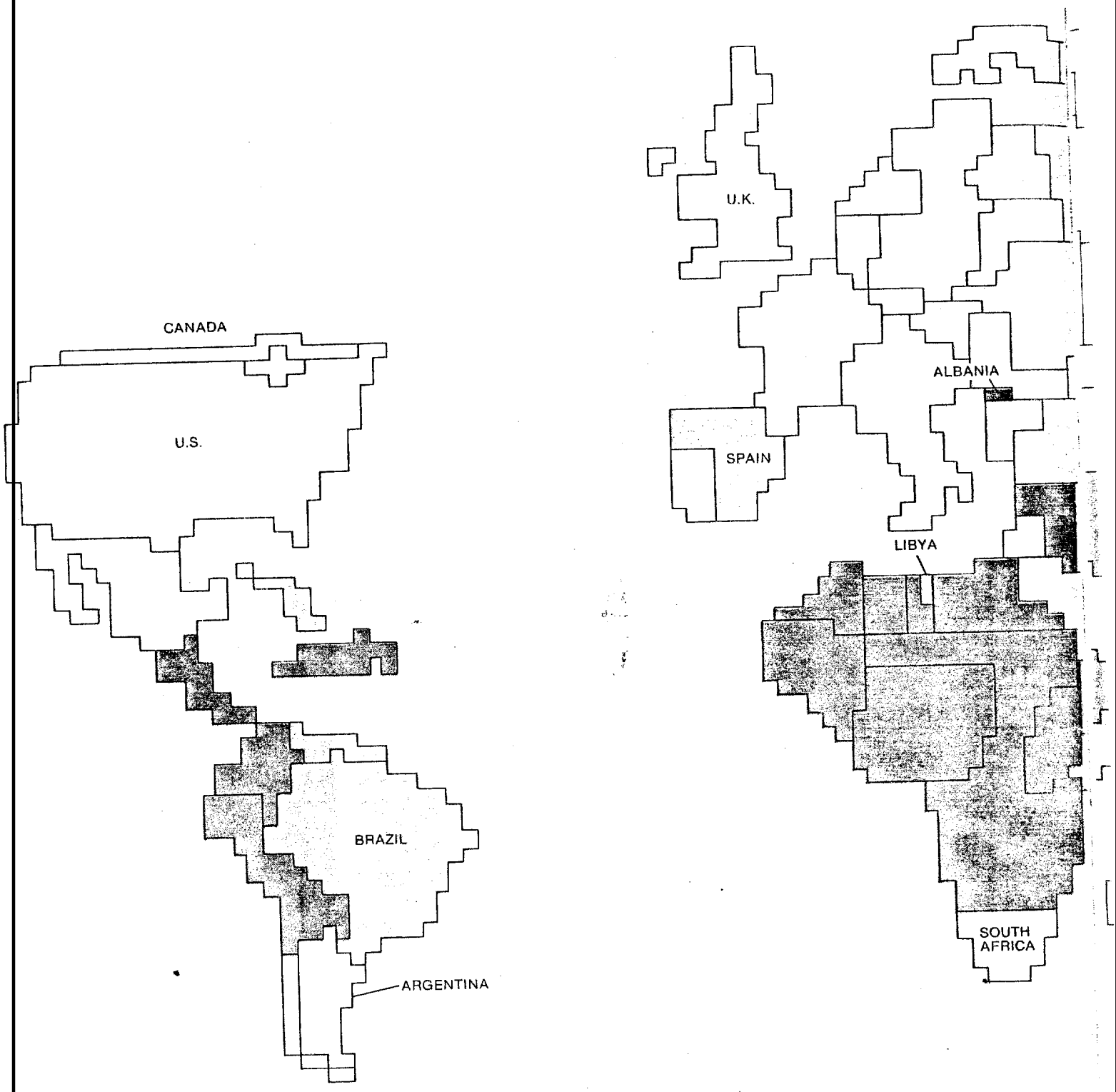
The statistics with which the public is bombarded are of little help. What is the layman to make of statements that a billion people suffered from hunger and malnutrition last year, that 10 million children the world over are so seriously malnourished that their lives are at risk, that 400 million people live on the edge of starvation, that 12,000 people die of hunger each day and that in India alone one million children die each year from malnutrition? If the world's food problem is to be brought under control, and I believe it can be, we must first draw conceptual boundaries around it and place it in a time frame as we would a famine.

First, then, just what is the chronic hunger of malnutrition and how widespread is it? The first part of the question can be answered with assurance; the second, in spite of the statistics cited in the preceding paragraph, is really a matter of informed guesswork.

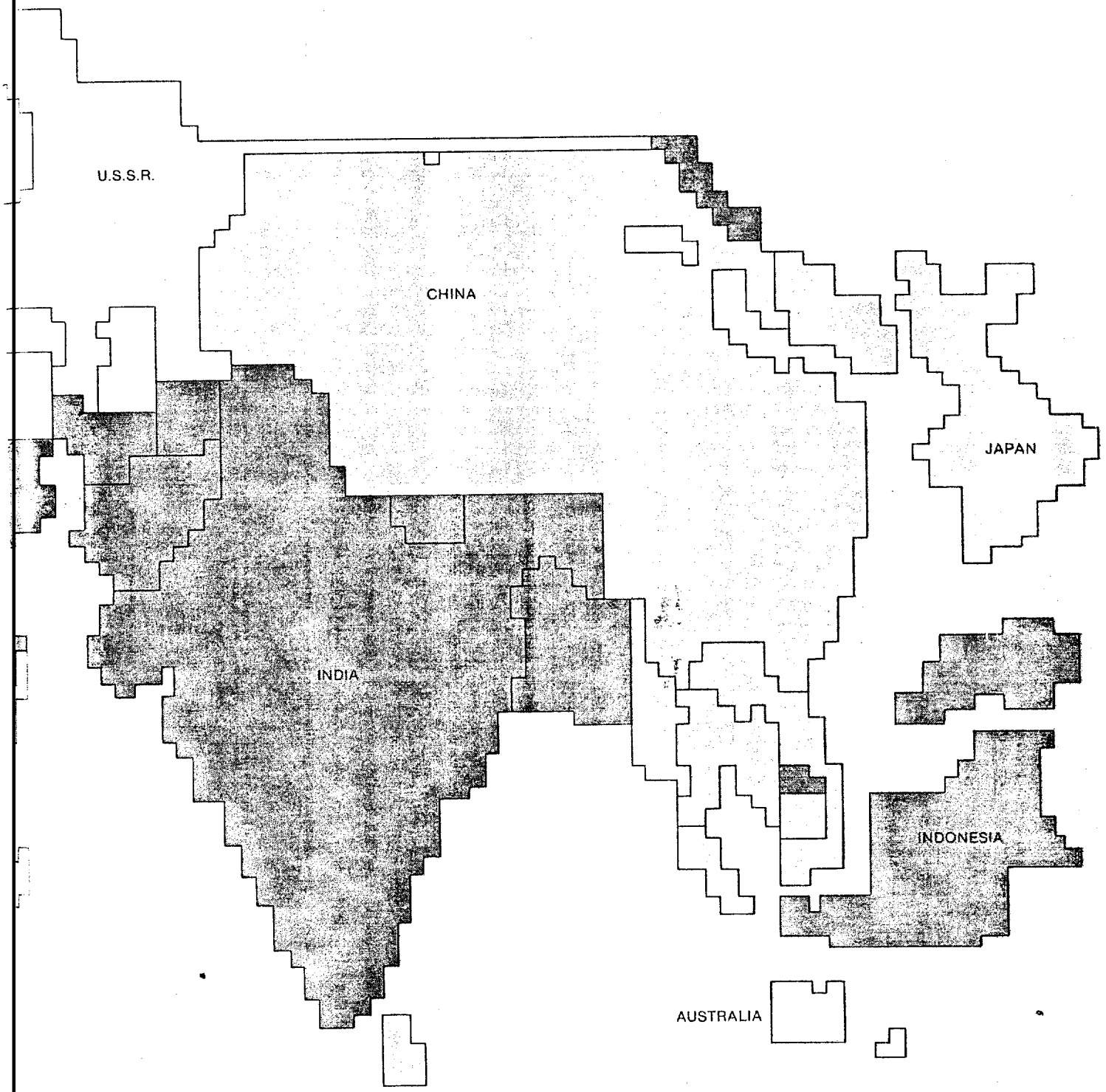
Malnutrition may come about in one of four ways. A person may simply not get enough food, which is undernutrition. His diet may lack one essential nutrient or more, which gives rise to deficiency diseases such as pellagra, scurvy, rickets and the anemia of pregnancy due to a deficiency of folic acid. He may have a condition or an illness, either genetic or environmental in origin, that prevents him from digesting his food properly or from absorbing some of its constituents, which is secondary malnutrition. Finally, he may be taking in too many calories or consuming an excess of one component or more of a reasonable diet; this condition is overnutrition. Malnutrition in this sense is a disease of affluent people in both the rich and the poor nations. In countries such as the U.S. diets high in calories, saturated fats, salt and sugar, low in fruits and vegetables and distorted toward heavily processed foods contribute to the high incidence of obesity, diabetes, hypertension and atherosclerotic disease and to marginal deficiencies of certain minerals and B vitamins. Bizarre reducing diets, which exclude entire categories of useful foods, are self-inflicted examples of the first two causes of malnutrition. The nutritional diseases of the affluent are not, however, the subject of this article. In areas where the food supply is limited the first three causes of malnutrition are often found in some combination.

In children a chronic deficiency of calories causes listlessness, muscle wastage and failure to grow. In adults it leads to a loss of weight and a reduced inclination toward and capacity for activity. Undernourished people of all ages are more vulnerable to infection and other illness and recover more slowly and with much greater difficulty. Children with a chronic protein deficiency grow more slowly and are small for their age; in severe deficiency growth stops altogether and the child shows characteristic symptoms: a skin rash and discoloration, edema and a change in hair color to an orange-reddish tinge that is particularly striking in children whose hair would normally be dark. The spectrum of protein-calorie malnutrition (PCM, as it is known to workers in the field) varies from a diet that is relatively high in calories and deficient in protein (manifested in the syndrome known as kwashiorkor) to one that is low in both calories and protein (manifested in marasmus).

Although protein-calorie malnutrition is the most prevalent form of undernourishment, diseases caused by deficiencies of specific vitamins or minerals are also widespread. It is true that the prevalence of certain classic deficiency diseases has decreased drastically since World War II. Beriberi is now rare and pellagra has been essentially eradicated, at least in its acute form; rickets is seen mostly in its adult form (osteomalacia) in Moslem women whose secluded way of life keeps them out of the sun, and scurvy is unlikely to be seen except in prisoners who are not provided with enough vitamin C. In contrast, blindness caused by the lack of vitamin A occurs with particular frequency in India, Indonesia, Bangladesh, Vietnam, the Philippines, Central America, the northeast of Brazil and parts of Africa. In remote inland areas (central Africa, the mountainous regions of South America and



LEVEL OF ENERGY obtained from food is portrayed on a map where the area of each nation is proportional to its population. Canada, for example, occupies a large area but has a relatively small population, whereas Japan has a large population in a relatively small area. The level of energy intake is indicated by the presence or absence of color. In the countries shown in dark color the average calo-



rie intake is less than adequate. (An adequate intake is defined by United Nations agencies as being about 3,000 calories per day for a man and 2,200 for a woman.) In the countries indicated by the light color the average calorie intake is adequate or as much as 10 percent above adequate, and in the countries represented in white the average calorie level is higher than adequate by at least 10 percent.

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the Himalayas) goiter, the enlargement of the thyroid resulting from a deficiency of iodine, is common. The World Health Organization estimates that up to 5 percent of such populations are afflicted with cretinism, the irreversible condition caused by iodine deficiency in the mother before or during pregnancy. From 5 to 17 percent of the men and from 10 to 50 percent of the women in countries of South America, Africa and Asia have been estimated to have iron-deficiency anemia.

The human beings most vulnerable to the ravages of malnutrition are infants, children up to the age of five or six and pregnant and lactating women. For the infant protein in particular is necessary during fetal development for the generation and growth of bones, muscles and organs. The child of a malnourished mother is more likely to be born prematurely or small and is at greater risk of death or of permanent neurological and mental dysfunction. Brain development begins *in utero* and is complete at an early age (under two). Malnutrition during this period when neurons and neuronal connections are being formed may be the cause of mental retardation that cannot be remedied by later corrective measures. The long-term consequences, not only for the individual but also for the society and the economy, need no elaboration.

Growing children, pound for pound, require more nutrients than adults do. A malnourished child is more susceptible to the common childhood diseases, and illness in turn makes extra demands on nutritional reserves. In addition many societies, still believing the old adage about starving a fever, withdraw nourishing foods from the child just when he needs them most, thus often pushing him over the borderline into severe malnutrition. So common is the cycle of malnutrition, infection, severe malnutrition, recurrent infection and eventual death at an early age that the death rate for children up to four years old in general, and the infant mortality rate in particular, serve as one index of the nutritional status of a population as a whole. For infants less than a year old the death rate is about 250 per 1,000 births in Zambia and Bolivia, 140 in India and Pakistan and 95 in Brazil (for all its soaring gross national product). The rate in Sweden is 12 per 1,000 births; in the U.S. the average is 19, but in the country's affluent suburbs the rate equals Sweden's, whereas it rises to about 25 in the poor areas of the inner cities and as high as 60 for the most poverty-stricken and neglected members of the society: the migrant farm workers.

How reliable the figures for the developing nations are, however, is another matter. In most instances statistical reporting is as underdeveloped as the rest of the economy. Deaths, particularly of one-day-old infants, often go unreported. In all probability the rates are higher than the ones I have cited.

More precise nutritional assessments are attempted in two ways. One is to construct a "food balance sheet," which puts agricultural output, stocks and purchases on the supply side and balances them against the food used for seed for the next year's crop, animal feed and wastage and hence derives an estimate of the food that is left for human consumption. That amount can then be matched against the United Nations Food and Agriculture Organization's tables of nutritional requirements to obtain an estimate of the adequacy of the national diet.

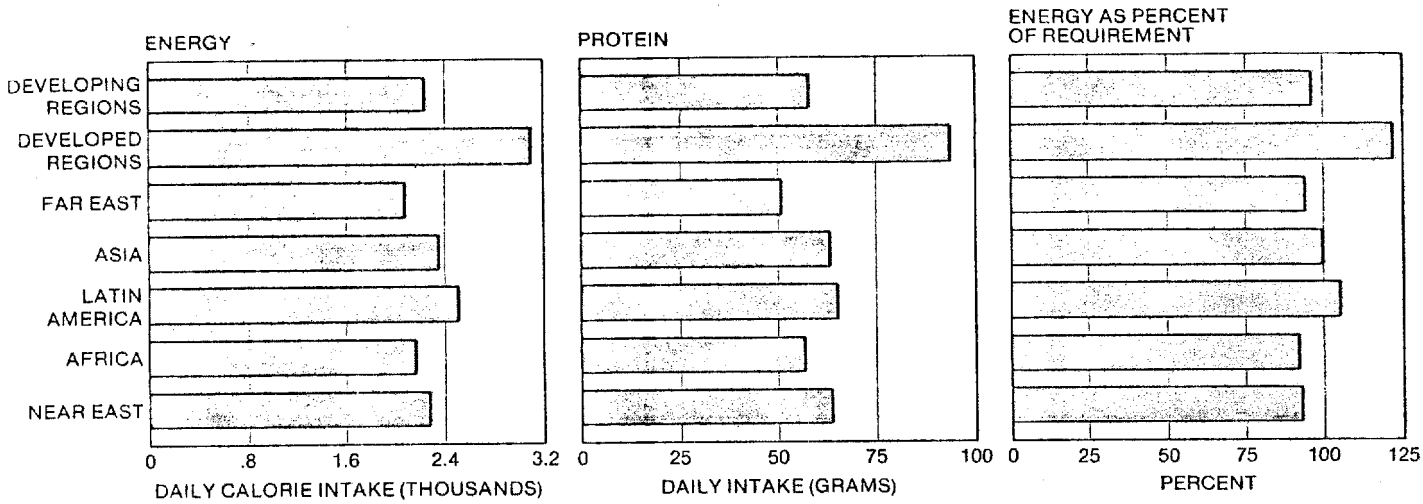
This method has a number of drawbacks. For several reasons it tends to result in underestimates. One is that it is difficult to estimate the agricultural production in developing countries with any degree of accuracy. Farmers have every incentive to underestimate their crop: they may be able to reduce taxes and the obligatory payment of crops (often as much as 60 percent of the harvest) in rent to the landlord. Second, the foods included in the balance sheet tend to be the items that figure prominently in channels of trade: grain, soybeans and large livestock. Other farm products—eggs, small animals, fruits and vegetables—vital to a good diet but grown for family consumption or sold locally are almost impossible to count and so are ignored.

On the other hand, the balance-sheet method has certain tendencies toward overestimates. For example, it is extremely difficult to estimate the postharvest loss of crops to insects, rodents and microorganisms. The loss is known to be close to 10 percent for the U.S. wheat crop and is probably higher for other crops, even with the advanced technology available. In some tropical countries the loss can run as high as 40 percent. For all these reasons figures on food production do not provide a particularly accurate index of the amount of food actually available for consumption or the types of food actually consumed, and they make no attempt to differentiate patterns of consumption within a population. They do, however, provide rough estimates of the state of nutrition by regions [*see illustration on preceding two pages*].

The second way of estimating the degree of malnutrition within an area is to extrapolate from data compiled from hospital records and cross-sectional surveys. Statistics on illness, however, tend to be as unreliable as mortality statistics. The criteria for admission to a hospital on the basis of malnutrition vary from country to country; the records from rural areas may be sparse; the poor, among whom malnutrition and its related conditions are most likely to be found, are the least likely segment of the population to seek medical help, and if they do seek such help, the condition may then be so far advanced that the diseases associated with malnutrition, such as infantile diarrhea and pneumonia, may claim all the physician's attention, so that he misses or ignores the underlying cause.

Projections based on the results of 77 studies of nutritional status made among more than 200,000 preschool children in 45 countries of Asia, Africa and Latin America place the total number of children suffering from some degree of protein-calorie malnutrition at 98.4 million. Percentages ranged from 5 to 37 in Latin America, from 7 to 73 in Africa and from 15 to 80 in Asia (excluding China). These surveys, however, did not employ standardized procedures. In some of them clinical assessments were made and in others the children were measured against international weight tables. Thus, although the general indications of such studies are useful, figures derived from them are rough at best. In order to assign reliable figures to the degree of hunger and malnutrition in the world today we would need large-scale surveys that included both clinical examinations based on an established definition of malnutrition and individual consumption surveys that determine the amount and types of food eaten and the distribution of food within each family unit.

Even if the figures derived by these methods are doubtful, the situation they reflect is clear. In my judgment it would seem reasonable to set the number of people suffering from malnutrition at 500 million and to add to that another billion who would benefit from a more varied diet. The largest concentration of such people is in Asia, Southeast Asia and sub-Saharan Africa. Clinical surveys and hospital records indicate that malnutrition wherever it exists is severest among infants, preschool children and pregnant and lactating women; that it is most prevalent in depressed rural areas and the slums of great cities;



AVAILABILITY OF CALORIES AND PROTEIN is portrayed for the developed and developing regions and for several specific developing regions. The figures reflect the average daily diet per person in the various regions and are based on data assembled by the International Task Force on Child Nutrition for the UN Children's Fund. The figures for Asia refer to the centrally planned economies.

that the problem is lack of calories as much as lack of protein; that (except in areas where the people subsist largely on manioc or bananas) where calories are adequate protein tends to be adequate too, and that although a lack of food is the ultimate factor in malnutrition, that lack results from a number of causes, operating alone or in combination. A nation may lack both self-sufficiency in food production and the money to buy food or to provide the farm inputs necessary to increase production; the poorer members of the population may lack income to buy the food that is available, and regional factors, such as customs in child-feeding and restrictions on the movement of supplies, may prevent the food from getting to the people who need it most.

On the basis of these findings one can divide the nations of the world into five groups. The first group consists of the industrialized nations, where food is plentiful but pockets of poverty persist. Here governments are able to deal with problems of malnutrition through food assistance to the poor, nutrition and health programs and nutrition-education programs. The chief members of the group are the U.S., Canada, the nations of Western Europe, Japan, Australia, New Zealand, Hong Kong and Singapore.

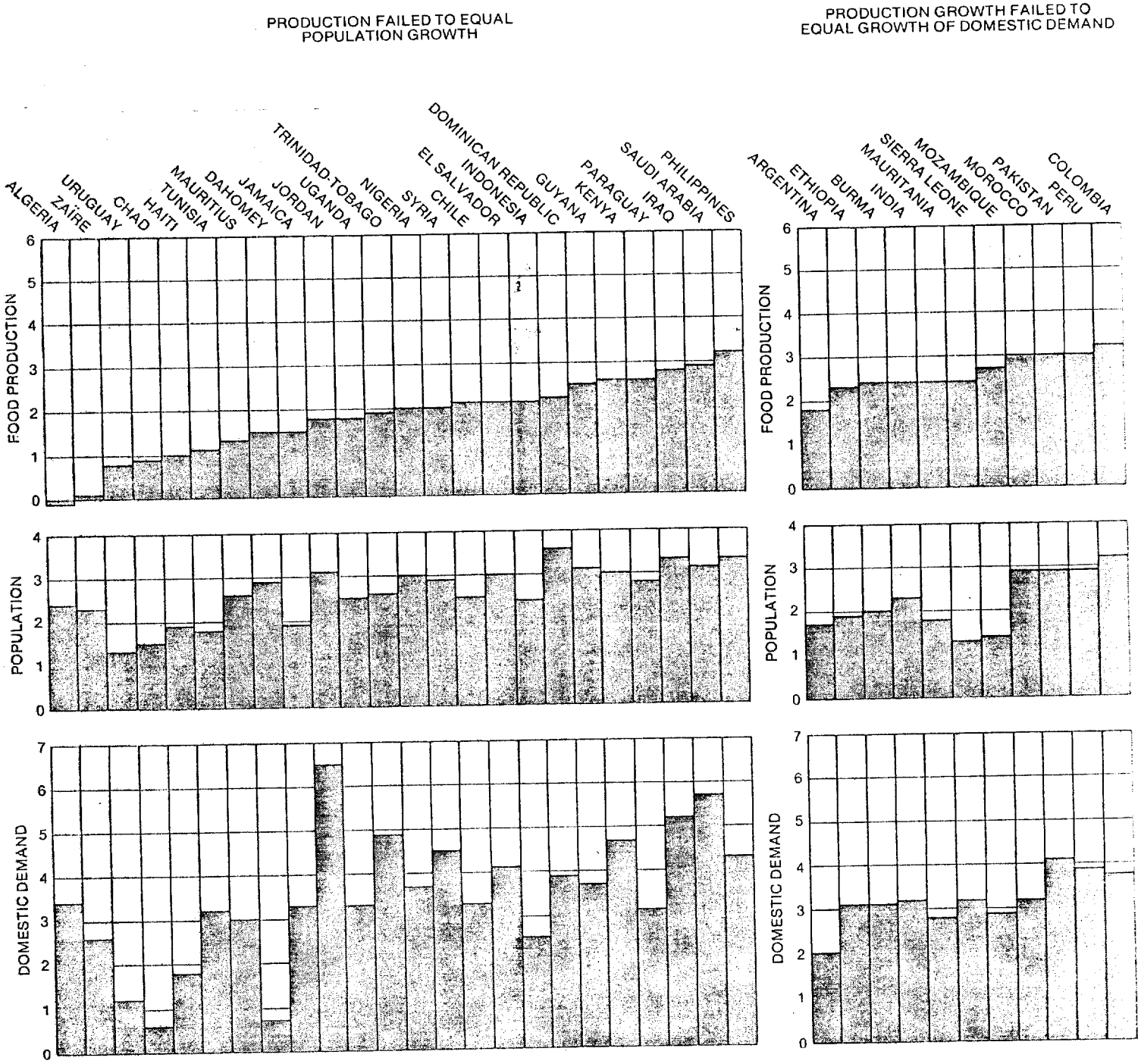
The second group consists of the nations with centrally planned economies, where whatever the economic philosophy the egalitarian pattern of income distribution together with government control of food supplies and distribution have seemed in the past few years to insure the populations against malnutrition due to hunger. In this category are mainland China, Taiwan, North Korea, South Korea, North Vietnam and South Vietnam. In the third group are the nations of the Organization of Petroleum Exporting Countries (OPEC), whose overall wealth is undeniable but whose pattern of income distribution does not ensure that this wealth will benefit the poor. Fourth is a group of countries in Asia, the Near East, Central America and South America that are already self-sufficient or almost self-sufficient in food production at their present level of demand. The demand, however, is impeded by an uneven distribution of income that is reflected in malnutrition in large segments of the population. Brazil, for example, has the highest economic growth rate in the world, but malnutrition is rampant in the northeast and widespread in the shantytowns surrounding the large cities.

The fifth group includes the nations the UN designates as "least developed." They have too few economic resources to provide for the people in the lowest income groups. Many of the countries are exposed to recurring droughts, floods or cyclones; some are ravaged by war. All 25 of the least developed nations are poor in natural resources and investment capital.

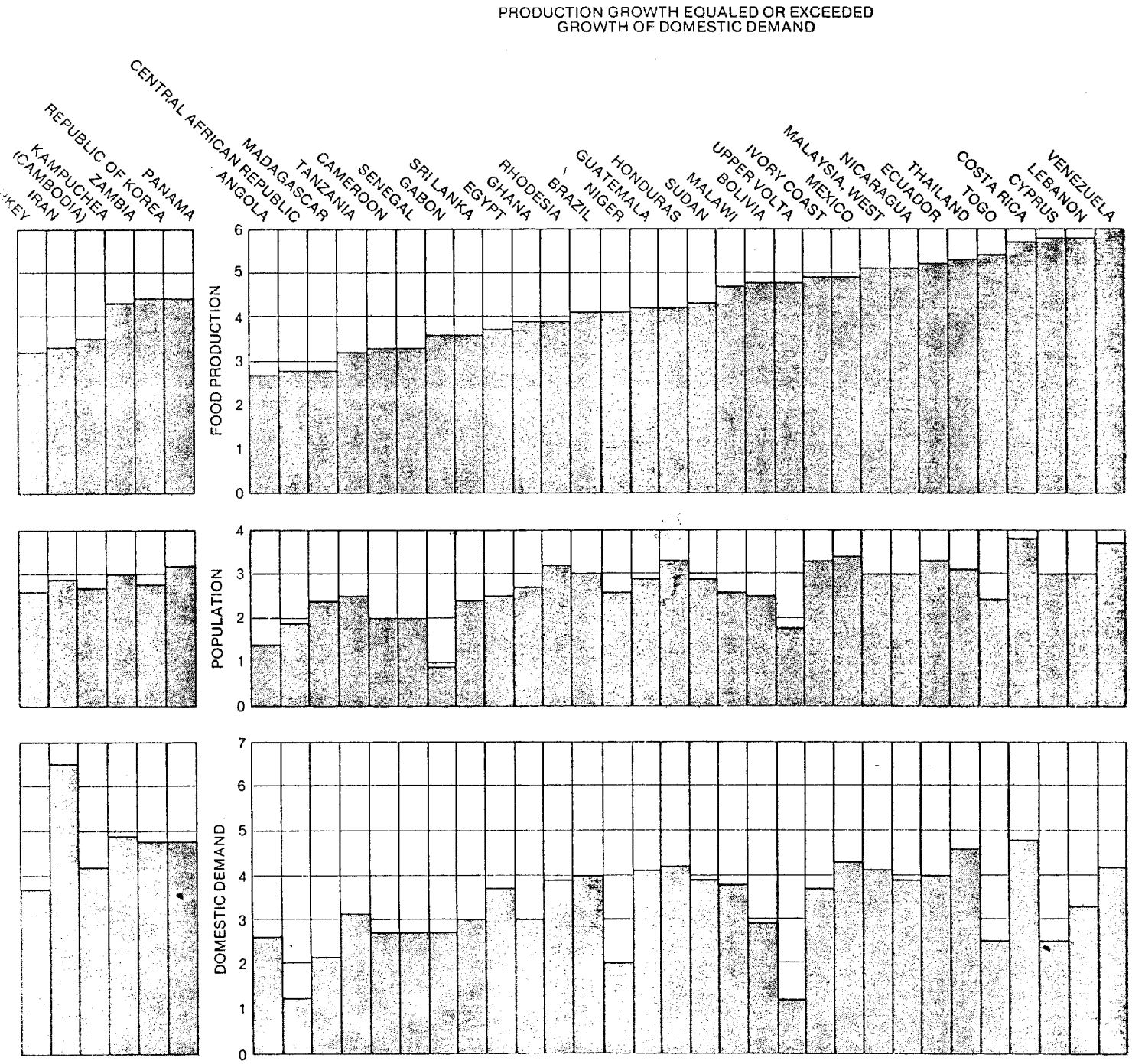
Looking back today, it seems incredible that in 1972 it appeared the world might soon, for the first time, be assured of an abundant food supply. The new wheat varieties of the "green revolution" had taken hold in Mexico and northwestern India, and the new varieties of rice developed in the Philippines promised a high-yield staple crop for the peoples of Southeast Asia. The harvest from the seas was still rising spectacularly (from 21 million metric tons in 1950 to 70 million in 1970—a steady increase of about 5 percent per year, outstripping the world's annual population increase of 2 percent). The worldwide production of grain was rising by an average of 2.8 percent per year, and there were substantial reserves in the form of carry-over stocks held by the principal exporting countries and of cropland held idle in the U.S. under the soil-bank program. The prospect was so rosy that the FAO suggested in 1969 that the food problems of the future might be those of surplus rather than shortage.

Although two sudden and short-term simultaneous crop failures in a number of areas and the sharp rise in oil prices were the immediate cause of the food crisis of 1972–1974, it has since become clear that four long-term factors that had been building up quietly for a long time were in any case about to alter the hopeful situation permanently. (The first short-term reversal, a reduction of crops in several parts of the world because of unfavorable weather in 1972, gave rise to a second: the massive purchases of grain by the U.S.S.R. that eliminated American reserves and caused the international prices of wheat, corn and rice to rise sharply. Moreover, the increase in oil prices effectively put the green revolution out of the reach of such countries as India, Pakistan and Bangladesh, which are poor in petroleum and other resources and have gone about as far as they can in increasing yields with traditional methods of farming. The increase in oil prices also dislocated the economies of the wealthy nations, reducing their contributions to international aid.)

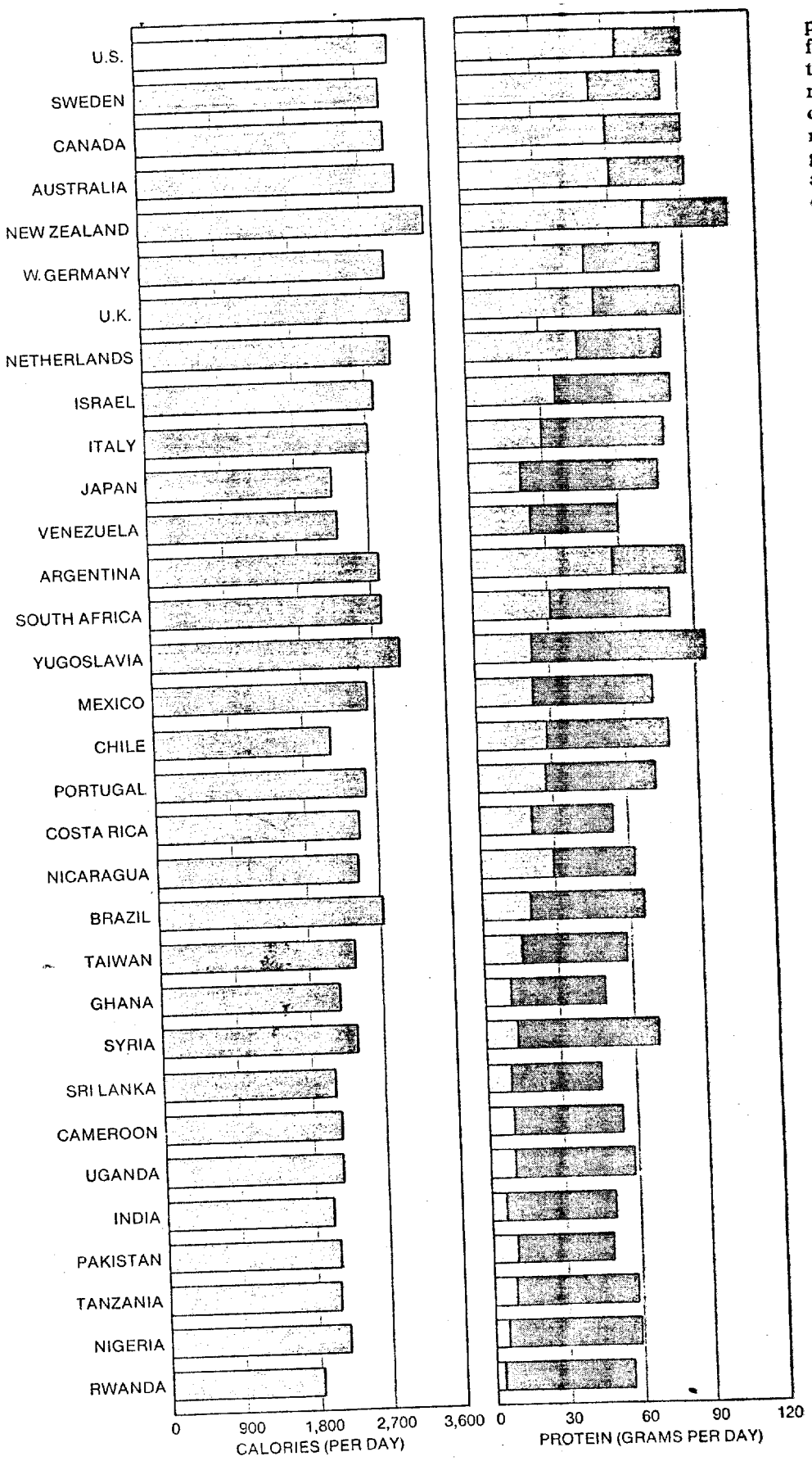
Even though the situation is less serious now than it was in 1974, it is more



TRENDS IN FOOD PRODUCTION are traced for 71 developing countries on the basis of how each country's average annual change in food production (an increase for every country except Algeria) compares with the country's change in population and in domestic demand for food, a category that reflects not only increases in population but also the economic status of the people and their changes in preferences for food, as in a tendency to eat more meat. Each bar reflects an average annual percentage change for the period from 1953



through 1971. In the group of 24 nations beginning with Algeria and ending with the Philippines the rise in food production failed to keep pace with the growth of population. In the next 17 nations (Argentina through Panama) the growth of food production exceeded the population growth but fell short of the change in domestic demand. In the final group of 30 nations (from Angola through Venezuela) the rise in food production exceeded population growth and rise in domestic demand. Data are from UN Economic and Social Council.



NUTRITION AND NATIONAL ECONOMY are compared in a chart that lists countries according to their gross national product as apportioned on a per capita basis. The bars at the left show the average daily calorie intake of the people in each country. In the bars at the right the full length of the bar represents the average daily protein intake of each person in grams per day, and the colored portion of the bar indicates how much of that intake is animal protein.

precarious as a result of the long-term factors. The primary long-term factor is the growth of the human population: 80 million people per year, the equivalent of the population of the U.S. every 30 months. Moreover, the population is growing most rapidly in the areas that are experiencing the greatest nutritional difficulties.

In considering the effects of population growth, however, one must bear in mind the phenomenon known as the demographic transition. It is the process whereby societies move from a stage of high birth and death rates to one of low birth and death rates. Usually the decline in death rates precedes the decline in birth rates by from one generation to three generations. On both sides of the transition the result is a stable level of population. The developed countries have made the transition or are well along in it; the developing countries are now making the transition but have traveled varying distances through it.

Alongside the inequality in population growth as a long-term factor affecting the food supply is an even greater inequality in the patterns of producing and utilizing food. It appears to be historically inevitable that as people or societies become wealthier their consumption of animal products increases. This means that more of their basic foodstuffs (grains, legumes and even fish) that could feed human beings directly are instead fed to domesticated animals such as cattle and chickens. The efficiency of the conversion of plant food into animal food varies with the animal product but is in no case higher than the level of about 25 percent attained in milk and eggs.

The net effect of this trend is that rich countries consume far more food per capita than poor ones. For example, it has been estimated that in China each person is adequately fed on 450 pounds of grain per year; 350 pounds are consumed directly as cereal or cereal products and 100 pounds are fed to domesticated animals. In the U.S. the average individual consumes more than 2,000 pounds of grains per year; 150 pounds are eaten directly (as bread, pasta, breakfast cereal and the like) and the rest, more than 90 percent of the total, is fed to animals.

The third source of pressure on the world's food supply has been the diminishing effectiveness of the fishing industry, an important source of protein for many poor nations. In 1970 and 1971 the total catch remained steady at about 70 million tons. It dropped abruptly in 1972 to less than 55 million tons. The reasons for the decline are overfishing and pollution.

Finally, it has become apparent that the "miracle" of the green revolution requires more time, more work and more capital than was thought in the first flush of enthusiasm. I shall not elaborate on this point, since the green revolution is discussed in other articles in this issue. In sum, the situation as it exists today is precarious but manageable, barring some catastrophe such as a massive crop failure in the U.S., which is currently the granary of the world.

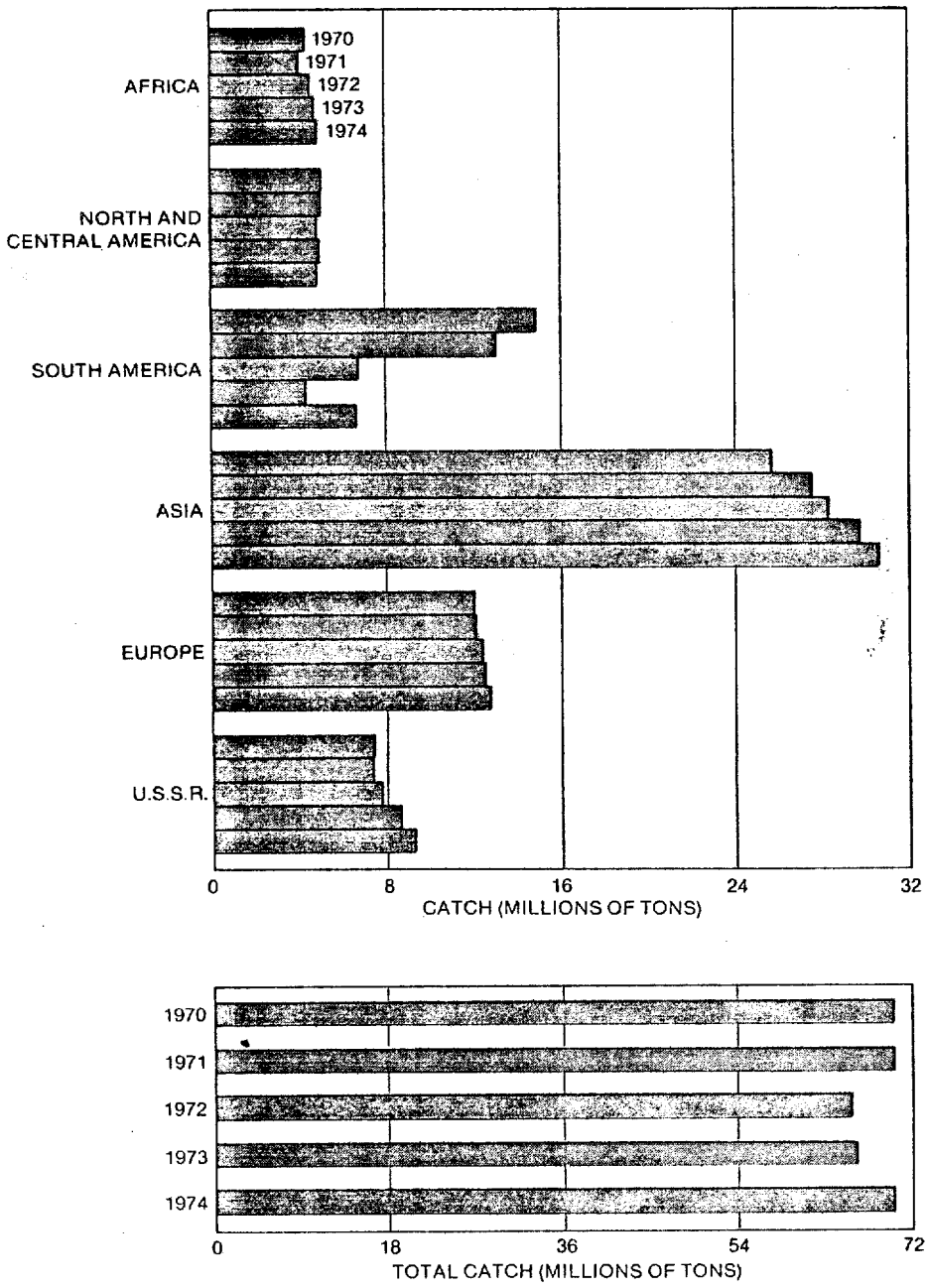
What of the future? Let us first consider three advances that could be made in dealing with famine. Their common aim is to sight and attack incipient famines in an early stage of development.

The first requirement is an early-warning system. It would employ weather satellites, economic indexes (such as the movement and amounts of food in a region) and clinical indicators. One of the most sensitive clinical indicators is provided by the charted weight and growth curves for children in the most vulnerable socioeconomic sectors of a society.

The second requirement is a permanent small international organization that would keep track of such information for every region and monitor it for any sign of an impending emergency. The agency would maintain manuals on how to proceed against disaster and famine, would hold periodic training sessions for key people from each nation, would draft contingency plans (listing likely requirements and sources of food, medicine, transportation and personnel) and would explore such matters as stockpiling essential supplies and setting up alternative systems of distribution. In an emergency the organization would stand ready to assist a national relief director.

The third requirement is an adequate grain reserve, distributed strategically around the world. It would serve as a standby supply for nearby countries while grain shipments intended for them were diverted to the stricken area. This arrangement might not avert a famine, but it would prevent one from becoming a major disaster.

Several things can also be done to deal with malnutrition. For the next few years it will be necessary to continue to provide food relief where it is needed. The least developed countries may require special assistance in the form of food distribution and feeding programs for some years to come. Those nations should also be helped to develop methods to increase their ability to store food and to distribute it to vulnerable areas in times of emergency.



WORLD FISH CATCH appears to have stabilized at about the level of 1970 after declines in 1972 and 1973 that resulted mainly from drops in the South American catch. In most other regions catch has increased slightly. Data are from UN Food and Agriculture Organization.

Simple and inexpensive programs are available to eradicate certain diseases of malnutrition, and they should be instituted. The blindness resulting from a deficiency of vitamin A can be prevented with two injections per year of 100,000 units of the vitamin, at a cost of a few cents per person. Goiter can be prevented by the iodization of salt, also at infinitesimal cost.

In the intermediate term (the next 15 years or so) the goal must be to make the developing nations independent in their food supply. The fish catch appears to have stabilized at the 1970 level. The production of animal foods that compete with human beings for grain should be reduced. (Grazing animals, which utilize land that cannot be cultivated and crops that cannot be eaten by human beings, are another matter.) The development of new foods is still in the future. The only sure resource is the green revolution, which still has the potential of doubling or tripling yields in some areas.

Therefore it is important to begin immediately the construction of fertilizer plants, preferably right at the source of supply (the flare gas around the Persian

Gulf and in Nigeria, for example) or in the needy countries. The task should be furthered by international assistance and by oil sold by the OPEC nations at concessional prices.

Another step, which entails something that Americans do well, is to help the food-deficit nations set up agricultural research and extension services, with the aim of adapting the green revolution to a tropical, labor-intensive agriculture and of assisting the small farmer to obtain an increased yield while maintaining a varied production of small animals, fruits and vegetables so that he is not dependent on large tonnages of one crop for an adequate income. Such countries can also be helped to develop ways of protecting a crop once it is harvested and of establishing an indigenous food industry that can package and distribute the food. A system of international credit that favors the small farmer and the small businessman and promotes a more equitable distribution of income and opportunity should be established. Finally, an international system of weather forecasting should be activated so that future crop failures will not come as a surprise.

These actions will buy time for the next 25 years. If the population of the world is then between six and seven billion, as seems likely, new sources of food will have to be at hand—on the dinner table, not in the development stage. Unfortunately the nations that will need the new foods the most desperately have neither the financial resources nor the technological skill to do the necessary research, and the nations that do have these things have so far felt no urgency about doing it. The objectives of the research should include the intensive development of aquaculture, the establishment through genetic techniques of new species of animals (such as the beefalo) and of grazing animals that can utilize forage more efficiently, the domestication of some wild animals, the development of one-cell microorganisms as food and the direct synthesis of food from oil. Work on all these objectives should now be under way.

To sum up, we know who is hungry, if not precisely how many people are affected. We also know why. Economists often say that expanded food production will solve the problem. Social reformers maintain that the need is for more equitable distribution. The evidence shows that we must and can have both.

The Development of Agriculture in Developing Countries

The poor countries can feed themselves if their agriculture is modernized and their rural economies are restructured. That requires infusions of technology and capital from rich nations

by W. David Hopper

If the people of the poor countries are to be fed, the food will have to come from their soil, their resources and their farm economies. The surplus production of a few exporting countries can serve on occasion to buffer the impact of bad weather or other calamities, natural or man-made, but there should be no illusion that the world's food security can be ensured by abundant harvests from the fields of Kansas and Saskatchewan, Argentina and New South Wales. Very few of the developing nations give evidence of having understood that food independence is an internal affair, and that if agricultural development is given priority, it can lay the foundation for modernizing an entire economy. The rich industrial nations have also not fully recognized that such development, on which depend both the world's future food supply and an easing of the tension between the rich and the poor, calls for a massive transfer of technology and capital from rich to poor countries.

Alternatives have been suggested, to be sure. One, known euphemistically as the lifeboat analogy, holds that the earth can support only a limited number of people and that those of us who are safely aboard must not jeopardize our ability to survive by extending a helping hand to the billions of others who would swamp the vessel. A modified version of this ethic is called triage, after the battlefield aid-station practice of categorizing the wounded in three groups: those likely to survive without immediate attention, those likely to die in any case and those who can be saved if they get immediate attention. Under this rule some countries would receive help but the Bangladeshes of the world would be abandoned. Both of these approaches seem to me almost as impractical (dying countries are not as easy to dispose of as drowning people or stretcher cases) as they are indecent.

A third suggestion, infinitely more humane, is based on the fact that rich populations consume about five times as much grain as poor ones because they process most of it into meat—an inefficient conversion. If North Americans were to reduce their bloated diets by about a third, the argument goes, they would make 78 million metric tons of cereal grains available to those who need it. The trouble with this is that the 78-million-ton dividend would be reduced as the American population grows and would soon fall behind the growing populations and rising standards of food consumption in the developing countries; this form of distributive economics cannot for long do anything but distribute poverty. Moreover, merely saving food does not give anyone the money to acquire that food. Finally, the domestic political and economic obstacles to reducing American meat output make such a program not only ineffective but also unlikely. There is room for distributive justice in the world, but it should take the form of economic assistance, commodity-pricing agreements and trade reforms that give the poor nations a better chance at development.

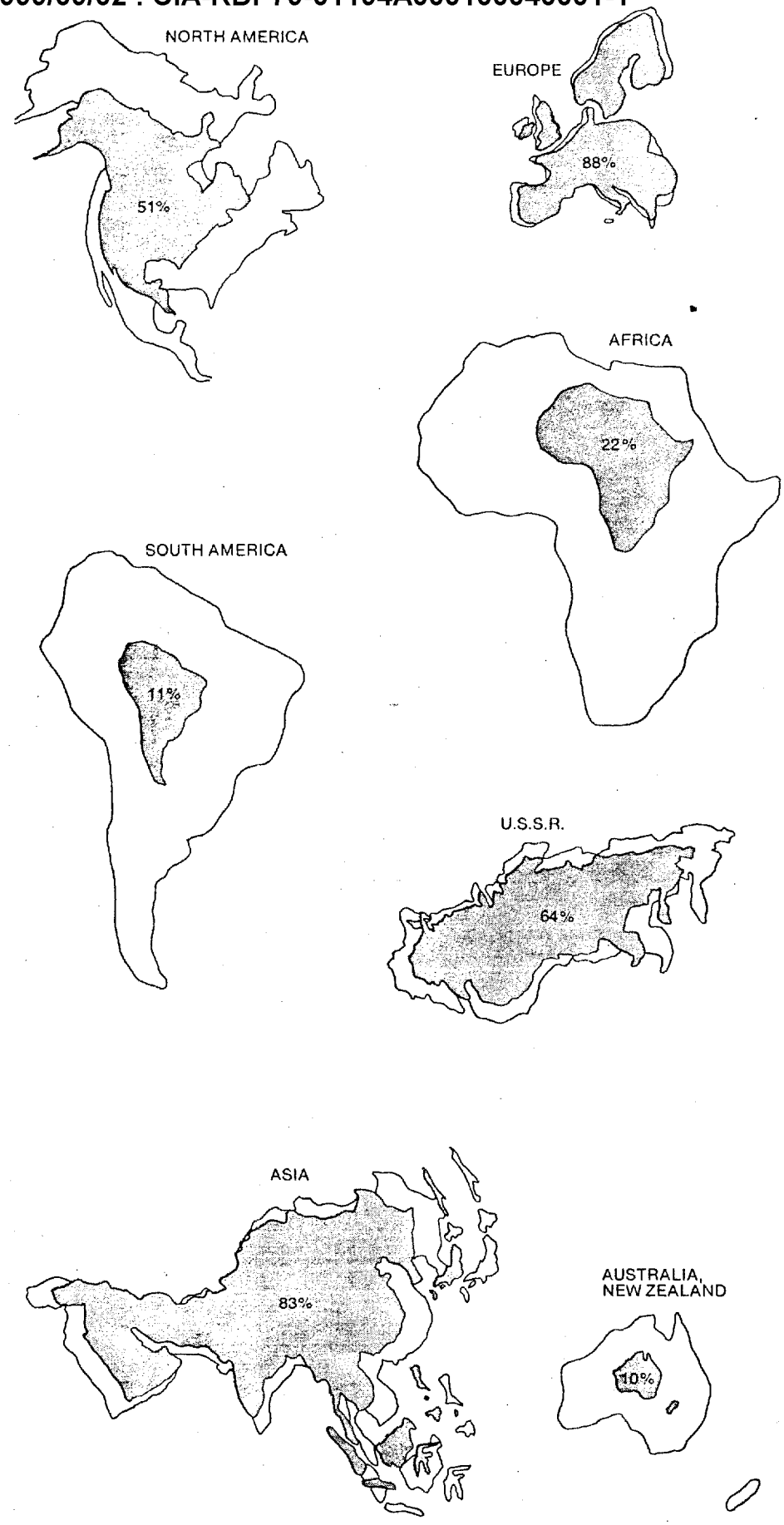
As I said at the outset, that development should be in the first instance agricultural, something that is hard to impress on most developing-country governments. They tend to prefer such attributes of modernity as national airlines and smoking industrial plants to simple farm-to-market roads, bags of high-yielding wheat seed, rural credit cooperatives and other levers of agricultural transformation. And yet most of the developing countries are better endowed for agricultural progress than for any other kind of economic advance. The developing world lies largely on and between the tropics of Cancer and Capricorn. It is a belt of warm temperatures, of generally abundant (if often seasonal) rainfall and of ample, year-round solar energy to be converted into chemical energy for storage in plant and animal tissue.

The tropical and subtropical resources of the developing countries are now mainly exploited by farming techniques that have remained almost unchanged for centuries. Yields per hectare and per farm worker are very low (which largely accounts not only for the world food shortage but also for the poverty of most of the world's farmers). It is now clear, however, that where modern plant varieties and farming techniques are introduced, farmers succeed in wresting from their land single-crop yields two or three times as large as

the traditional return; multiple cropping of two or three crops on the same piece of land—something that is peculiarly feasible in the Tropics and sub-Tropics—gives yields from four to eight times larger than traditional ones. Specialists in agricultural development now believe new farming systems can be specifically designed for various tropical and subtropical conditions that hold immense promise of greatly enhanced output, better year-round utilization of farm labor and a significant opportunity to improve the nutritional and economic well-being of the small cultivator. That is the first step toward not only a new agriculture in the developing countries but also economic health.

The significance of the "green revolution" derives not so much from its numerical impact on food output as from its demonstration of what is involved in the modernizing of traditional agricultures. The widespread, rapid adoption of high-yielding varieties of wheat and rice gave proof that peasant farmers were not slow or stubbornly resistant to change. Aggressive adoption of new farming techniques had a long history where cash crops were concerned, but the myth persisted that because most of the food grown in developing countries is destined for the cultivator's own consumption, traditional production technologies would be slow to change. This was not the case. Within four years of the first widespread release of the seed of new high-yielding wheat varieties in South Asia those varieties occupied practically all the land suited to their cultivation. In response to yield differences of 200 to 300 percent over traditional plant varieties, and with the important incentive of grain prices that made high-yield farming extremely profitable, the Asian peasant proved to be as innovative as any in the world; the stereotype of the traditional farmer, slow to change and stubbornly resistant to progress, died a much-deserved death.

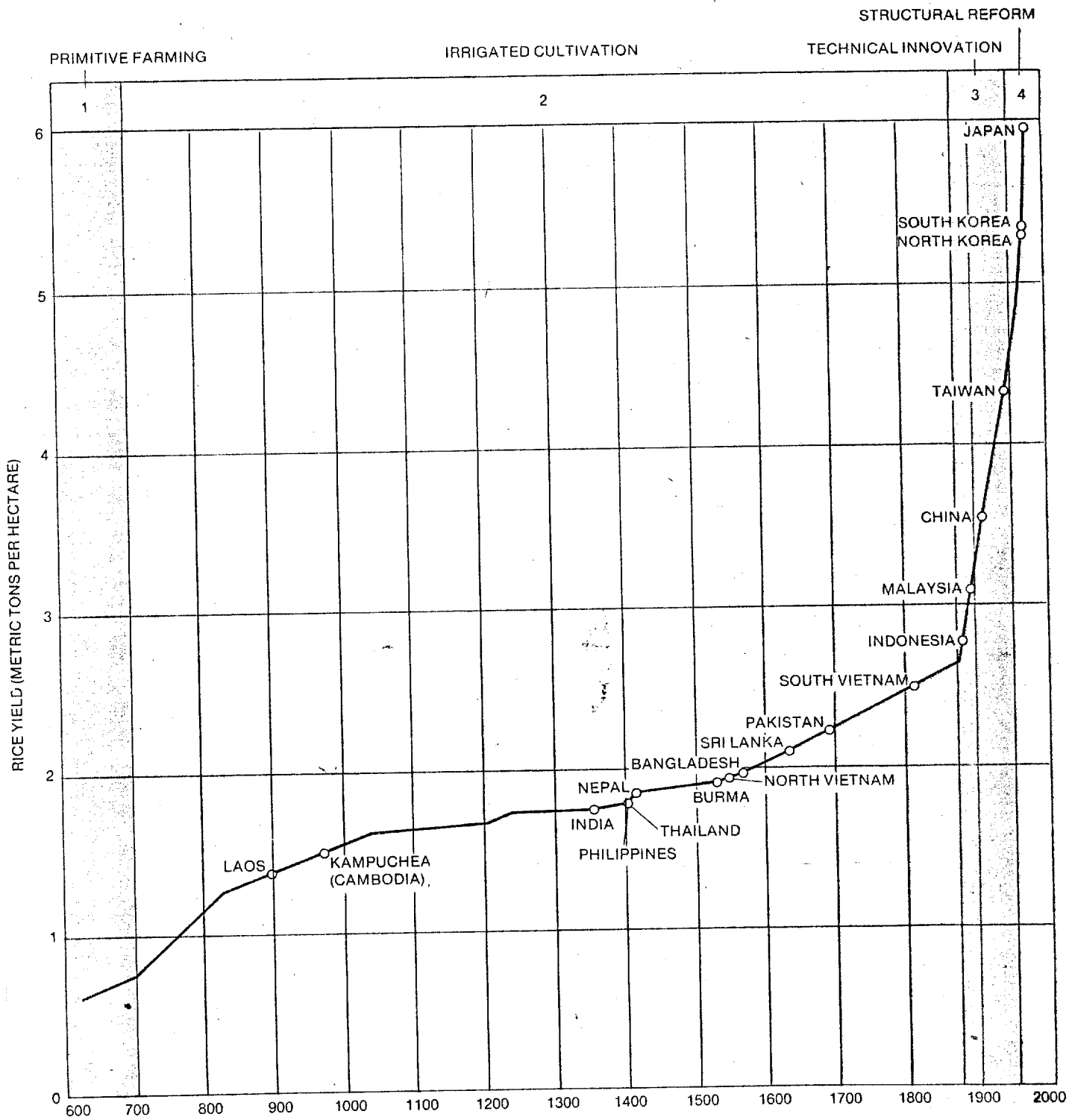
The experience with high-yielding wheat and rice was important on several counts. It was the first time large numbers of farmers had made significant innovations quickly in their food-production methods. It was the first time many developing countries had achieved substantially higher yields of food crops from previously cultivated land through the application of nontraditional technologies derived from scientific research; until then increases in food output had come either from extending cultivation to uncultivated land or from improving land with irrigation facilities. And finally, it provided the first clear evidence that, if new farming technologies do add greatly to yield, if the added yield can return a profit beyond the enhanced cost of the new methods and if farmers have access to the production



EXPANSION OF FARMING to arable but as yet uncultivated land would be one way to increase the world's food production. The outline maps show the world's major landmasses, sized in proportion to the area of their potentially arable land. The silhouette map (*color*) with-in each outline shows how much of that potential arable land was being cultivated as of the mid-1960's. The numbers give the cultivated area as a percent of the potentially arable area.

factors (such as seed, fertilizers and insecticides) and the capital resources (such as irrigation facilities and farm machinery) they need in order to apply these methods effectively, then aggressive innovation will follow.

Subsequent research has identified access to production factors and the expectation of economic returns from innovation as crucial requirements. The high-yielding varieties differed from traditional genetic types in their response to plant nutrients, particularly to nitrogen, which is usually the major limiting factor in the warm soils of the Tropics [see "The Amplification of Agricultural Production," by Peter R. Jennings, page 180]. The farmers' access to supplies of fertilizer was therefore critical in fostering innovation. A large quantity of crop water was also indispensable. High-yielding crops make maximum use of solar energy only when their leaf canopy is dense. A dense plant population absorbs (for photosynthesis, respiration and transpiration) much more water than the thin crop cover of traditional,



INTENSIFICATION OF FARMING on land now being farmed is the other way to grow more food. This means moving farming in developing regions to higher stages of development, in effect recapitulating the historic progression exemplified here by the case of Japan. Kunio Takase of the Asian Development Bank found that typical rice yields in Japan increased (*black curve*) as Japanese agriculture moved from the traditional stage through the advent of irrigation to scientific agriculture and finally to structural transformation. Current yields in most Asian countries, where less than 50 percent of the rice land is cultivated [illegible] second stage, as plotted.

low-nutrient farming. The farmers who could benefit from adopting the technologies of the green revolution were those within easy reach of depots handling fertilizer supplies and whose fields were either supplied by irrigation systems with abundant water or were located in areas of assured rainfall.

On the economic side modern techniques of food production require purchased inputs, something that was not usual in traditional farming. Although most traditional farmers have had some contact with a cash economy, for many of them the risks of farming, and in particular the vulnerability of the farm family to cash indebtedness arising from a crop failure, put a brake on innovative behavior. This is particularly true for farmers with small landholdings and little accumulated wealth. Unassisted, they are the last to change their practices; they wait until more affluent neighbors have experimented with the new methods, and in many circumstances they avoid risk by not adopting the new ways at all. For them and even for many of their wealthier neighbors the adoption of new agricultural technologies depends not only on the effect on production, possible profit and access to supplies but also on the availability of credit, of risk insurance and of farm-extension advice, which reduces the likelihood that one will unwittingly neglect some important component of what is often a complex package of interlocked farming practices. The need for cash inputs for food farming implies the need for access to product markets, since there must be some way of obtaining money from the sale of crop surpluses to pay for the production factors. Thriving markets depend on transportation networks, storage facilities, processing plants, a system for the dissemination of market information, the availability of credit for traders and so on.

Those are some elements of the infrastructure required for a market-oriented agriculture; some others are complexes of technological research services, economic institutions to support farmer credit and to facilitate trade, extension advisory services for farmers and the industrial base to produce farm inputs. Such institutions and facilities are weak or lacking in developing countries, which is why the way to world food security is also the way to their economic development.

The new dwarf wheat and rice varieties, together with fertilizer and assured water, more than doubled India's wheat output between 1968 and 1972, gave Pakistan an exportable rice surplus and brought the Philippines within striking distance of self-sufficiency in food. The opportunity for profit that those varieties offered farmers stimulated an unprecedented dynamic of development in the regions suited to their cultivation. Private-farmer investment in irrigation, in land improvement, in modern tillage equipment and in improved storage facilities was a major result of the transition from a traditional basis of food production to a scientific basis.

The green revolution experience contains two broad lessons. The first is the importance of the impact on land areas already under the plow of modern agricultural technologies that are economically rewarding for the cultivator to apply and whose application is capable of being supported by an off-farm infrastructure of the appropriate services. The second is the lack of much interaction between the social and cultural institutions of a society (such as the pattern of land tenure) and technological and economic change. Land-tenure reform has long been held to be a necessary first condition to generating growth in farm output, for example. It is undisputed that very large landholders may, and often do, keep land unfarmed or otherwise fail to maximize its agricultural productivity. In such cases land redistribution or some form of economic incentive or punishment is appropriate in order to make the land productive. In regions that are already cropped or grazed to the limit of traditional technologies, however, farms can benefit from modern methods whether they are large or small. And there is evidence that if they are properly assisted with nonfarm services, all those who work the land will increase their output, regardless of their position on the land-tenure ladder. Judging by the record of the diffusion of the dwarf varieties of crops, it is true that small farmers, having fewer resources, are slower to adopt new methods. Once the new practices have proved to be profitable, however, and assuming that the availability of credit is not a barrier, small farmers can and do become as innovative as larger landholders. This is not to deny that rural institutional reform is vitally necessary in many, if not most, developing countries. Its justification, however, rests primarily on the need for the better distribution of social, economic and political justice; it is only marginally relevant to the expansion of farm output.

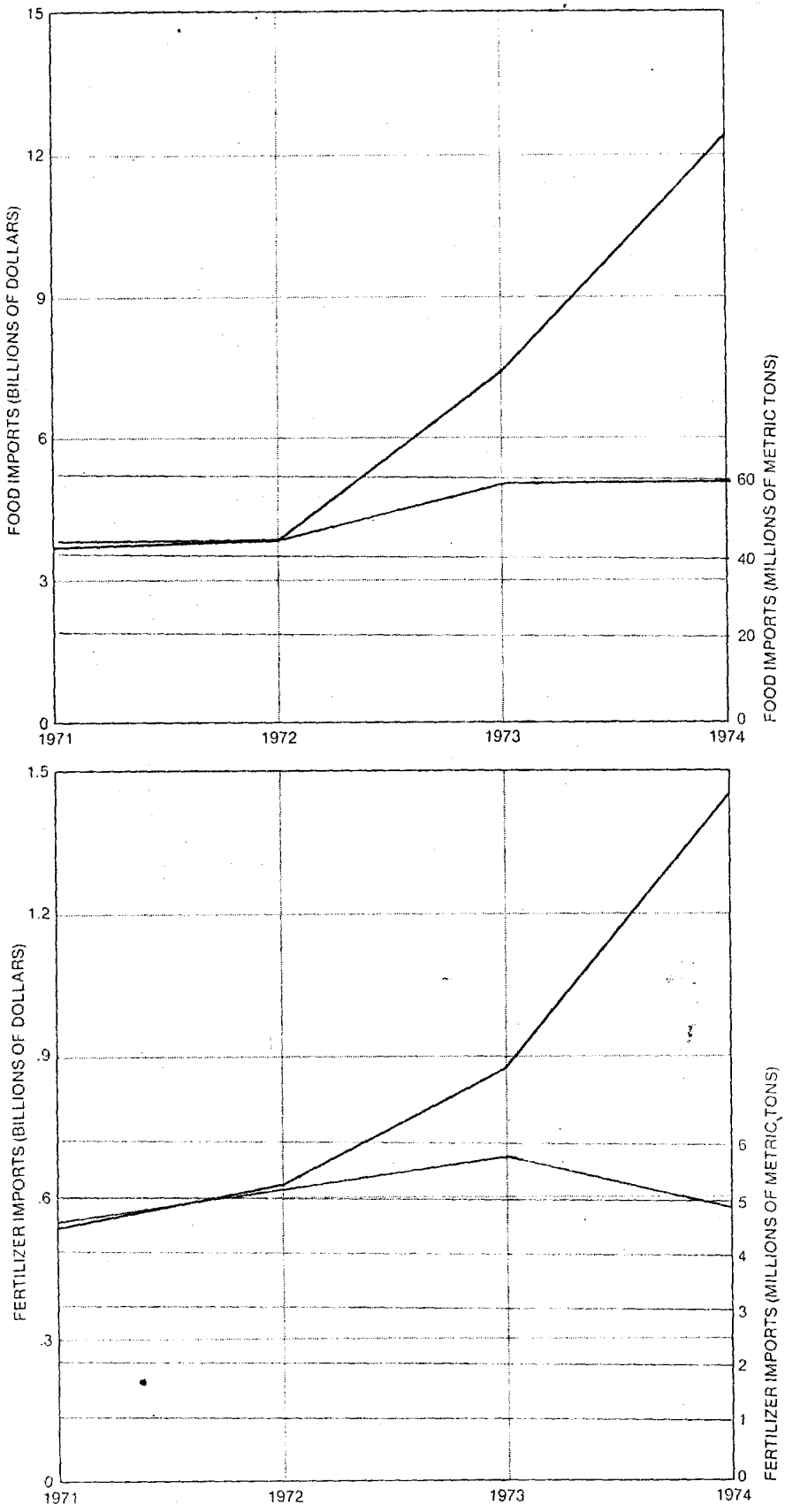
In a recent study the International Food Policy Research Institute estimated that in order to avoid a deficit position by 1985 the developing countries must increase their cereal-grain output at a rate of approximately 4.25 percent per year from 1976 on. That is two and a half times the 1.69 percent rate they attained between 1967 and 1974 and more than one and a half times the 2.5 percent rate that was the average for the past 15 years. There are basically two ways of achieving this growth in output: by the expansion of farming to land not now being cultivated and by the intensification of production on land already being cultivated.

Large areas of the Tropics are not farmed or grazed, and they constitute a huge reservoir of future production [see "The Resources Available for Agriculture," by Roger Revelle, page 164]. The southern half of the Sudan is potentially one of the richest farming regions in the world, with the soil, sunlight and water resources to produce enormous quantities of food—as much, perhaps, as the entire world now produces! The water is useless today: the headwaters of the White Nile, blocked in their northward flow by high plateaus, spill out over the land to form great swamps. To unlock the promise of the southern Sudan those swamps would have to be drained, a rural infrastructure put in place and the nomadic cattle raisers of the region somehow changed into sedentary farmers. The capital costs of such an undertaking would be as large as the promise, and the time required would cover generations. Yet the potential is real and untapped, and as world food shortages persist such a reserve cannot long be neglected.

The extensive llanos of Latin America—the flat, grassy plains north and south of the Amazon basin—are unexploited tracts that, with a sufficient investment in rural infrastructure, could be made highly productive for ranching. Other areas with an immense potential for adding to human food supplies are the savannas of Africa, the tens of millions of hectares of semihumid land south of the Sahara now closed to human habitation by onchocerciasis, the river-blindness disease, large regions of tropical forest and even some of the desert regions of the Arabian Peninsula, North Africa and western Asia.

Before these reservoirs of future food production can be tapped, research on the farming and development technologies suited to their individual ecologies will have to be undertaken and the political will and political action of nations and the world community at large will have to be mobilized to ensure a sustained flow of development resources. The Sudan, for example, is desperately poor, with a gross national product about equal to the 1974 net income of the International Business Machines Corporation. From this economic base the Sudanese alone cannot possibly subjugate their swamps, harness their rainfall and establish a farm economy on their tremendous land resource.

The second and much greater potential for expanding food production lies in the intensification of farming in areas that are already being cultivated or grazed. The productive capacity of [illegible] cannot be doubted: they are already supporting almost two-thirds



INFLATION has made it harder for developing countries to import the food they need or the inputs required to grow it. The charts show the amount of money (*black curves*) spent in four recent years by developing countries to import food (*top*) and fertilizer (*bottom*), along with the quantities of food or fertilizer (*color*) the money bought. Top chart includes China and oil-exporting developing countries; bottom one does not. Data were compiled by Overseas Development Council from publications of United Nations Food and Agriculture Organization.

of mankind on a traditional, low-yield technological foundation. If these resources were exploited by modern means, no child would need to know hunger and no people would need to fear famine. For example, if its glacial waters and rainfall were harnessed and its farmers better supported by modern off-farm services, the 40 million hectares of the Indus-Ganges-Brahmaputra plain of Pakistan, Bangladesh and India could be made to yield upward of 20 metric tons of cereal grain per hectare per year, or about 80 percent of the world's present cereal output. The capital cost would be high, perhaps as much as $50 billion over the next 25 or 30 years, but that is about 17 percent of the estimated global expenditure on armaments and military establishments in the single year 1976. These river basins, if developed, alone would meet world food needs for the next 14 years, even allowing for a growth in demand of 4.25 percent per year.

Similar comments can be made about almost every other farming area of the tropical and subtropical developing world. In the South Asian case I have just cited, however, there is the advantage of a fairly highly developed rural economy; the need now is for a large investment in structural transformation so that the entire rural sector can be geared to the demands of a high-productivity agriculture. This structural transformation is the last stage in what has been seen as a four-stage progression in agricultural development. The long first stage is that of traditional farming, with reliance on traditional implements and practices and on rainfall for water. In the second stage the productivity of the land is improved by irrigation and drainage, by the enhancement of soil nutrients through better incorporation of organic materials and by the better timing of crop production through improved implements for cultivation. The third stage is marked by the introduction of scientifically developed techniques. Cultivation of dwarf varieties on irrigated land with purchased fertilizer is a typical development of this stage; another is the introduction of vaccines and dips to control livestock diseases. The fourth stage is the structural transformation of a rural economy, which involves establishing the full range of institutions and infrastructures needed to support a high-productivity agriculture.

The history of Japanese agriculture provides the clearest example of the four stages. Traditional Japanese farming relying on rainfall returned rice yields of less than one metric ton per hectare. The extension of irrigation between A.D. 600 and 1850 raised yields to 2.5 tons. The Meiji restoration in the 1870's ushered in a long period of scientific innovation in which high-yielding

varieties, fertilizers and other chemicals, improved implements and better agronomic practices were investigated by scientists, tested by a network of prefecture research stations and then demonstrated to farmers. Between the late 19th century and World War II rice yields rose from 2.5 tons per hectare to four tons. The postwar reorganization of Japan's farmland, the strengthening of farm-supply and marketing industries and trading channels, the establishment of farmer organizations and the opening of more agricultural schools and colleges—in brief, the structural transformation into a complex modern rural economy—pushed rice yields to the present level of almost six tons per hectare, and many observers believe eight tons will be reached in the not too distant future.

In contrast to Japan, most of the other nations of Asia are only now making the transition from the first to the second stage, from traditional farming to an agriculture based on increased land productivity. The extension of irrigation and drainage, essential to high-productivity rice cultivation, is being laboriously pursued in the South Asian and Southeast Asian nations. Except in western Malaysia, where the irrigation potential is well developed, rice yields are still below two tons per hectare. The introduction of scientific production technologies and the new dwarf, high-yielding varieties in these nations has been mainly limited to areas commanded by irrigation; in India and Pakistan about 30 percent of the cropped area is so commanded. Indeed, the present evidence strongly suggests that entry into the stage of successful technological innovation in the developing countries of Asia depends on a prior capital investment in the productivity of the land. That is, the second stage must precede the third.

Most of Africa is still in the first stage of traditional farming. In order to unlock the potential of their soils the African nations, the poorest in the world, must therefore be prepared to make a colossal investment in land productivity, in agricultural scientific research and extension services and in the structural development of their farm economies. Large areas of Africa are and will continue to be mainly devoted to the raising of cattle. The development of watering places, improved ranges, disease-control centers, meat-packing establishments and other facilities could dramatically enlarge Africa's ability to add to world food supplies, particularly to the supply of protein. Africa's potential is suggested by its existing examples of modern farm development. Some of the areas that were settled by European farmers are among the most productive in the world. Their high productivity can be traced to the large investments made in roads, supply depots, markets, farm equipment, research and extension and farmers' organizations, and in the economic institutions and government policies necessary to make all those elements function.

In Latin America, where there is an abundance of unfarmed or traditionally farmed land, the overall problems are not unlike those of Africa. The recent upsurge in Brazilian agriculture, if it is sustained, will soon carry that nation into cereal export markets. If the development plans of Venezuela and Colombia meet with even partial success, those nations should also be net contributors to world food supplies. Chile, Argentina and Peru have large unexploited farm potentials that are currently unfulfilled because of government economic and development policies for rural areas.

If the output from single crops grown on land now being cultivated or grazed through traditional techniques can be multiplied by five or six, as it has been in Japan, or even by two to four, as it has been on the limited-rainfall central plains of North America, present world production would almost double. If the potential for the multiple cropping of the warm Tropics is tapped, global output could climb five or six times above its present level of approximately 1.2 billion metric tons of cereals.

Intensive multiple cropping in the Tropics implies extensive irrigation and mechanical tillage. Supplementary water in the dry seasons is a precondition for wresting from the land two or three crops a year. And the short intervals between crops makes rapid land preparation and careful timing of farm operations a necessity, something that can be accomplished only with modern power sources and implements. The results are dramatic. Single-crop yields can be tripled in the course of a year if planting times are kept short and rapidly maturing varieties are sown. If synergistic crops are interplanted in the rotations so that they overlap from one planting to the next, the output of the land can be raised another 50 to 60 percent. The combined effect—improving single-crop yields in each segment of a multiple-crop rotation—has raised the total output of a hectare of land from a traditional one-crop-per-year level of less than two tons to more than 20 tons. Such results have been attained on carefully controlled experimental plots; ordinary farmers, properly guided, could be expected to increase their present yields between five and seven times.

As one considers the tropical farming world and the technology now available or soon to be available, there can be no grounds for pessimism about the latent potential of the world to feed increasing numbers of people for a long period ahead. Whether that latent potential will be harnessed to the benefit of man is the question. There has been much talk in both the developed and the developing nations about the need to accelerate agricultural development. The need remains, but the required political actions are not being taken.

Part of the blame can be placed on the developing countries themselves. Agricultural development is expensive and other, often more glamorous priorities of modernization shoulder aside its claim for scarce resources. Rural development is also a politically charged endeavor. City dwellers are more clamorous of attention, and their demands are more urgent and visible than those of a traditional peasantry. Keeping food cheap to appease urban consumers often leads to policies that destroy the economic incentive for modernizing farms. And the rich countries are always offering food on easily negotiated concessional terms. The food generosity of the industrial countries, whether in their own self-interest (disposing of food surpluses) or under the mantle of alleged distributive justice, has probably done more to sap the vitality of agricultural development in the developing world than any other single factor. Food aid not only has dulled the political will to develop agriculture but also, by augmenting domestic production with grain grown abroad, has kept local prices at levels that destroy incentives for indigenous farmers. In the last analysis making surplus food cheaply available to the developing countries in normal times has reinforced the already strong tendency of those countries to neglect local agriculture; it is easier on their national budgets to farm the fields of the U.S. and Canada.

Among the large, populous developing nations only China seems to have brought its agricultural development into an approximate balance with demand. China imports wheat and exports rice; the net has recently been on the import side, but since about 1971 China has been essentially self-sufficient in food. Authoritative Chinese data are hard to find, but on the evidence available Chinese agricultural output rose by about 3.4 percent per year between 1960 and 1974. Estimates of population growth in China are even sketchier, but it seems to be between 1.5 and 2 percent per year, and decreasing. If these data are correct, and barring emergencies, the outlook for the Chinese food situation is good.

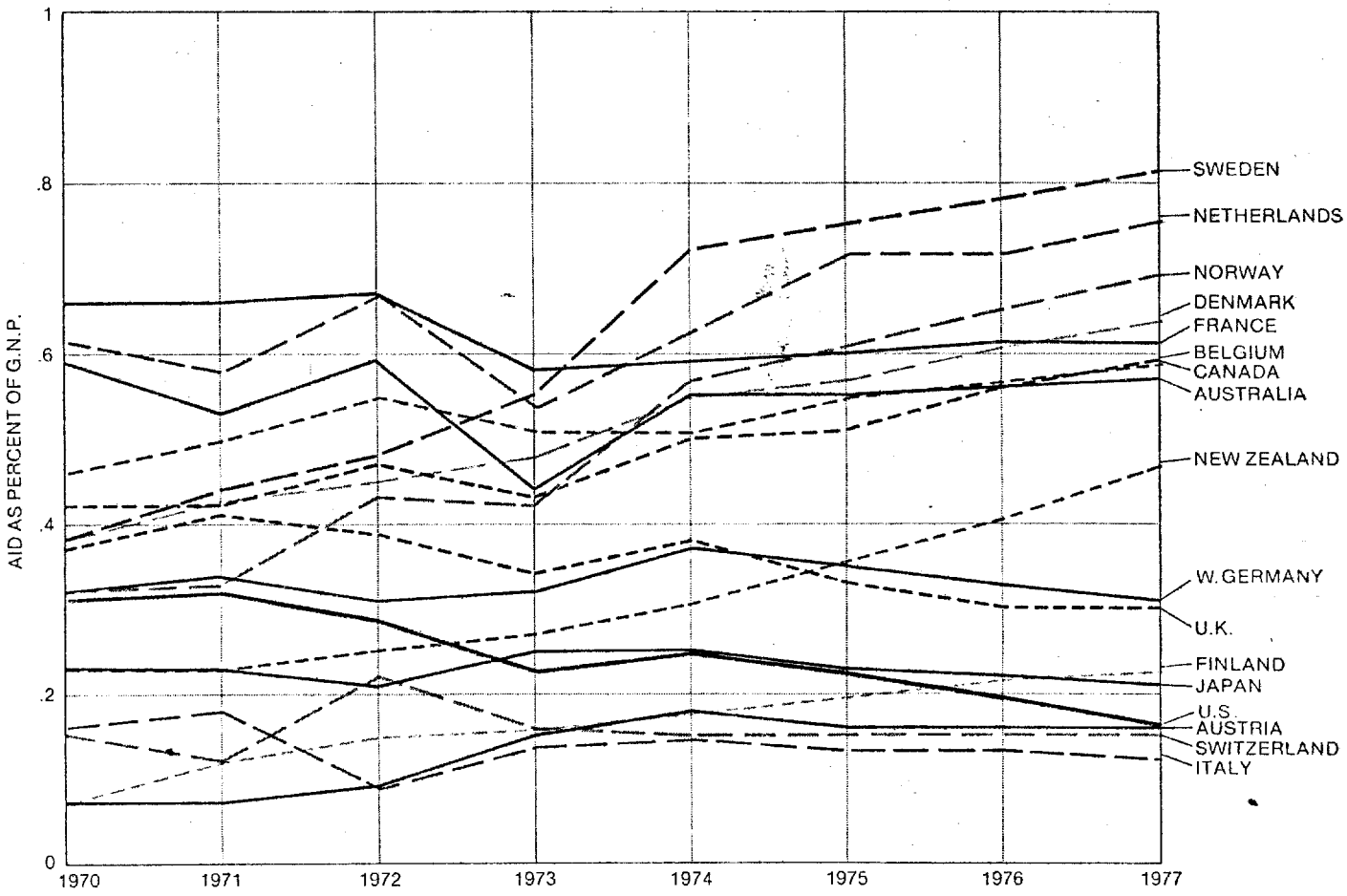
China has accomplished its agricultural growth largely by mobilizing and disciplining its farm labor. The role of the political cadres in providing leadership and social control in the commune structure is well documented. Personal incentives, work assignments and tight enforcement of social discipline multi-

ply the effectiveness of traditional labor-intensive methods. The Chinese are also emphasizing modern technical inputs, and these will increase markedly in the future as the plan for a very large expansion in fertilizer capacity is met.

The Chinese experience rests on the Maoist philosophy that the way to communism in China is through its rural masses, not through the heavy industrial development of the Russian model. China, unlike most other developing countries, has given pride of place in its development to the transformation of traditional farming. Whether China's methods of effecting the transformation are applicable to other societies and other cultures is a debatable question; the unique characteristics of Chinese culture may be more important for China's rural success than any particular techniques for accomplishing political and social change. Other countries, notably Tanzania, are experimenting with forms of social development that adapt many features of the Chinese model to their circumstances. It is too early to pass judgment on these activities, but they are worth watching for the lessons to be learned.

Food aid aside, the record of the developed nations is no better than that of most of the developing ones. As a group the rich nations have been devoting decreasing proportions of their gross product to official development assistance for developing nations. An inadequate percentage of that aid goes for agricultural and other rural purposes: in 1974 it was about 23 percent, or a little more than $2.6 billion, an amount far below the need. Moreover, much of that is accounted for by what is called technical assistance, which means paying one's own nationals to work in developing countries. That does not provide capital, which is what the poor countries need above all.

The 1974 World Food Conference was given a figure of $5billion a year for the next 20 to 25 years as a conservative estimate of the foreign exchange needed by the developing countries for investment in food production if the world is to attain a secure annual food supply. To mobilize such resources the conference called for the creation of three new international bodies: the World Food Council, the Consultative Group on Food Production and Investment and the International Fund for Agricultural Development (IFAD). Since the conference in 1974 there has been some progress. The council, a body of representatives from ministries of agriculture in 36 nations, has met twice since 1974 to review efforts being made to implement the global development of agriculture and food-producing capacity. The consultative group is striving to coordinate worldwide investment in agriculture. IFAD was formally agreed to in June, with an initial subscription of close to $1 billion by the Western industrial countries and the members of the Organization of Petroleum Exporting Countries (OPEC). This year the Arab countries established an Arab Authority for Agricultural Investment and Development with an initial capitalization of $525 million and a six-year plan for investing $2.8 billion in rural development and food production in the Middle East, with particular attention to developing the resources of the southern Sudan. The various agencies of the World Bank have given increasing priority to agriculture and rural development, doubling their support for those categories



DEVELOPED COUNTRIES are now devoting a smaller proportion of their output to official development assistance than they were in the mid-1960's. The curve of official assistance as a percentage of gross national product for member countries of the Development Assistance Committee of the Organisation for Economic Co-operation and Development. The UN target for official development assistance is .7 percent. Data for 1977 are estimated by World Bank on the basis of national policy statements and appropriations.

in 1975 compared with the previous year.

Even if it is considered narrowly in terms of eventual payoff, capital devoted to agricultural technology and infrastructure is well invested. Irrigation offers a good example. A long-term global approach to food security must rest on the development of water resources and the widespread extension of modern irrigation technologies. Nowhere is this better demonstrated than in Israel, where farm output has grown some eightfold in the past 25 years, largely through the efficient utilization of water. Modern water-resource development and the accompanying irrigation and drainage works are capital-intensive and expensive. A recent investigation sponsored by the French Ministry of Cooperation has found that even the rivers and groundwater of the semiarid Sahelian zone of Africa, the scene of a recent devastating drought and famine, could be harnessed over the next 75 years to provide crop water for almost 2.5 million hectares, at a cost likely to be in excess of $25,000 per hectare. The return on such an investment is hard to calculate, but a conservative estimate of yield would be 10 tons of cereals per hectare per year, or an output of about $1,500 per hectare: a 6 percent gross return. That is a minimum return, since it is likely that land of such value would be planted to crops with a higher economic return than cereals provide.

The relevant question for mankind, however, may not be one about investment return. It may rather be: What is the long-run cost of not initiating now a program of investing in man's future food supply? Water-resource development has a long gestation time before it yields benefits, and so do many other elements of agricultural modernization. Political leaders in both the rich and the poor countries have a short time horizon; they focus on immediate concerns. Yet future food supplies depend not on the application of more fertilizer to existing fields this year or next but on a joint and shared commitment by the developed and the developing countries to the long-term and expensive development of the world's untapped farm resources.

It is important to recognize that the world's food problem does not arise from any physical limitation on potential output or any danger of unduly stressing the "environment." The limitations on abundance are to be found in the social and political structures of nations and in the economic relations among them. The unexploited global food resource is there, between Cancer and Capricorn. The successful husbandry of that resource depends on the will and the actions of men.