Food

The task of feeding everyone adequately calls for an investment in the agriculture of developing countries of more than $100 billion. Without a fairer distribution of income many will still go hungry

by Nevin S. Scrimshaw and Lance Taylor

Adequate nutrition for all human beings must be one of the major goals of development between now and the year 2000. Its achievement will be difficult and uncertain even if sufficient global production of food is attained. Although technical advances in food production, food conservation and food processing will be needed to ensure food availability, meeting food needs will depend even more on greater social equity and fairer income distribution within the developing countries themselves. External assistance can be of some help, but the outcome in each country will be determined by the effectiveness of measures undertaken by its government. With heightened awareness of food issues around the world and of both the potential and the limitations of the introduction of new high-yield crop-plant varieties (the "green revolution") 1980 is a good time to attempt an assessment of the prospects for providing all human beings with their nutritional needs by the end of the century.

One way to begin the assessment is to look at the recent past. In the 15-year period between 1961 and 1976 food production in 94 countries classified as developing market economies by the United Nations Food and Agricultural Organization (FAO) expanded at the rate of 2.6 percent per year, barely keeping abreast of overall population growth and failing to attain levels capable of meeting increases in demand due to rising incomes. In 1975, according to the conservative FAO estimate, more than 23 percent of the people in 86 countries with a total population of 1.9 billion were undernourished. On the brighter side, food production expanded faster than population in 24 developing countries. Against an annual population growth rate of 3 percent these countries raised their production of staple foods by 3.9 percent per year. In India, which accounts for nearly a third of the total population in the 94-country FAO sample, yearly average gains in food production (2.6 percent) slightly exceeded population growth (2.4 percent) over the 15-year period. The experience of China, which is not included in the FAO sample, is uncertain, but the evidence is that it is close to being self-sufficient in food production, exporting some crops in most years while importing other crops to meet local needs.

Collecting food statistics and judging nutritional adequacy for scores of diverse populations is understandably difficult. Planners begin by collecting information about patterns of food production and consumption, country by country. The FAO compiles such information for the 90-odd countries classified as developing and for the 30-odd countries regarded as developed. One presentation of such information is the food balance sheet, an accounting of the different types of food available for human consumption. Most of the developing countries have a diet consisting mainly of a single staple plus a small number of other foods. For example, in Afghanistan and Pakistan the staple is wheat, and in Mexico and Central America it is maize. In the region of the world with the largest populations, China and southeastern Asia, the staple is of course rice.

A food balance sheet is computed by adding food imports to domestic food production and subtracting exports, estimated losses, seed and animal feed. The remainder is the food available for consumption. Although such an accounting helps to give a broad picture of the food system, its estimates are clearly subject to large errors. Moreover, a food balance sheet provides no information on how the available food is distributed among socioeconomic groups, among families or within families.

A more desirable starting point would be data on actual food consumption. Even when such data are available, however, they are usually reported only for an entire household because of the difficulty and cost of ascertaining what each member consumes. Family-consumption studies nonetheless demonstrate the extent to which food consumed by a household varies with income. The source of supply can be either the market or foodstuffs produced at home, but in either case the consumption of protein and the total calories increase with family income. Diet patterns also change with income. Up to a certain income level, roughly from $250 to $300 per person per year (in 1980 U.S. dollars), the calorie intake from the local staple-food energy source tends to increase. At higher income levels calories from fats, sugars, fruits, vegetables and animal products play an increasing role. Careful studies in selected regions, for example Brazil, show that both the amount and the nutritional quality of protein rise directly with income.

The implication of such observations is that the monotonous, cereal-based diet of the poor in developing countries is a matter of economic necessity rather than choice. A poverty-level family in a stable social environment may be undernourished simply because it cannot afford a better diet. Disruption of the

INTENSIVE CULTIVATION typical of farm areas in the highly productive northern Great Plains states of the U.S. is represented by the enhanced false-color Landsat image on the opposite page, which covers an area of approximately 7,500 square miles in the corn belt of northern Iowa and southern Minnesota. The rectangular strip-field pattern of agriculture characteristic of the region is aligned precisely along north-south, east-west axes. The path of the satellite, and hence the orientation of the image, is slightly askew (by about 13 degrees of arc). The border between Iowa and Minnesota runs diagonally (due east-west) across the upper half of the page. The principal crop grown in the region is corn, with a small admixture of soybeans and other crops. The image was acquired in October after most of the fields had already been harvested. The darkest fields have also been tilled, exposing the rich black soil for which the area is noted. The lightest fields have been harvested but not yet tilled; cornstalks and other trash account for their high reflectivity. The yellowish fields have standing ripe crops (mainly corn) that have not yet been harvested. The reddish fields have alfalfa and other forage crops. The irregular red shapes result from vegetation along streams and in other uncultivated spaces.

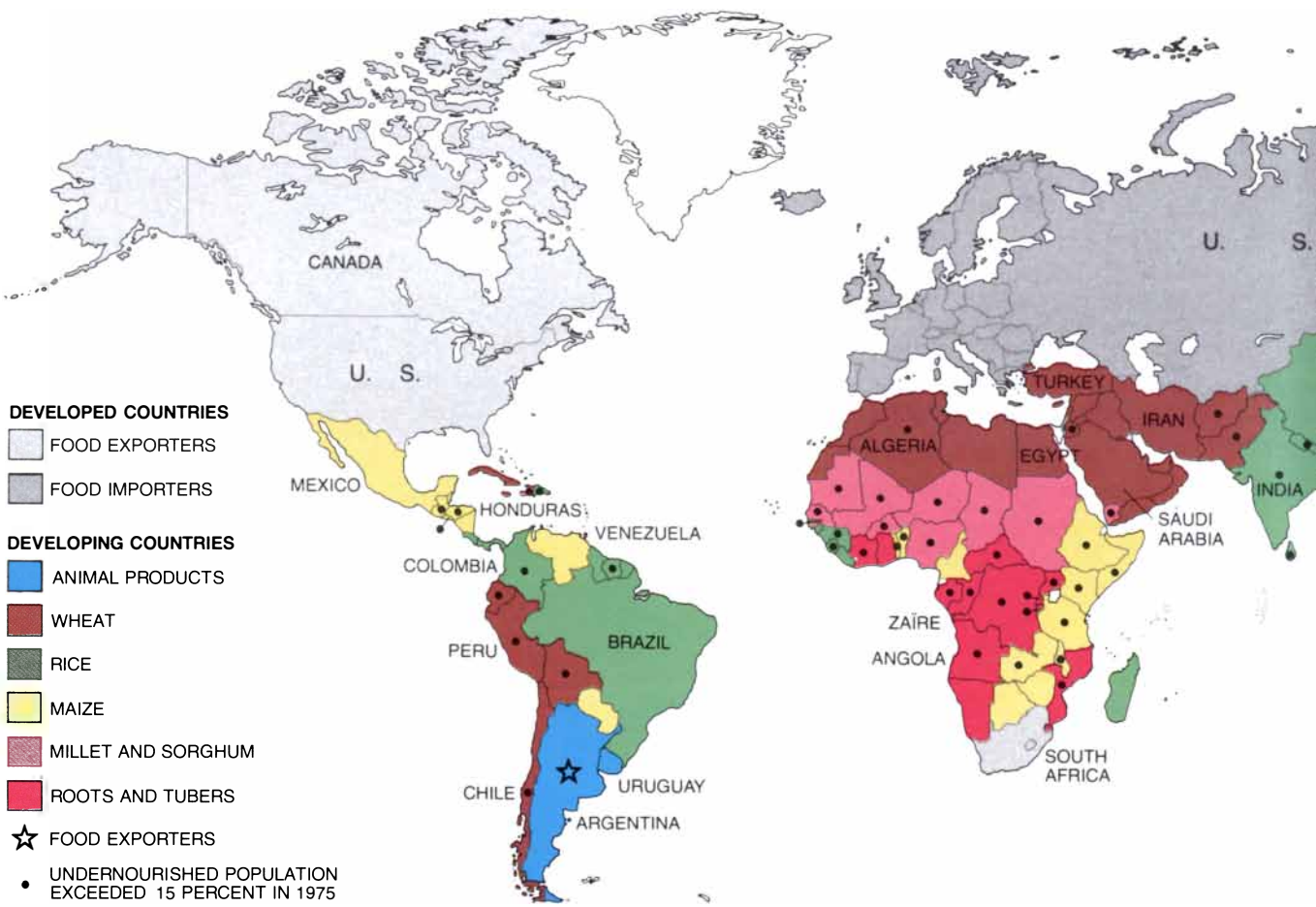
environment by war, migration or social pathology can only intensify the malnutrition of a poor family. Such disruptions aside, malnutrition is a clear sign that a family cannot get enough food through the usual channels of production, purchase, barter or welfare distribution.

Working with the relation between food consumption and income, several recent studies have tried to estimate the number of undernourished people in the world. One procedure is to present the observed distribution of household income in a country in a Lorenz curve [*see illustration at left at top of page 84*]. The horizontal axis shows percents of the population ordered by their level of household income: the bottom 20 percent, the bottom 40 percent and so on. The vertical axis gives the percent of income that each population share receives. A typical Lorenz curve may show, for example, that the poorest 20 percent of the households receive 5 percent of the income, the bottom 40 percent receive 15 percent and so on. The Lorenz curve connects the points relating population and income shares.

Information about a country's income distribution, as summarized in a Lorenz curve, can be combined with food-supply data from a food balance sheet and the observed relation between household income and food consumption to estimate the distribution of food consumption by household. The fraction of households with predicted levels of calorie consumption per household member that fall below a certain cutoff point can be considered undernourished. The FAO estimates that even with the cutoff set at the low value of 1,600 calories per day (only 20 percent above the basal metabolic rate) more than 436 million people, or 23 percent of the population, are undernourished in a sample of 86 poor countries.

A working group at the new United Nations University in Tokyo has recently emphasized that the FAO criterion provides for only minimal physical activity. The stringency of the FAO calorie standard can be judged from the observation of Fernando Viteri of the Institute of Nutrition of Central America and Panama that when male agricultural laborers are offered food freely, they can consume 3,555 calories per day without gaining weight. A World Bank estimate based on assumptions less stringent than the FAO's indicates that 1.1 billion people, or more than a fourth of the world's population, are undernourished.

The countries with populations most subject to undernourishment are those where the staple foods are either millet and sorghum or roots and tubers. In the FAO survey of food supplies in 1975 more than 15 percent of the population was undernourished in nine of the 10 countries in which millet and sorghum are the chief energy source and in 10 of



WORLD FOOD RESOURCES AND DIET PATTERNS are depicted for the developed countries and for the developing countries followed by the United Nations Food and Agricultural Organization (FAO). Populations in the developed countries (roughly defined as those with annual per capita incomes greater than $300 in 1979 U.S. dollars) have for the most part an adequate and varied diet. Only four countries in the world are major exporters of cereals: the U.S., Canada, Australia and Argentina. Virtually all the rest, with minor exceptions such as Thailand, are net importers. The color key shows the predominant source of food calories in 90 developing countries according to the most recent FAO classification. China and Mongolia, not included in the FAO list, are classified among the rice countries. A number of smaller countries, also omitted by the FAO, are assigned a diet similar to that of their neighbors. Black dots identify 52 developing countries where more than 15 percent of the population was undernourished by FAO standards in 1975. (The FAO defines a diet containing fewer than 1,600 calories per day as inadequate; a typical "first world" diet averages about 3,100 calories per day.) The "third

the 11 countries in which roots and tubers are the chief source [*see illustration below*]. Millet and sorghum, although hardy crops, are looked down on by the more affluent consumers, who consider them to be poor people's foods. They were included to some extent in the plant-breeding studies that made possible the green revolution, but in most parts of the world they have not shown major increases in yield, largely because increased supplies of fertilizer and irrigation water have not been provided to make the most of improved seed. Without irrigation even millet and sorghum do poorly in a severe drought. The famine of the 1970's and the continuing precarious food situation in the belt of countries south of the Sahara result to a large extent from the combination of marginal rainfall and the region's dependence on millet as its staple crop.

Even in countries with a fairly adequate overall food supply undernourishment persists because of gross inequality in income distribution and the lack of welfare programs for the poor. This is most striking in relatively prosperous Latin-American countries such as Chile, where wheat is the staple and more than 15 percent of the population remains undernourished in spite of successful agronomic efforts. Similarly, maldistribution of available food is evident in countries such as El Salvador, Guatemala and Honduras, where the diet is based on maize.

world" countries where wheat (*brown*) and rice (*green*) are the principal crops have been the most successful in meeting food demand. In 11 of the 17 countries where maize (*yellow*) is the chief crop more than 15 percent of the population was undernourished in 1975. In populations that subsist on millet and sorghum (*pink*) or roots and tubers (*red*) some degree of malnutrition is virtually universal.

Although a country's staple food is its primary source of carbohydrate, it must also serve as the principal source of protein for much of the poor population. The degree to which this source of low-quality protein is supplemented by more valuable, or at least complementary, sources of protein depends on income. Total protein consumption rises with income in parallel with calorie consumption. The nutritional inequality among income groups is thus intensified by differences in the composition of the protein consumed. The diet of poor people is lower not only in total protein but also in the proportion of total protein from animal sources and legumes. As a result the differences in the fraction of protein that can actually be utilized are even more marked than the differences in total calories. Whereas only 30 to 40 percent of the inadequate protein calories can be utilized in the diet of the poor, 50 to 60 percent of the more abundant protein calories can be utilized in the diet of the most affluent fraction of the population [*see illustration at right at top of page 84*].

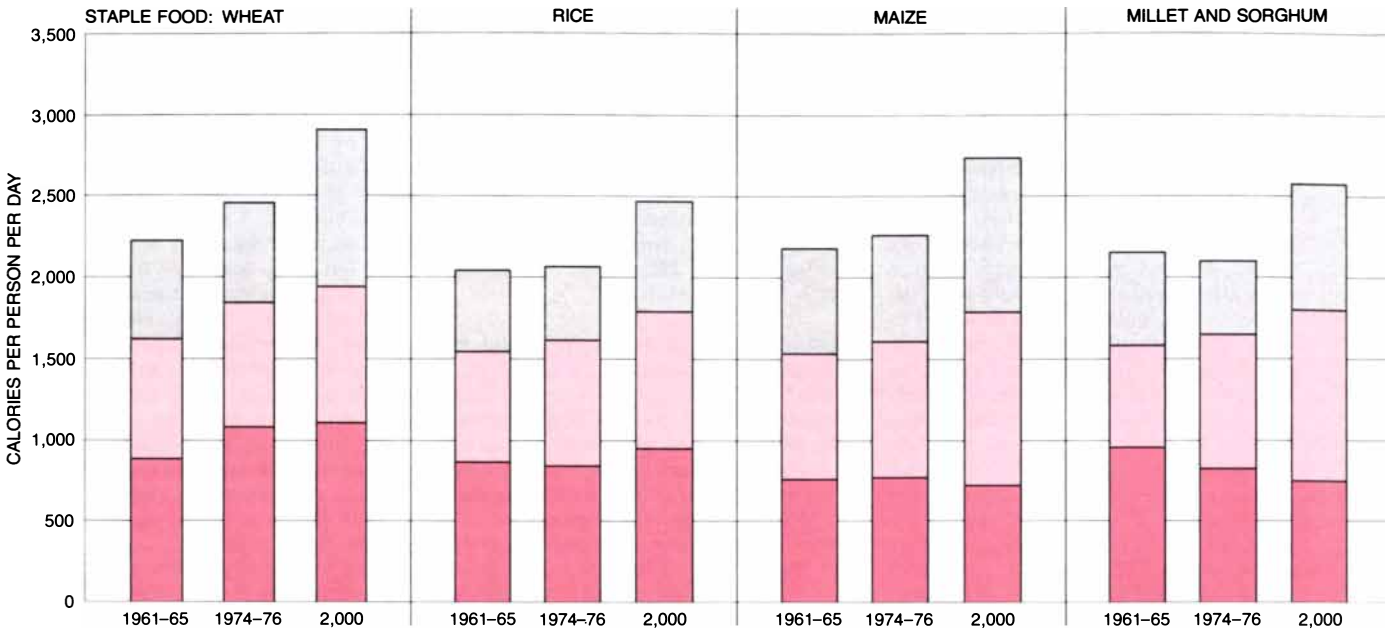
Within the family itself dietary deficiencies can arise for a variety of reasons. Preschool children are particularly at risk between the time when breast milk is no longer adequate as the sole source of food and the time when the children fully share the family diet. In developing countries this critical period is most commonly between the ages of four to six months and 18 to 24 months. In this period between 15 and 25 percent of the children suffer malnutrition and retardation of growth to the degree that their weight is between 25 and 40 percent less than that of well-nourished children. The percentages vary so much from country to country that overall estimates are difficult, but judging by retardation in weight for age the World Health Organization conservatively estimates that more than 500 million children in each age cohort suffer second-degree malnutrition or worse. If one were to choose weight-for-age criteria closer to normal values than those adopted by the WHO, one could reach numbers considerably higher than 500 million. Evidence is accumulating from many studies that there is a correlation between impaired physical growth and development and increased susceptibility to infection. The impairment is also found to alter performance on some tests of learning and behavior, with the prospect of diminished adult capacity.

The malnutrition of infants and preschool children will not necessarily be eased by increases in overall food supply or even by a higher average level of family food consumption. Educational and public-health measures can sometimes improve the lot of the preschool child, but there are limits here as well, depending strongly on the cultural environment of the family. For example, in some cultures the unconscious withholding of care from certain children can be interpreted as a socially sanctioned form of population control.

The burden of such observations is that any substantial reduction in undernutrition will depend on policies aimed not only at increasing the supply of food but also at its equitable distribution in meeting human needs. The task will require raising both the relative income and the social status of those now most impoverished. Increased income is likely to be most effective in a market-oriented economy, where food production will respond to an increase in demand. Nevertheless, a discussion of ways to remedy undernutrition can be given more focus by first considering the role of farmers as the ultimate suppliers of the world's food.

Running a manufacturing plant involves many complex decisions, but running a farm is hardly less complex and includes uncertainties of nature that the manufacturer is spared. In order to gain a better understanding of the decisions a small farmer faces in a poor developing country the week-by-week activities of a single farmer and his family in Yojoa, a small Honduran village, were carefully recorded for a year. On six hectares (15 acres) of land the farmer raises maize, rice and beans, along with chickens. With cash from the sale of his produce and the services of his oxen and oxcart the farmer buys seed, fertilizer, occasional labor, household necessities and clothes for his family. The inputs and outputs to this miniature "agribusiness" make an intricate web [*see illustration on pages 86 and 87*]. What cannot be shown on such a chart is the careful timing required to keep everything running smoothly and on schedule.

A small farmer with five hectares in the Punjab area of Pakistan faces a quite different but no simpler set of problems. Timing is again crucial: he can get two crops per year by adroit crop selection and land allocation. After his principal food crop, wheat, is harvested in May, he can plant rice and maize in June and July and harvest both before wheat must be planted again in November. Elsewhere on his small farm he is simultaneously growing beans, cotton (in sequence with a late oilseed crop such as rape or mustard), sugarcane and fodder



TRENDS IN DIET PATTERNS between the early 1960's and the mid-1970's, with a projection for the year 2000, have been charted for 88 developing countries by the FAO. Countries where the staple food is wheat have shown the strongest gains and promise to do best overall by the year 2000. The rice countries, which include those with the largest populations, made no gain in calories per capita in the dozen years separating the first two bars but are expected to show a significant improvement by 2000. (As in other FAO studies, China is not included.) Although maize production per capita appears to have stabilized, the populations in maize-growing countries have been adding calories from other foods, a trend that should continue. Supplemental foods will also be essential if diet is to improve in countries

for draft animals [*see illustration on page 88*]. How much land area to devote to each is a difficult decision, depending partly on relative prices and also on practical constraints such as the possible crop rotations, the need to have enough fodder for the animals and to have enough mechanical energy or manpower on hand to harvest one crop when it is time to plant another.

For the farmer and his family a good harvest is close to being a life-and-death matter. He has strong incentives for avoiding risk. As students of peasant agriculture have long emphasized, the traditional resistance to change in the countryside is based on this fact. Time-tested agricultural techniques have pulled peasant communities through good times and bad, and farmers have no guarantee that any new technology will do as well.

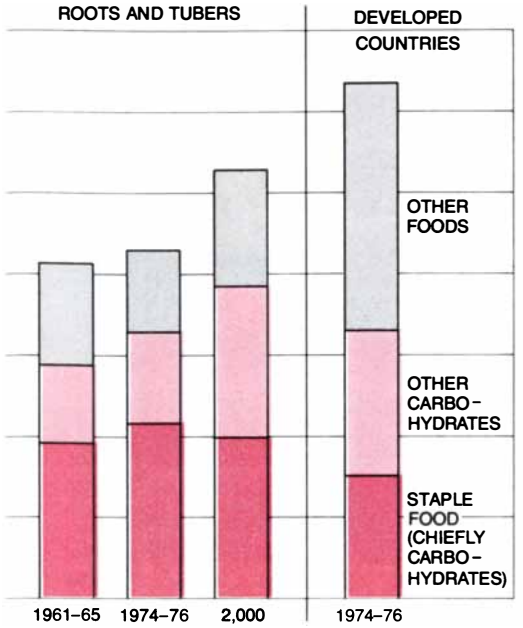
Moreover, risk-sharing institutions in agriculture often help to maintain an inegalitarian economic status quo. Cases in point are the usual forms of sharecropping and the high interest rates the poor are charged by the village moneylender. Such social inventions minimize risk at the expense of perpetuating the unequal distribution of both income and food. In effect the precarious social position of rural poor people forces them to accept low average food consumption year after year in return for social guarantees that in a bad year they will not be allowed to starve by the moneylender, the landlord, the government authority or other beneficiaries of the system's economic surplus. When agriculture is a component of a market-directed economy, the traditional risks of a food shortage in a region are complicated by fluctuating prices for nonfarm commodities. Landless laborers and other poor people tend to be victimized as their pay for labor lags behind rising prices in times of inflation, whereas the holders of surpluses in the system often find ways to cushion themselves against inflationary shocks. A well-known means of such cushioning is preferential access to official credit.

The experience of most poor farmers scarcely prepares them for turning to their own advantage the growing variety of technical innovations and the institutional improvements offered by the government and other agencies. A measure of the importance of such innovations and improvements to the poor farmer is provided by Pakistan, where the reliable provision of water for irrigation and of inexpensive power sources for threshing and other operations has in recent years led to large gains in agricultural output. Also central to the green revolution, along with higher-yielding seed, have been cheaper and more reliable sources of chemical fertilizers and pesticides and modern knowledge of multiple-cropping practice.

The consequences of such developments must be evaluated in both social and economic terms. Will the large absolute profits derived from exploiting new technology induce large landowners to mechanize and throw their traditional tenant farmers off the land? The immediate beneficiaries of the new technology must make fateful decisions. The way they use their new surpluses may further depress nutritional levels in a region at the same time that total food production is going up.

Against this background of microeconomic considerations let us now assess the potential for increased agricultural output on a large scale. Land, water and fertilizer are the major agricultural inputs, along with energy, which is a significant component in all three and essential for mechanization. Although the dramatic increase in energy costs in the past seven years has certainly been burdensome for agriculture in the developing countries, it has not had the crippling impact that might have been expected. The explanation, briefly, is that as long as crop prices remained strong the cost of additional fertilizer was amply repaid.

Could there be, on a worldwide basis, a shortage of land suitable for agriculture before the year 2000? It seems unlikely. There is room to exploit both the "intensive margin" of increasing yields and the "extensive margin" of irrigation and bringing larger areas under the plow. Since the mid-1960's a number of estimates have been made of the total amount of arable land available around the world. Roger Revelle of Harvard University, who has summarized the estimates, calculated in 1974 that the total world area available for cropping (counting more than once those areas where multiple crops are grown) is about 4.1 billion hectares. Less than half



where the staples are millet and sorghum or roots and tubers. The last bar shows the typical diet pattern in developed countries. In such countries roughly half of the daily calories are supplied by separated fats and oils, animal products, sugar, fruits and vegetables.

of this area is now cropped in any given year, so that there is substantial room for agricultural expansion, provided capital is available for land reclamation and irrigation.

Indeed, the situation may be better than it seemed only a few years ago. A new collection of soil maps prepared by the United Nations Educational, Scientific and Cultural Organization was recently given a fresh analysis by a group at the Wageningen Agricultural University in the Netherlands. The Wageningen group has found that only about three-fourths of the cultivable land in southeastern Asia is now in use; in earlier estimates the fraction had been as high as 93 percent. The areas of potentially cultivable land in Africa and South America are far larger, more than 600 million hectares in all. Argentina alone has roughly the same amount of cultivable land as India and has a population only 4 percent as large as India's. Brazil, which now farms 47 million hectares, has another 50 million hectares of savanna that is considered suitable for soybeans and wheat (if the aluminum-rich soils are properly treated), and this is without touching the ecologically fragile Amazon rain forest.

Working with FAO data, Alan Strout of the Massachusetts Institute of Technology recently estimated that bringing a hectare of new land under cultivation will produce .9 metric ton of cereal grain, a year's supply of food for about five people at the FAO minimum nutritional standard of 1,600 calories per day. If the land is well irrigated, the total production increases about fourfold to 3.5 metric tons. Revelle has estimated that land available for crops through future irrigation is 1.1 billion hectares, or enough to feed more than 10 billion people at twice the FAO levels.

The greatest potential increase in food production lies, however, in the more intensive cultivation of the somewhat less than two billion hectares currently devoted to crops. As against the 3.5 metric tons of cereals that can be expected from a well-irrigated hectare, Strout estimates that the same hectare can yield between nine and 13 tons of crops if it is supplied with a ton of nutrient content in fertilizer (nitrogen, phosphate and potash). Remarkably, there do not seem to be any diminishing returns to the application of fertilizer across a range from 20 kilograms (.02 metric ton) per hectare in India to more than 500 kilograms per hectare in Belgium and the Netherlands. To be sure, chemical fertilizer requires costly oil or natural gas for its production, but the amounts required are less than 1 percent of the current level of world petroleum use. The potential crop increase from the application of chemical fertilizer is of course in addition to what might be achieved with organic fertilizer or the recycling of organic wastes.

The benefits to be expected from the increased application of fertilizer, compared with the benefits from irrigation or bringing in additional land, can be seen in a study by Strout of the contribution made by these inputs and others to total crop production in a 90-country FAO sample between the early 1960's and the mid-1970's [*see top illustration on page 85*]. The contribution of new cropped land has declined since the early 1960's as the share attributable to irrigation has held steady and the share attributable to fertilizer has gone up. Fertilizer was responsible for 40 percent of the increase in crop output realized between the early 1960's and the mid-1970's. In the same period the application of fertilizer in developing countries increased about fourfold, or at a rate of nearly 10 percent per year. Although there were worldwide shortages of fertilizer and rapidly rising prices for it in the mid-1970's, the annual increase since 1975 has actually exceeded 10 percent. Extrapolation of such growth rates in conjunction with Strout's yield estimates suggests that there could be crop surpluses in parts of the "third world" by the mid- or late 1980's.

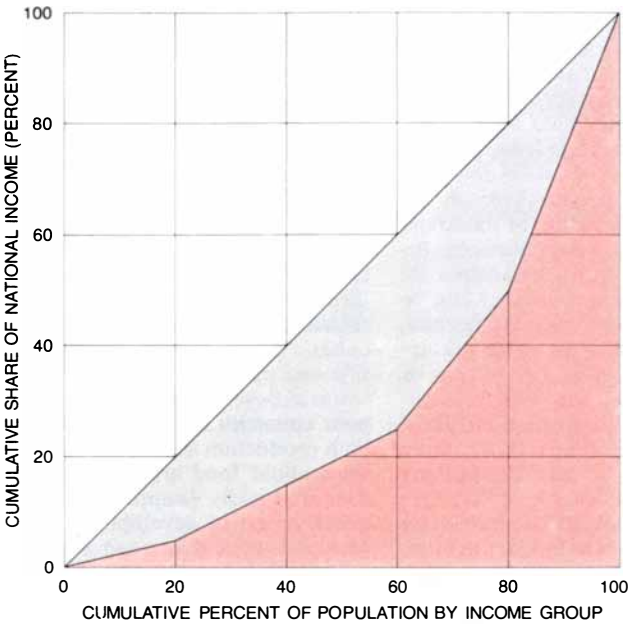
How widely the various means of increasing food production will be applied nationally and globally over the next two decades depends on countless decisions to be made by millions of farmers large and small, by their suppliers and by the people for whom they produce or to whom they sell. Obviously many of the decisions can and will be influenced by policies adopted by governments, by international agencies and research organizations and by the corporations that are playing an ever larger role in the production and distribution of agricultural raw materials and food.

One of the major uncertainties is price policy. Food and agricultural decisions are by their very nature highly decentralized. The only way most consumers and producers can communicate is through the market or an equivalent bureaucracy. The mutual isolation of economic agents—producers on the one side and purchasers on the other—gets worse as development proceeds. Even in poor countries farm households where both production and consumption decisions about food are made under one roof are rapidly disappearing. As an inevitable part of development, decision making is guided increasingly either by government directives or by price signals from the market. In market economies the key question is how to make the best of a situation where a price change not only elicits an economic response but also can alter real income and the distribution of economic power.

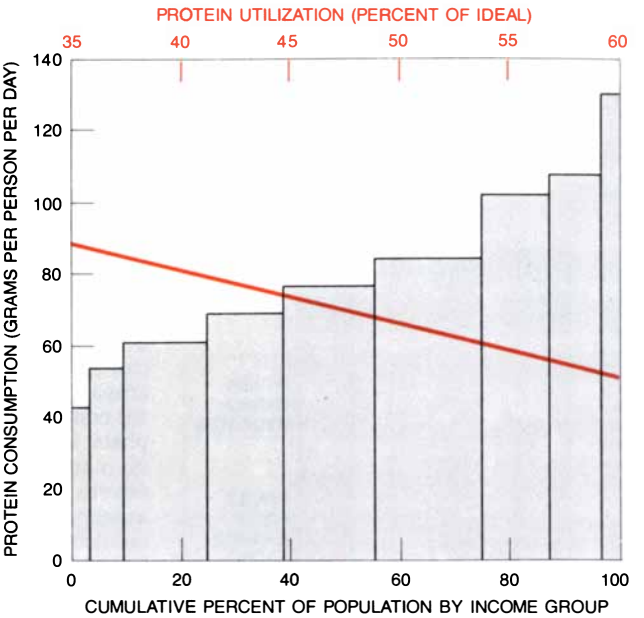
An entire school of agricultural economists has followed the lead of Theodore W. Schultz of the University of Chicago in asserting that most farmers in developing countries are "poor but efficient." That is, they respond to price incentives and maximize profits within the limits of the available technology. One corollary of this view is that if the prices are manipulated by the government, they can easily be "wrong" and lead to a faulty allocation of resources. Examples are easy to cite. In Egypt the government controls the procurement prices of cotton and wheat but not the consumer price of meat. As a result crops have shifted from cotton and wheat toward clover, which is used in part to fatten animals for relatively well-to-do consumers in the towns. To take another case, the application of fertilizer responds almost everywhere to the ratio of fertilizer cost to the farm-gate price of the final crop; if the ratio goes up by 10 percent, fertilizer application per hectare drops by a percent or so.

Such observations suggest that price policy is a powerful tool and one that governments cannot afford to wield carelessly. It is now recognized that there were harmful "second generation" effects in the policy of setting high crop prices to hasten the green revolution. One effect was an increase in the displacement of farm labor by machines. Moreover, high government-supported prices and technically induced profit increases for grain production led to a drop in legume production. With legumes scarce and more expensive the already marginal diet of low-income groups declined further.

Farm price policies obviously have



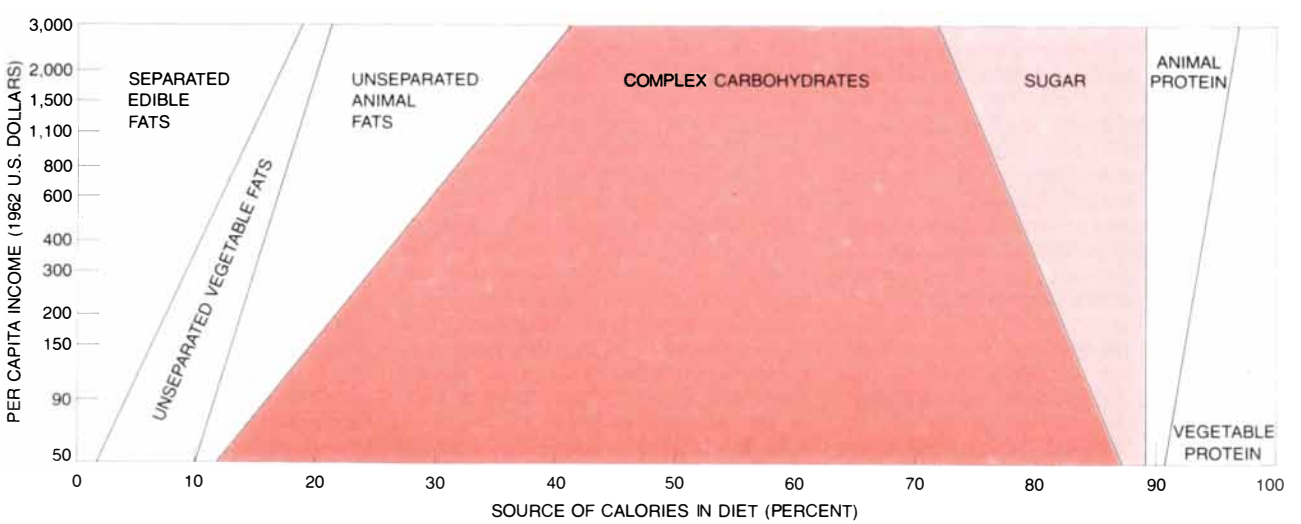
DISTRIBUTION OF HOUSEHOLD INCOME in a country can be summarized in the form of a Lorenz curve. Percentiles of the population, ordered by income level, are shown along the horizontal axis; percentage shares of the national income are represented on the vertical axis. In this Lorenz curve, which is typical of a fairly prosperous country, the poorest 20 percent of the population gets 5 percent of the income, the bottom 60 percent gets 25 percent and the bottom 80 percent gets 50 percent. A widely used measure of income inequality is the Gini coefficient, which is calculated as the ratio of the area (*gray*) lying between the diagonal line and the Lorenz curve to the area of the lower triangle. Here the ratio between the two areas is .4. The larger the ratio, the less equitable the distribution of income.



PROTEIN CONSUMPTION BY INCOME GROUP is a valuable index of the adequacy of a country's nutrition. A general finding is that total intake of calories and total intake of protein both increase with income. Unfortunately not only do poor people consume less protein than the more affluent but also their protein is low in quality, being deficient in legumes and particularly in animal products. The data for protein consumption by income group plotted here are based on the diets of 9,125 families in various parts of Brazil. The slanting line shows how much protein of the type actually consumed by families of different income levels would be needed to meet the FAO "safe level." One can see that the diets of the poor are even less adequate than would appear from total protein consumption alone.

long-term effects as well. The capital investment required for irrigation, land clearing and leveling, drainage and technical innovation in agriculture is substantial. In the recent FAO study *Agriculture: Toward 2000* it is estimated that the total agricultural investment in the 90 developing countries on the FAO list will be $52 billion by 1980, $78 billion by 1990 and $107 billion by 2000. Much of the investment will come from within the economies of those countries, but the above amounts include an increase in the share of foreign exchange devoted to agricultural investment from 16 percent in 1980 to 29 percent by 2000. These are huge sums compared with the few billions of dollars currently channeled to poor countries each year for agricultural purposes by the World Bank, the International Fund for Agricultural Development and similar institutions.

The implication is that the savings



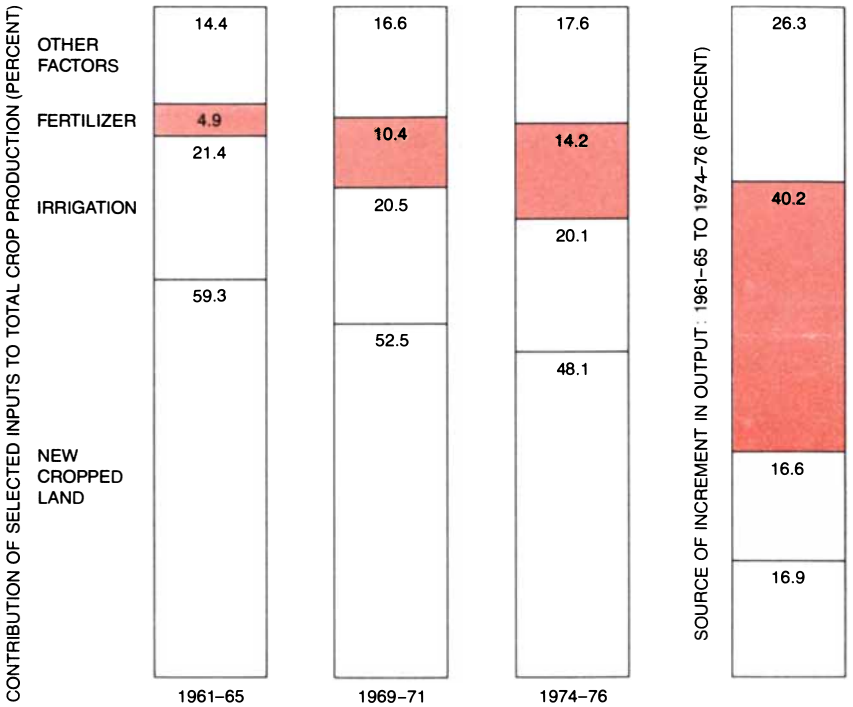
VARIATION OF DIET WITH INCOME exhibits a pattern that is remarkably consistent worldwide. At the lowest income level most calories in the diet are supplied by the country's main food group, usually a cereal, which contains small amounts of vegetable fats and proteins in addition to carbohydrates. With rising income calories from the main food group are supplanted by separated edible fats, by unseparated animal fats and proteins and by sugars. The diagram is based on the food balance sheets of 85 countries for 1960–62, which were analyzed by J. Perisse, F. Sizaret and P. François of the FAO. Not shown is that total calorie intake also rises sharply with income.

counterpart of this investment will have to be generated within the poor countries themselves. As Arthur Lewis of Princeton University has emphasized, in a capitalist system savings are generated by shifting the real-income distribution toward high savers, that is, the most prosperous groups in the society. Such a distributional change can be effected by raising food prices, which reduces the real income of the low-saving poor because food already absorbs much of the family budget. Unless remedial steps are taken one could well have the paradox that price changes designed to raise food output will harm precisely the poor families, particularly in the towns, who need the food most; the food will be priced beyond their reach.

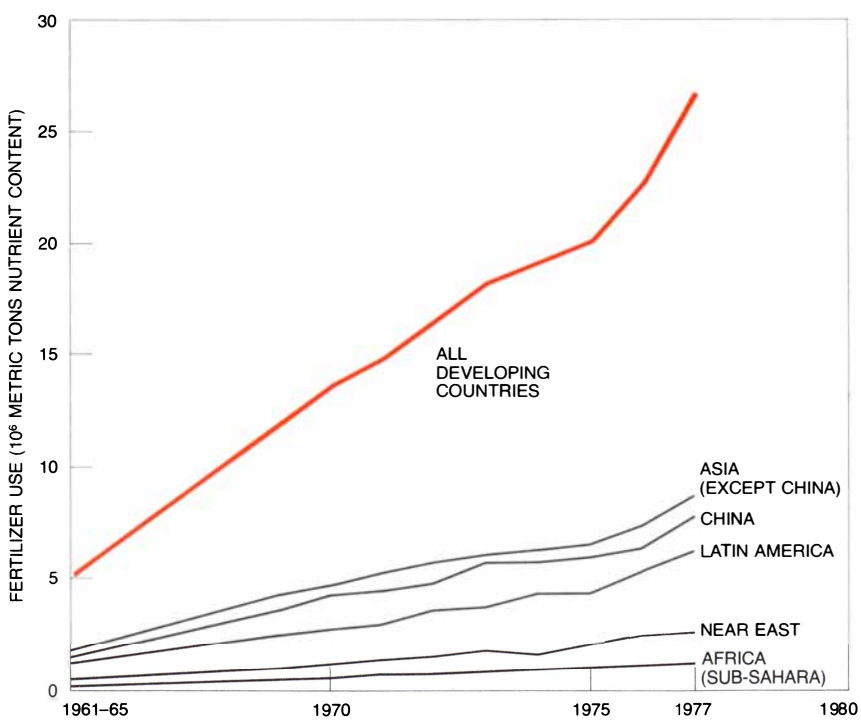
Experience in Sri Lanka, in the state of Kerala in India and in a few other places suggests that both producer incentives and consumer real incomes can be protected by a well-designed system of consumption subsidies for staple foods, as is also done in the U.S. and other developed countries. Many more schemes of this kind may become necessary if rapid agricultural growth is pursued in largely market-oriented economies. The World Food Council, one of the new UN organs created in response to the food crises of the 1970's, is now trying to encourage aid donors to support such programs.

At least as important as price policy in guiding and raising farm output is technology policy. What innovations should the government encourage? What kinds of agricultural research should it undertake? Almost superhuman judgment seems to be called for in the area of food, because it is just here that many promising initiatives have had unforeseen and unfavorable second-generation consequences, have not taken hold as widely as predicted, have failed disastrously or have simply been irrelevant. The technologies themselves may not have been at fault, but the policy environment in which they were applied did not always benefit the poorest groups. Still, without the technological advances the overall food situation could certainly have been much worse.

The widespread introduction into developing countries of Western concepts for rearing infants is a different but nonetheless instructive kind of example. The substitution of cow's milk or commercial infant-feeding formulas for breast-feeding by poor mothers living under adverse conditions has often been harmful for infants. The formula is often overdiluted because the mother is trying to eke out the costly supply of it, and it may be contaminated by dirty water and unsanitary preparation. Beyond that the infant is deprived of the factors in breast milk that can protect it from the ubiquitous pathogens in poor environments.



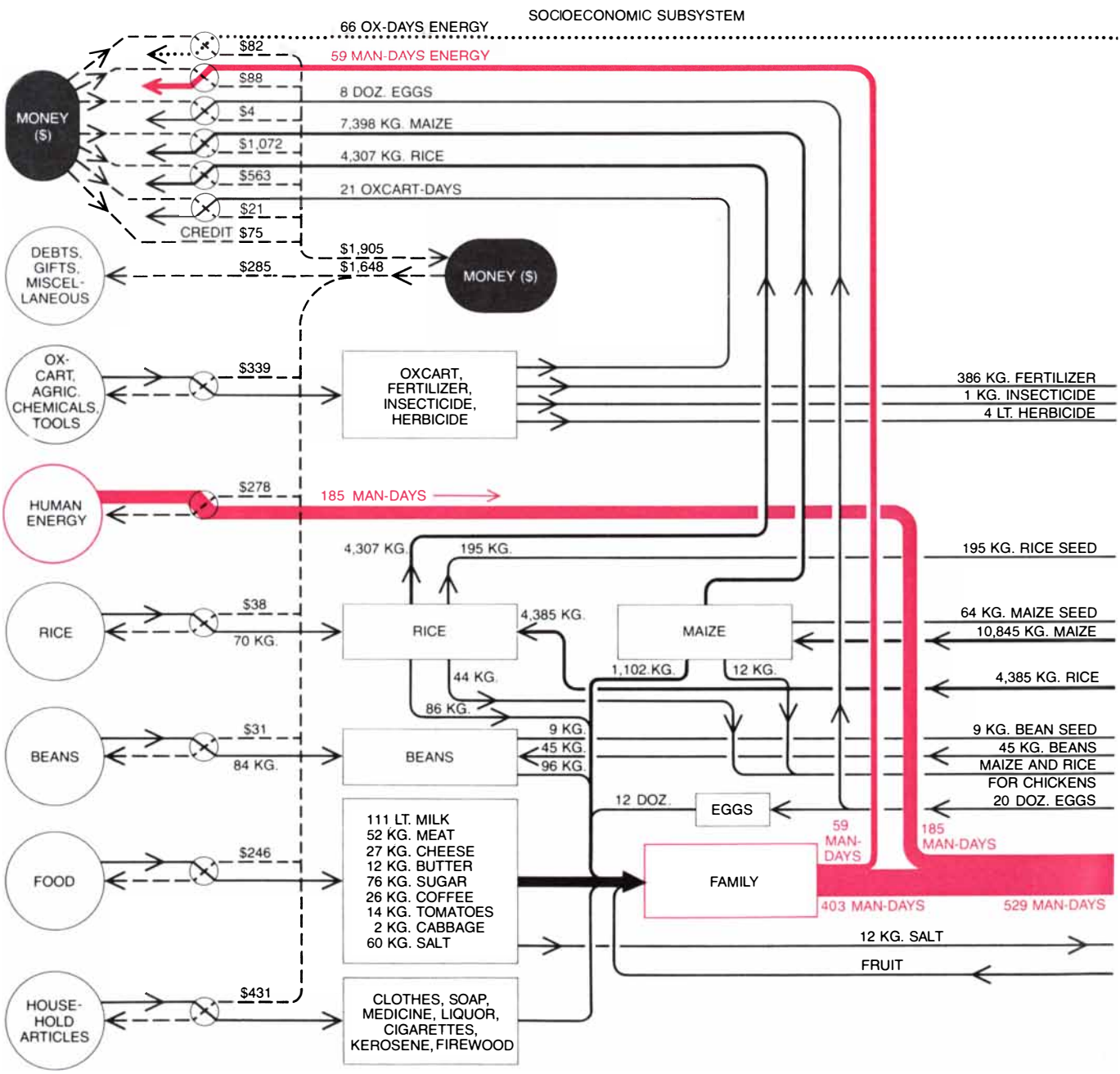
VALUE OF FERTILIZER in raising crop production is demonstrated in an analysis of factors contributing to total crop production in 90 developing countries in three periods between 1961 and 1976. The contribution made by bringing new land under the plow has declined since the early 1960's; the share attributable to irrigation and other factors has held fairly steady; the contribution attributable to fertilizer has risen sharply. The last bar shows that fertilizer was responsible for two-fifths of the increase between 1961–65 and 1974–76. The analysis was done by Alan Strout of the Massachusetts Institute of Technology on the basis of FAO data.



SHARP RISE IN FERTILIZER USE was reported in most developing regions of the world between 1961–65 and 1977. In spite of the slowdown due in part to oil shortages in 1974 and 1975 growth resumed strongly in 1976 and 1977. Over the 15-year period ending in 1977 the fastest annual rate of growth was in the Near East (12.4 percent), followed by Latin America (11.6 percent). In Africa, China and the rest of Asia the growth rates were respectively 8.3, 8.9 and 8.7 percent per year. The curves are again based on Strout's analysis of FAO data.

Among the innovations that were once heavily supported and publicized but that have since fallen by the wayside one may remember fish-protein concentrate for human consumption and protein from single-cell algae grown on petroleum substrates. The proposals themselves are technically feasible, but they proved not to be economically viable and also resulted in food products people did not like. Opaque-2 maize (which has a high content of the essential amino acids lysine and tryptophan), antarctic krill and the wheat-rye hybrid triticale all seem to hold promise, but it is too early to predict their success. In short, it would be unwise to bank on technological breakthroughs for the long-term solution to food shortages.

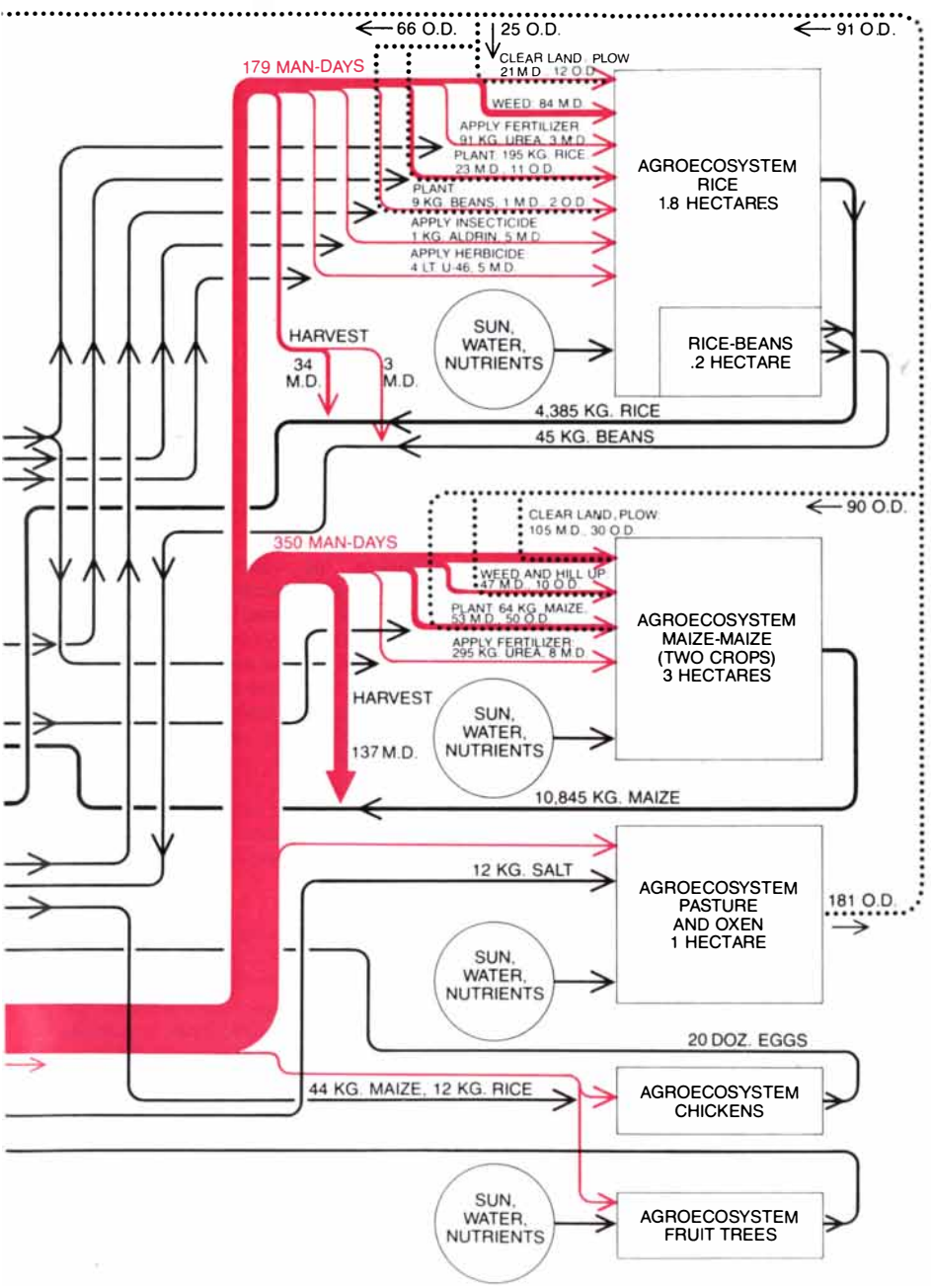
In retrospect one characteristic common to unsuccessful food innovations is that they were supported "from above" and had little relevance to the problems perceived by the people the innovations were supposed to help. A successful new technology has to fit the entire socioeconomic system in which it is to find a place. Security of crop yield, practicality of storage, palatability and costs are much more significant than the advocates of new technologies have recognized. For example, the better protein quality in tortillas made from opaque-2 maize is only a second-order benefit to a poor family on the margin of subsistence if the new maize does not match the yields of older varieties or is more vulnerable to insects. There is optimism that new high-yielding varieties of



INPUT-OUTPUT MODEL OF FARM SYSTEM in a small Honduran village, Yojoa, was constructed by Robert D. Hart, an agronomist with the Centro Agronómico Tropical de Investigación y Enseñanza in Costa Rica. For a year beginning in May, 1976, the owner of a typical small farm was interviewed weekly to record in detail all the flows of money, materials and energy on the farm. In the model money flows in a direction opposite to the flow of materials and energy. Most of the flows were associated with the flow of money. The farmer earned a total of $1,830 in the year by selling maize, rice, eggs and family labor and by renting out his oxen and an oxcart. His to-

opaque-2, with harder kernels to thwart insects, will be more widely accepted.

To such technical difficulties must be added a second set of complications: economic and political power relations strongly influence the outcome of those innovations that are put to use. In the Anglo-American tradition Schultz and most other economists stress private profitability as the key factor in guiding technical change. Actually profitability is neither a necessary nor a sufficient condition for a new technology to be adopted, let alone for it to benefit the poor. One example is the tendency for new methods to favor large landowners, as has been demonstrated in the case of Argentina by Alain de Janvry of the University of California at Berkeley. Amit Bhaduri of Jawaharlal Nehru University in New Delhi argues that efforts of peasants to break out of debt bondage by adopting more profitable rice-growing methods in West Bengal have been frustrated by village moneylenders who prefer things as they are.



tal expenditures for the year amounted to $1,648, leaving a net surplus of $182. There was a strong interaction among the "agroecosystems" represented by the farm. For example, the pasture-oxen system yielded 181 ox-days of energy, of which 90 were used in double-cropping the "maize-maize" system, 25 were used in the rice-bean system and 66 were rented for plowing and hauling. Some smaller labor inputs do not appear here because they were not recorded.

Innovations that carry high rewards for big agribusiness groups likewise may harm segments of the population and even reduce the availability of food in a country. For example, the production in some areas of Mexico of fresh vegetables for export to the U.S. worsens the food situation when the more profitable new crops take over land formerly used to grow staple foods. In Central America, to cite another example, modern beef-production operations have expanded greatly in recent years in response to a strong U.S. demand; not surprisingly the local price of meat has climbed steeply, further reducing consumption among the poor.

The details of any one of these examples can be debated but all of them contain an element of truth that most economists find necessary to accept. When a new technology promises to alter substantially the profits and losses associated with any production system, those who hold the balance of economic power will strive to maintain and improve their position. Since large segments of the population of many developing countries are close to the subsistence margin and essentially powerless, they tend to be the losers unless they are aided by a government policy that takes into account the needs of all sectors of the economy.

In spite of the above risks the sheer weight of growing population makes it essential that capital formation and technical change in the food system proceed. Moreover, the effort must be made in the third world itself. It is simply not feasible for the major grain-exporting countries (principally the U.S., Canada, Australia and Argentina) to create exportable surpluses large enough to meet the projected food needs of poor countries. Even if it were possible, there is no mechanism to ensure that poor people would have the money to acquire the grain that might be made available. External food aid is by its very nature incapable of solving distribution problems within the recipient country. Similarly, other proffered first-world contributions such as Western agricultural technology will fail or have harmful side effects unless they are redesigned to suit local circumstances. With all of that said, there are important areas in which agricultural research can be of decisive value.

One is the development of new ways to apply simple tools to the elimination of bottlenecks in food production. Readily utilizable energy is often a limiting input to agricultural production: energy for pumping water, threshing grain and tilling land for shortened crop intervals. Important work aimed at relieving this limitation is being done by a number of groups around the world. One broad goal of the work is the development of multiple-cropping systems for small farmers in the hope of increas-

ing yields, reducing the need for fertilizer and pesticides, conserving soil and raising productivity on small plots of land. The widespread adoption of multiple cropping will require local research, effective instruction methods and access to necessary credit. The potential of multiple cropping is nonetheless quite promising because the technology is naturally labor-intensive and can contribute much to rural employment and development.

Effective land reform, which might be called social engineering if not technology, fits in nicely with small-farmer innovations such as multiple cropping. Yields per acre are usually far higher on small landholdings than they are on larger farms, since families use their many hands to exploit what we have described as the intensive margin. With appropriate support facilities and appropriate technology land distribution to favor small-holder agriculture has already played a large role, and it can play a much larger one in improving both agricultural production and rural-income distribution.

On another front food losses in developing countries often exceed 20 percent for cereals and legumes because of rodents, insects and molds. The losses for fruits and vegetables in tropical countries are likely to be more than twice as high. Badly needed are new techniques of food storage and preservation designed for poor households and villages. The problem is the focus of a major program of the United Nations University.

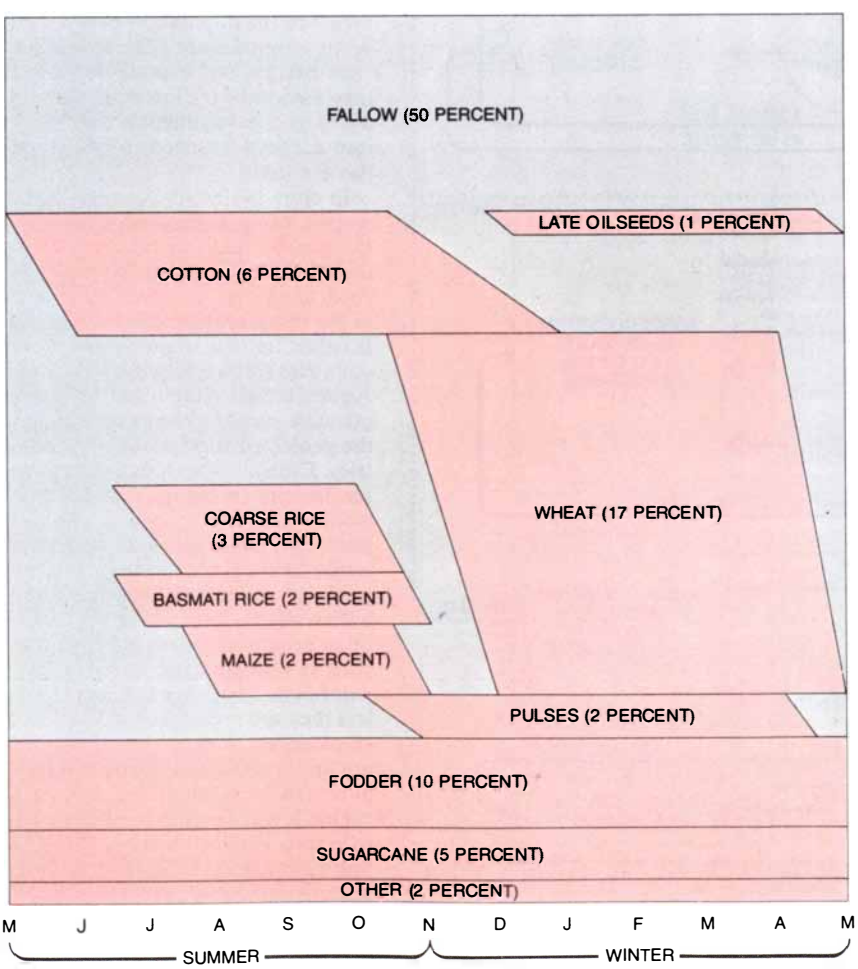
Western technology can also contribute greatly to the prevention and control of disease. The worldwide eradication of smallpox and the means to prevent measles and whooping cough by immunization are examples. The frequent episodes of diarrhea and other infectious diseases, coupled with the high prevalence of intestinal parasites in poor countries, decrease nutrient absorption and increase nutrient losses. The successful treatment of such afflictions requires health care that actually reaches down to individual poor families. A new program of the WHO has as its major purpose the delivery of primary health care [see "People," by Halfdan Mahler, page 66].

Finally, innovations in economic policy can be directed specifically to aid the rural and urban poor. Where land reform is politically feasible, it can secure both nutrition and employment for the poor. Food subsidies can substantially improve their nutritional status. Various methods have been employed, ranging from subsidized sales in special shops to food-for-work programs. A promising food-subsidy program is now being developed through the health-care system in Colombia. In Bangladesh the distribution of sorghum is being subsidized, and several countries are planning food-stamp systems for the poor. A more general redistribution of income would be even more valuable, but in many parts of the world that will not soon be achieved.

Producer incentives and technical imports can also be designed to help small landowners, sharecroppers and the rural landless. General price subsidies are usually not cost-effective because they are likely to benefit large producers and even industrialists rather than the low-income producers. Complex local power networks (often reflected at the higher level as well) may oppose or pervert price-subsidy policies for their own ends. Nevertheless, such programs should be instituted where they are needed.

Concern for macrolevel development, industrialization, advanced technology and transnational investment must be matched by concern and respect for the small farmer and for small food-production and food-processing activities. In some developing countries producer cooperatives are an important means of bringing increased resources and bargaining power to the small farmer. The result is not only improved food production but also higher incomes, less hunger and malnutrition and better overall health.

Food production and consumption are close to the core of all human cultures. Proper respect for what we do not understand about the operation of the food systems of individual countries and societies is needed to avoid mistakes. Programs should be tailored to regional and national circumstances. The final objective should be not only to ensure enough food to meet the effective demand (that is, food that someone will pay for) but also to see that human needs for food are met. This means that world food and nutrition problems cannot be solved by concentrating on production alone. Equivalent attention must be given to appropriate distribution and consumption. In most countries and most programs distribution has been slighted.



CROP CALENDAR OF A FARMER in the Punjab of Pakistan suggests the complexity of decisions he faces in choosing crops to maximize his return from a farm with a cultivable area of five hectares (12.5 acres). With irrigation he can obtain two crops per year, but at the same time he must allow for seasonal variations in supply and demand. Another major problem is having enough mechanical equipment and manpower available when he needs them. He must have enough of both on hand in November and December to plant wheat as he harvests cotton.

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