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ABSTRACT

Dimensions of the deteriorating world food situation are examined. Prepared for the congressional Subcommittee on Science Research and Technology and the Subcommittee on Domestic and International Scientific Planning and Analysis, the document focuses on the need to improve living standards of the rural poor in developing nations. The document is presented in nine sections. Section I presents an overview of agricultural development in poor nations and calls for worldwide cooperation to increase prosperity. Section II evaluates attempts to solve world food problems through synthetic foods, mechanized farming, and increased food production in the United States. Section III outlines a strategy to increase food production by introducing farmers to modern methods and providing financial assistance. Sections IV and V characterize economic needs and aspirations of developing nations. Section VI outlines agricultural research needs. Section VII reviews national and international programs dealing with agricultural research and development. Section VIII suggests how the United States can improve its agricultural research efforts. The final section concludes that hunger and poverty can be effectively reduced through technological and financial cooperation between developing and developed nations. (DB)

WORKING PAPERS

THE ROCKEFELLER FOUNDATION

THE WORLD FOOD SITUATION
A NEW INITIATIVE

BY STERLING WORTMAN

PREPARED FOR THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
AND THE
SUBCOMMITTEE ON DOMESTIC AND INTERNATIONAL SCIENTIFIC PLANNING AND ANALYSIS
U.S. HOUSE OF REPRESENTATIVES
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CONTENTS

During the past decade, there has been a growing awareness of the deteriorating world food situation. We now know of the urgent need for massive efforts to increase agricultural productivity in scores of developing countries and simultaneously to raise the incomes of hundreds of millions of their farmers and other rural people. It is hoped that such efforts, if successful, will buy time for population growth rates to be reduced.

The bulk of the basic food supplies of the agrarian nations are produced by the many farmers with tiny landholdings, often in remote and isolated areas, plus those people in coastal areas who depend upon near-shore fisheries and aquaculture for a livelihood. For the most part the gains in productivity and income of these rural people - the poorest of the poor - will require the development for and use by many farmers of new high-yielding, science-based crop and animal production systems tailored to the unique combination of soil, climate, biological, and economic conditions of every locality in every nation.

The Dimensions of the Challenge

More is at stake than meeting the food needs of people, important as that is.

First, in nation after nation, the rural people, who still comprise 50 to 80 percent of the population, are becoming restless. They are increasingly aware, as a result of mass communications, of the comforts of life enjoyed by small but affluent segments of their societies. Yet they see no hope for an improvement of their own conditions or those that their children will face, and continued neglect of the rural people will cause unrest, violence, and the overthrow of governments. These people want improved food supplies, housing, health care, and education. Their only realistic hope is through increased income, based

on increased productivity; few if any governments, nor any outside entity, can provide these basic needs free. These rural people must be helped to help themselves.

In my view, freedom as we know it is very much at stake. As the survival of the rural people is increasingly threatened, they are susceptible to any ideology that they perceive will provide the basic necessities and some of the amenities of life.

The People's Republic of China has one solution to the food and population problem. Last year it was my privilege to accompany a group of ten distinguished American scientists on a month-long study of China's agricultural and rural development. We found that China has thrown massive resources into an effort to increase agricultural productivity, to create other forms of employment in rural areas, and to improve incomes and standards of living for rural people. China has succeeded remarkably well, and deserves to be commended. Wherever we traveled on our 3,000-mile trip through several regions of the country, people were well fed, the children were in school, health care was provided, families had housing, and everyone was working - all this, of course, with a high degree of regimentation and with state control over the mobility and thinking of the people. Groups in other countries are becoming aware that China, and perhaps others, have a solution to the food, population, and poverty problem.

It seems fair to conclude that the struggle for individual freedom as we know it largely will be won or lost in the impoverished rural areas of the less-developed countries. The central question before us is: Can ways be found to meet the basic needs of the masses of rural people while offering individual freedom rather than severe regimentation? Taiwan and Japan have succeeded as well, and pro bly better, than the People's Republic of China, but there are few other developing countries that have as yet attempted systematically to raise productivity and income of their rural people.

Second, continued neglect of agricultural and rural development abroad will affect adversely American farms and other businesses, particularly as they involve international trade. Agriculture is the basic industry of most developing countries. If productivity of large numbers of small farmers can be increased in the poorer countries, and if for added millions of farm families there is an increase in disposable income, markets will develop for imported food supplies and for products of urban industry. Employment will be generated in rural trade centers as demands for goods and services increase. As standards of living improve, there will be new outlets for American products as well as for those of other countries. Clearly it is in the interest of the United States and its business community to promote prosperity in the countrysides of the developing nations, since this could lead in most cases to general economic development and increased ability of nations to trade internationally for products, farm or industrial.

Third, higher food prices world-wide will accompany continued neglect of agricultural development abroad. Most subsistence farmers, using little power other than human labor to cultivate impoverished soils, eke out their livelihood by producing basic food crops (table 1) and some animal species. If their productivity remains low and static, food deficits will continue to climb as they have since the 1940's, and prices of food in the United States and elsewhere will continue to rise because of tightness of markets. It certainly is in the interest of the American consumer that productivity of food crops, even those we grow in the United States, be increased in the poor countries.

In most discussions of the rationale for U.S. assistance to poor countries, the humanitarian aspects are properly stressed. But there are other reasons as well. If the United States has any interest in the expansion of world markets, in the retention

of open markets for U.S. products, in the preservation of individual freedom, and in the maintenance of food prices at reasonable levels, it should turn much more seriously to the task of assisting nations to improve their agricultural productivity and increase the prosperity of their rural people.

The challenge is one of urgency. It calls for massive, long-range, world-wide cooperative efforts following a strategy that, fortunately, is reasonably well understood by a number of authorities. The U.S. could provide much of the needed professional and scientific leadership, for we have expertise in our universities, in the U.S. Department of Agriculture, in industry, and in some private organizations. We now need to establish the strategy, make it known, provide the necessary funding on a sustained basis, and organize our efforts to make them more effective.

Three Nonsolutions

There are three often-mentioned "solutions" that are important but do not address the basic causes of the world food problem.

First, increased production of food in the United States is not a solution. We must find ways to increase the productivity of our own agriculture to allow this nation to continue its international trade, to maintain its balance of payments, and to enable it to respond to emergency needs for food anywhere associated with calamities. However, continuing allocations of food aid to governments who neglect their own rural areas is counterproductive: that simply allows governments to put off the relatively tedious and unglamorous task of enabling their own people to help themselves.

Second, U.S.-style, large-scale mechanized farming in the developing countries is, generally speaking, not a solution. While large-scale farming may be quite useful in some thinly

populated areas of some countries, and may be helpful to nations needing to get food supplies under national control quickly, there remains the problem of distributing the resulting food to the hungry, who have no money. Some argue that products from such large farms would be destined for urban consumers, but this would only deprive the small farmers of markets for their own produce, with all of the adverse consequences discussed earlier.

Moreover, most large-scale mechanized agriculture is by its very nature less productive per acre or hectare than small-scale farming can be.

The farmer with a small landholding, as in Asia (table 2), can use very intensive, very high-yielding systems of "gardening" involving intercropping, multiple cropping, relay planting, and various other techniques that require attention to individual plants. U.S. agriculture is highly productive from the standpoint of output per man-year of the operator's time, but it is not as productive per unit of land as are the highly intensive systems used in part of Asia and elsewhere. And amounts of arable land per person are already only a fraction of an acre in some countries.

The third nonsolution to the general world food problem is the production of synthetic foods, single-cell protein, or food combinations. These may be quite useful, but they must be purchased by someone, the hungry have no money, and these approaches offer no increase in incomes for the poor.

Main Elements of a Strategy

A principal objective of the world-wide effort mentioned earlier must be to increase incomes of rural dwellers, bringing them into the market economy. Most such farmers produce basic food crops (table 1) or animals for home consumption, barter,

or sale locally. The strategy deals with both sides of the food-problem equation: increased production of food and increased purchasing power of masses of the poor.

Meeting Farmers' Requirements

Farmers, even those who are uneducated and have small landholdings, will adopt new systems provided that four conditions are met:

1. There must be available to them more highly productive and more highly profitable farming systems. These systems must be complete. For crops, this means suitable varieties, plus fertilizer-use practices, plus means of disease and insect control, plus associated cropping practices. Development of such systems involves sophisticated work which properly trained scientists can do, but which is beyond the capabilities of the usually poorly trained "extension specialist."
2. The necessary inputs - fertilizers, seed, pesticides, and credit - must be available to the farmer when and where he needs them, and at a reasonable price. Systems for distribution of these products in the rural areas must be in place, and must function.
3. The farmer must be shown, usually on his own land or that of a neighbor, how to utilize effectively the new technological system. Again, the average extension agent, normally a purveyor of information, is useless in such a situation. In developing countries, the agent must be able to outfarm the farmer as well as have command of new technology. For this reason, the term "extension agent" is being abandoned abroad in favor of "production specialist" - denoting a person with sufficient technical and farming skills to work with farmers in experimenting with new systems on their own lands.

4. The farmer must know before he invests in new plantings or other operations that there will be at harvest a market for his product at a price upon which he can depend, for the small farmer cannot take great risks. A "market" requires roads, transport, effective demand for products, favorable prices.

Forcing the Pace

Well-organized campaigns are needed now to force the pace of agricultural development, moving it at a speed with which few nations have had experience. There must be fast-moving scientific efforts to develop the technology including the identification of the complete new systems for use at the farm level. Provisions must be made for the supply of the inputs and for marketing. Road networks need to be extended, both for supply of inputs and for marketing of produce. Power grids must be elaborated, means of using the media must be devised, systems of providing credit to small farmers, requiring additional innovation, must be set up - in short, the full range of institutions required for a market-oriented agriculture must function. Great numbers of people will need to be trained, mostly on the job, as they participate in direct effort to develop agriculture and rural areas.

Involving the Universities

Some authorities now believe that the long-term development of higher agricultural educational institutions can be justified only if the personnel of those institutions are from the outset actively involved with other agencies in acceleration of agricultural development. Faculty must not be aloof from the day-to-day work of development; the time-span for action in poor countries is too short, and it is a waste of scarce manpower. Our universities represent a magnificent resource to assist institutions of other countries to become so involved, but all should

understand that universities abroad, with their concentrations of talent, must be at the forefront of drives for increased production and prosperity - and immediately.

Assignment of Responsibility

The government of each nation must be responsible for the food supply of its own people and for the development of its rural areas. Only the individual government can determine amounts to be imported or produced locally. Only the government can set the policies, strengthen the institutions, and reach the farmers. Outside agencies can assist, and assist they must, but that is all they can do.

Our nation, and others, can and must help devise and implement strategies, provide technical assistance and funds for foreign-exchange components of programs. Increasing orders of magnitude are indicated, both on a bilateral and a multilateral basis. Wise investments in agricultural research, training, and development by an agrarian nation yield among the highest returns.

Creating the Will to Act

Finally, developing-country governments must have the will to embark on well-organized, long-range agricultural development efforts. Until recently, this desire too generally has been lacking. Some feel, as I do, that availability of continuing food aid has contributed to complacency. At any rate, increasing numbers of political leaders of poorer countries now seemingly want to take action, and are requesting help.

Characteristics of the Developing Countries

In considering the nature of technical assistance required by the developing countries, it is important to realize how varied a set of conditions they present.

In mid-1973 the world population was 3.86 billion, with an annual rate of population growth of 2.0 percent, a projected

doubling time of 35 years, with over a billion people to be added by 1985 (table 3). Of this increase, about two-thirds (670 million) were expected to be added in already overpopulated Asia.

Most of the developing countries are quite poor by North American or European standards (table 4). In 1970 the U.S. per person gross national product was $4,760; for Canada, $3,700; for the U.S.S.R., $1,800. Of 151 nations listed by the Population Reference Bureau in 1970, there were 94 with per capita gross national products of less than $500. The nations are terribly poor and, generally speaking, income levels among the masses of the rural people are well below the average in each individual country.

The nations vary markedly in size. Of 162 United Nations members and geopolitical entities in 1973, 34 had populations of less than 1 million, and 108 had less than 10 million people (table 5). These smaller nations cannot expect to have the full range of scientific and other professional services required in all of the fields of activity important to their development. They must in many cases rely on external scientific and other resources for expertise, particularly in view of the low incomes associated with their small size.

Many of these nations have achieved independence since World War II, particularly with the breakup of the great empires. Of 43 nations listed as "least developed" or "most seriously affected" by the recent economic crisis, 36 have become independent since 1945, and 29 since early 1960. In general, the colonial powers did much to develop the export crops and some animal species destined for sale abroad, but the basic food crops were neglected. It should be recalled that a quarter-century ago there was not the same pressure of population on the land that exists today in these same countries. People generally were left to shift for themselves with regard to their food supply. Consequently, while

numerous centers for research on coffee and cacao or rubber or jute were established decades ago, few such centers were established for wheat, corn, rice, the food legumes, root crops or vegetables, or other basic crops.

The developing nations now have governments that must give attention to the needs of their people if the governments are to survive, and a new political will to deal with agriculture is emerging. The departure of expatriates left most nations without expertise, with weak institutions, and in many cases without the reliable sources of supply or market outlets that previously existed.

In governments of most developing countries, persons in authority are military men, lawyers, businessmen, medical doctors, engineers, economists, or religious leaders. Few know much about agriculture or the science that underpins it, which means that science-based agricultural development opportunities must be described to them in terms that are understandable - a reasonable requirement.

The Basis for Hope

Given the complexity and the magnitude of the development task that lies ahead, it is fair to ask if there is any hope. The answer is yes. In my view, there have been a number of developments in recent years that suggest that the world now has the capability, perhaps for the first time in history, to deal with the food and poverty problem effectively. Let me list some of these hopeful developments.

First, the nature of the problem has become understood, but only recently. Projections of food requirements to the end of this century were probably first made in 1963 by Dr. Lester Brown of the USDA. The data suggested that imports by the less-developed countries might reach 68 million tons by the year 2000. Two years later Dr. Brown pointed out that before 1940 "the less-developed regions of Asia, Africa, and Latin American were all net

exporters of grain. Together they exported each year on a net basis 11 million tons of corn, wheat, rice, and other grains to the developed world. At the close of World War II, however, the less-developed world had lost its export surplus of grain, and the net flow of grain was reversed, moving from the developed to the less-developed world." The developing countries imported an average of 4 million tons of grain from 1948 to 1952. This increased to 13 million tons annually during the 1957-1959 period, to 20 million tons in 1961, and to about 25 million tons in 1964. Dr. Brown concluded then, "According to the above indicators, one thing is evident. The less-developed world is losing the capacity to feed itself."

In 1966-1967 some 125 American scientists and other authorities undertook the first comprehensive appraisal of the newly recognized world food problem. They presented their recommendations in a 127-page summary report entitled The World Food Problem, supported by two additional volumes of background information. Last year a committee under the auspices of the National Academy of Sciences reviewed that now-classic report to the President and concluded that its findings are still generally valid and are still generally being ignored.

Since 1967 the Green Revolution has occurred, and the world has begun to mobilize for a major scientific and organizational effort to deal with some of the major technical and organizational problems. Increased production of the basic food crops everywhere has at last been accepted as a primary solution to the world food problem. And increased productivity and profitability of millions of farms large and small in developing countries everywhere has been recognized as a prerequisite to the economic development of those nations.

Second, the opportunity for improvement of agriculture is great. Much idle land in some countries still can be brought under crops, although amounts differ markedly among regions (table 6).

Also, yields of most food crops in most poor countries are still extremely low. For example, according to FAO figures for 1970, there were 126 countries in which corn was produced in significant amounts. For that year, the highest national average yield in the world - 7.2 tons per hectare - was obtained by New Zealand. For the U.S. (using 1971 data because 1970 yields were abnormally low), the average was about 5.5 tons. But there were 78 countries with national average yields under 1.5 tons, and 108 under 3.0 tons! The yield gap is large. This represents the world's greatest food reserve - on which nations now must call.

Third, the nature and limitations of technology transfer are reasonably well understood. The biological components of agricultural production systems generally must be developed in the regions in which they are to be used. The lack of food crop and animal research in tropical and subtropical areas has led to the establishment of ten international agricultural research and training centers in Asia, Africa, and Latin America. Their work is financed by a consortium of national governments, international agencies, and foundations, the support having grown from about $15 million in 1972 to a projected $65 to $68 million in 1976. A promising new approach to international cooperation has been established, at least in this area of scientific work.

Fourth, it has been demonstrated that governments can increase agricultural productivity rapidly if they will, and that farmers will change if they can. Only in very recent years has there been evidence that the small farmers can be reached if scientific and organizational efforts truly are directed to their needs.

Fifth, fertilizers are becoming available in sufficient quantity to allow their use for basic food crops in developing countries. At the turn of this century, chemical fertilizer production totaled only about 2 million tons. From then until World War II, there was only a gradual increase in production

and use, reaching about 7.5 million tons. Then production leaped ahead. From 1945 to 1955 production tripled to 22 million tons, doubled again by 1965, and now is approaching 80 million tons per year. The increase in fertilizer output and spread of fertilizer use to the vast areas in basic food crops in the developing countries are hopeful developments and must be encouraged.

Sixth, most major financial institutions and technical assistance agencies have greatly increased their emphasis on agricultural development. Among them are the World Bank and USAID. The world has in place most of the necessary assistance institutions to allow a world-wide agricultural development effort to be organized and financed.

Seventh, there is increasing evidence that national authorities of many of the developing countries, for reasons mentioned earlier, are now seriously interested in promoting their agricultural development and improving the standards of living of their rural people.

Eighth, while many mistakes have been made in the past in agricultural and rural development efforts, much has been learned recently about the development process and how to make it work at the accelerated pace required.

U.S. institutions have had relatively little experience in forcing the pace of agricultural development. For the past two decades, food generally has been in overall surplus supply in the U.S., and there has been no incentive to undertake a campaign to increase food production in this country; in fact, we have been more concerned with limiting output.

The surpluses during recent decades also indirectly limited the effectiveness abroad of our U.S. assistance efforts in agriculture. Until the late 1960's, it was U.S. policy not to support work on the major food crops abroad. Many authorities in and out of government believed that production elsewhere would adversely

affect U.S. sales of agricultural products, and that in any event the U.S. probably could cover the supposedly occasional deficits of the developing countries. But, by 1969, U.S. and Canadian aid agencies generally had been freed of such restrictions, and they began for the first time to support work on crops such as wheat, corn, and rice. That, in my view, was a major turning point in world efforts to deal with the food problem.

With provisions being made for development of some of the technology needed, with the increasing capacity to produce fertilizers, with the financial mechanisms in place to facilitate a world-wide effort to improve agriculture, with a new willingness on the part of professional leaders to take their rural development problems seriously, with the emergence of a strategy, the world seemingly has the capability to deal effectively with the problems of food and poverty - for the first time in history. It could not have done so five years ago.

Needs for Research

Needs for research must be dictated by the nature of the problems to be solved. One of the difficulties in dealing with the subject of research, at least for me, has been the lack of adequate terminology. Perhaps we should consider agricultural research in terms of the needed forced-pace campaigns, borrowing in part from the military. A spectrum of research efforts is needed - operational, tactical, strategic, supporting, and basic.

Operational or Farm-Level

This involves the identification - through experimentation on farms - of the specific combinations of crop and animal production practices that will provide maximum productivity and profitability on those farms. Much of this vast amount of research - or innovation, as some would call it - has been done by farmers themselves, particularly in the United States.

In the developing countries, most farmers have little education and are unaware of the vast array of technologies that they might employ. They cannot experiment or innovate as do their more sophisticated and better-educated American counterparts. Therefore, in the developing countries, the scientists must direct development of the local farm systems, and for the most part they must do so in representative farms of those nations. Perhaps 70 percent of the world's agricultural scientific manpower must be engaged in operational experimentation.

Tactical

In each nation, supporting the farm-level research effort, there must be one or more teams of scientists identifying or developing new varieties for possible use in those regions, developing fertilizer-use practices, testing and developing methods for control of locally prevalent diseases and insect pests, identifying new crop or animal production practices, and undertaking such other lines of work as best can be performed at regional experiment stations. Generally, tactical research is that undertaken for the specific purpose of identifying improved components of farming systems that operational people can combine as required to meet needs of farmers in particular localities.

Strategic

This category of research is aimed at the solution of those major problems affecting several areas of a country or a region of the world, or at the development of entirely new approaches to the removal of major barriers to improved production of a particular crop or animal species.

Such research should be in direct support of scientists engaged in tactical research in several regions of a single

country or in several countries - efforts aimed at putting scientific advances immediately to use as they are developed. Most of the main lines of research at the international agricultural research institutes at central experiment stations of the larger nations, and of our own major state experiment stations, would be of the strategic type.

Supporting

These fundamental but purposeful investigations generally are undertaken and financed because of the probable usefulness of findings in ways only partially known. Much of the supporting research related to the world food effort is being done by national agencies or at universities of the developed countries. One might include in the supporting category such efforts as work on nitrogen fixation and its potential applications to the grasses, on photosynthesis or respiration processes of economic crop plants, or on the nature of organisms causing plant or animal diseases.

Basic

Research undertaken to develop knowledge for its own sake with no predetermined use in mind. This is an important category of research on which all supporting, strategic, tactical, and operational advances depend.

An Example: High-Lysine Corn

Work on high-lysine corn illustrates such a spectrum of research efforts. Out of basic research on plant genetics came the capability to identify individual genes and their effects on organisms. This permitted the discovery of the opaque-2 and floury-2 genes in maize, which confer higher nutritional value upon the grain. Since that discovery at Purdue University, USAID has been financing supporting research at Purdue aimed at clarifying the nature of these genes and of ways in which their effects can be modified genetically.

At the International Maize and Wheat Improvement Center in Mexico, scientists are working deliberately to incorporate the opaque-2 gene into 29 maize populations and simultaneously to incorporate desirable grain characteristics, shortened plant height, and other generally desirable features; this is strategic work.

In a number of nations, scientists at the tactical level are testing high-lysine strains of corn from Mexico and elsewhere for potential use in their highland, middle-altitude, or lowland regions.

Finally, promising varieties containing the opaque-2 genes must be put into test at the farm level to determine the specific advantages or disadvantages they may have and to identify the specific combinations of practices that will be required to obtain highest yield and profitability on local farms; this is innovation or research of the operational type.

At any particular research center, one actually will find a mixture of these types of research, and it is not suggested that any category of research should be the exclusive responsibility of research groups at any given level in the system. It is important to point out, however, that any effective work at the strategic, tactical, and operational levels, wherever it is occurring, is possible only because of the past advances in research of the basic or supporting types. Conversely, support of basic, supporting, or strategic research will be of no value to mankind unless its benefits reach the farmer through the tactical and operational research avenues.

The entire system must exist and function. A substantial start has been made internationally toward that end, and this has major implications for the United States.

National Programs

In a growing number of developing countries, major efforts are under way to accelerate agricultural research and development.

Malaysia is planning a multiyear, $108 million program to strengthen its national research establishment, aided by a $28 million World Bank loan.

Indonesia plans to augment her present efforts with a $40 million, five-year program of improvement of work on rice, upland crops, highland vegetables, and rubber.

Brazil has a massive new federal program, involving several hundred million dollars, and the current training abroad of hundreds of agricultural scientists.

Guatemala has established a new national scientific and technological institute for agriculture (ICTA is its Spanish acronym) that is emphasizing increased production of several major commodities in the major regions of the country.

India, through its Indian Council for Agricultural Research and its agricultural universities, is becoming a leader in diverse types of agricultural research.

There are reports that a massive effort is under way in the Soviet Union to strengthen its agricultural research efforts, presumably mostly of the supporting type.

Many other examples could be given. The point is that there is a spreading movement among the nations of the world to bring advances of science to bear on the productivity of agriculture. These efforts in each country must, regardless of the nation's size, meet the needs for operational- and tactical-level research and innovation; and in the larger nations, there will be strong elements of strategic or even supporting research as well.

International Centers

Serving all nations is the new network of international agricultural research institutes supported by the Consultative Group on International Agricultural Research:

- The International Rice Research Institute (IRRI), in the Philippines
- The International Maize and Wheat Improvement Center (CIMMYT - from the Spanish), in Mexico
- The International Center for Tropical Agriculture (CIAT - from the Spanish), in Colombia
- The International Institute of Tropical Agriculture (IITA), in Nigeria
- The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in India
- The International Livestock Center for Africa (ILCA), in Ethiopia
- The International Laboratory for Research on Animal Diseases (ILRAD), in Kenya
- The International Potato Center (CIP - from the Spanish), in Peru
- The International Center of Agricultural Research for Dry Areas (ICARDA), with headquarters to be in Lebanon and Syria

In addition, there is the West African Rice Development Association, the Asian Vegetable Research and Development Center in Taiwan, and a new International Board on Plant Genetic Resources, with headquarters in Rome.

Each of these centers or programs is under the guidance of a board of trustees comprising eminent world authorities. Each receives a major proportion of its funding from members of the Consultative Group. Support of this system was one of the few activities receiving the general approval of nations at the World Food Conference. Interestingly, some of the oil-producing

nations already have begun to provide support to these activities through the Consultative Group; among the most recent new members are Iran, Saudi Arabia, and Nigeria.

These institutes offer strategic support for the many new national efforts, and some are heavily engaged in assisting nations directly with their in-country tactical or operational programs.

Centers of Specialization

The aid agencies of the United States, United Kingdom, Canada, the Federal Republic of Germany, and the Scandinavian countries, to mention a few, are making efforts to involve major research centers in their own countries in cooperative research with the international research centers or major programs of developing countries. In the United States, for example, Texas A & M University is working with CIAT on tropical animal diseases; several U.S. universities are cooperating with CIP or CIAT on potato and bean research respectively; and Oregon State University is working with CIMMYT and the Turkish national program on the improvement of winter wheat and the crossing of spring and winter types. Kansas State University is working with CIMMYT in attempts to develop entirely new crop plants by attempting to intercross major species - a technique that until recently has not been promising. Many other opportunities exist for cooperative research between U.S. institutions and those abroad, with benefits both to the developing nations and to U.S. farmers and consumers.

Basic research, so important to the entire effort, continues to be supported mainly in the United States, Canada, the European nations, the Soviet Union, Japan, and Australia.

These major new developments in agricultural research are of importance to the United States, for they will affect both our technical assistance effort and the improvement of our own agriculture.

Implications for the United States

While recognizing that the U.S. research effort still is second to none, and has a record of achievement of which we can be proud, there still are many ways in which it could and should be improved.

Basic Research

Basic research in this country is promoted primarily by the National Science Foundation, certain of the federal agencies, by industry, and by some private groups. Major investments have been made in the physical sciences, as a result of interest in space, in national defense, and in energy. And in the biological sciences considerable attention has been given to fields associated with the nation's interest in medicine. Some contend, however, that the biological sciences, other than those related to National Institutes of Health interests, have received relatively less support. If so, the imbalance should be corrected.

Supporting Research

The category of supporting research is receiving far too little financial support when one considers the importance of sustaining U.S. agricultural progress, of maintenance of reasonable food prices at home, of alleviation of food deficits and poverty abroad, and of increasing the efficiency of production abroad of those foods that are now imported and will continue to be in the future. The present weakness of our efforts probably can be attributed in part to the decades of surplus food production in this country and the understandable reluctance during that period to increase funds for production-oriented agricultural research at a time when surpluses were so costly to maintain. The weakness can also be attributed partly to the provincial nature of our agricultural research establishment. Because for decades our own research efforts have been so strong relative to those of other countries, involvement in international activities may not have

seemed useful or attractive. But that situation is changing rapidly, as research activities elsewhere are increased. One could cite many examples of the types of supporting research that are needed now, but mention of a few will illustrate this point.

First, the U.S. long has been a leader in plant exploration. An opportunity now exists, in cooperation with others, to systematically collect a wide range of major and little known plant species and to evaluate them for utility as major new sources of food, fiber, or for industrial purposes. The USDA could do this particularly well.

Second, animal diseases abroad continue to keep productivity low and prevent effective harvest for man's use of grasses and other forage plants; and some diseases represent a threat to this nation's ranchers if they should be introduced here. The U.S. should have, within three years, at least three or four major university or USDA research groups working intensively to identify effective controls for those major animal diseases endemic in Africa, Asia, and Latin America.

Third, major advances will be made abroad with the larger number of crop plants in the tropics and subtropics in the years ahead. Yet the U.S., as a leader in world agricultural research, has very limited knowledge of tropical agriculture, and that which exists is scattered among many individuals and institutions. The U.S. does not have a single major interdisciplinary center of tropical agriculture under its own flag. At minimum, the U.S. should have, within three years, one major research center in the Caribbean oriented toward cooperative work with the Latin American nations, and one in the Pacific concerned with cooperative work with nations and institutes of Asia. Such centers should be federally supported and should be under the guidance of boards comprising distinguished American authorities. Each center should provide a training ground both for substantial numbers of

young U.S. scientists and for personnel of other countries. Efforts should be made to stimulate the flow of information to the U.S. as well as to other countries. The centers should provide facilities at which students and faculty of our many universities could obtain experience and conduct research in tropical agriculture, perhaps combining research at the tropical centers with courses at participating universities, which would award any degrees.

Fourth, certain tropical diseases are rampant in many of the developing nations. The U.S. seemingly could make a major contribution to the alleviation of world suffering by arranging for three or four of our major centers of medical research to seek, on a continuing basis and in cooperation with others, effective means of control of the more important diseases, on a forced-pace basis.

Fifth, the more fundamental but purposeful work on our major food, fiber, and animal species - the supporting type - clearly has been neglected in this country during the years of surplus food production. Reportedly, National Science Foundation funds for basic research have not been available because such purposeful work was considered to be "applied." Meanwhile, funds for this work were not increased because of existence of costly surpluses. In short, it appears that this entire area of highly important work has fallen through a very wide crack in our national research effort.

The United States, through USAID, has been a major supporter, both financially and intellectually, of the system of international agricultural research institutes. That contribution of the United States is highly respected around the world and should be continued. Currently, the United States provides up to 25 percent of the budgets of approved programs of these centers - a reasonable level of U.S. support for a truly multilateral endeavor.

Technical Assistance Management

The United States should maintain a strong bilateral technical assistance program. The activities of the international banks and the international assistance agencies are improving and deserve continued and expanded U.S. support. However, the U.S. would do well, in my view, to maintain a strong bilateral program, for there is great strength in a pluralistic approach. It also should be emphasized that since 1969, when USAID first began to support intensive work abroad on major crop and animal species, it seemingly has greatly improved its knowledge and the effectiveness of its operations.

The task ahead is of such magnitude, and the implications for the United States are so important, that a permanent organization with the mandate to develop a U.S. strategy, and with funds to implement it, would seem urgently needed. It should have the major responsibility for effective U.S. involvement in a world-wide effort that would be, because of the biological, social, and political variables involved, far more complex than that of the space program. Our nation has the men of wisdom with the requisite experience to guide a new initiative. Activities in the research and development area are by their very nature long-term, and thus require a continuing effort with the institutionalization of knowledge. The effort would require the involvement of many of our universities, USDA and other agencies, our industry, and the many groups in this country that are ready and able to participate in a concerted, well-guided effort. To be effective, it would have to be freed to the degree feasible from varying political objectives and divorced from association with military assistance.

The United States needs a more coherent and substantially expanded program of grants to U.S. investigators concerned with

improving the productivity of agriculture at home and abroad, of grants to U.S. institutions to allow them to cooperate with institutions abroad on a long-term basis without jeopardizing their primary responsibilities to their own states or regions, of training awards to young people in the U.S. to allow them to obtain experience abroad as they contribute to the common undertaking. While the effort needed is great and complex, it need not be nearly as costly as the space program, for much of the cooperative activity elsewhere must be financed, and can be financed, by others.

A Magnificent Opportunity

Going back to an earlier theme, the world now has, for the first time in history, the capability to deal effectively with the problems of hunger and poverty. The future of our own children and our nation is clearly intertwined with that of people and nations elsewhere, and the wisdom of this nation's choices in the immediate future will markedly affect the nature of the world in which the next generations will live. While the food, population, and poverty problem is massive and complex, and will be extremely difficult to resolve, the existence of the world's new capabilities offers a magnificent opportunity, perhaps a fleeting one, to deal with it effectively, if governments have the will and the wisdom to act.

Table 1 The major basic food crops by region, 1971

	Developing Countries, by Region				World	
	Africa	Latin America	Near East	Far East	Developing	Total
Cereal Grains (millions of hectares)						
Rice	3.6	6.6	1.1	80.7	92.0	134.1
Wheat	6.9	8.7	19.7	24.8	59.6	217.7
Maize	10.9	26.7	1.8	13.1	52.6	111.6
Sorghum	10.2	3.8	3.5	17.4	34.9	42.7
Millets	14.1	0.4	0.9	19.8	35.3	68.0
Barley	4.8	1.3	5.4	3.6	15.1	79.7
Oats	0.1	0.6	0.3	-	1.0	31.3
Rye	-	0.5	0.7	-	1.1	18.7
Food Legumes (thousands of hectares)						
Soybeans	173	1,890	15	1,023	3,101	36,464
Dry beans	2,676	6,437	141	8,183	17,436	23,272
Groundnuts	6,426	1,209	472	2	16,689	20,040
Dry peas	532	176	7	947	1,631	8,988
Broad beans	464	307	184	-	956	4,706
Chick-peas	565	234	248	8,960	9,979	10,236
Pigeon peas	147	50	-	2,734	2,930	2,930
Cowpeas	4,747	7	8	32	4,787	4,847
Root Crops (thousands of hectares)						
Potatoes	270	1,127	257	719	2,373	22,294
Sweet potatoes	1,255	406	137	18	2,824	15,257
Cassava	5,743	2,597	200	2,165	10,716	10,836

Source: FAO Production Yearbook, 1972.

Table 2 Distribution of farm size in Indonesia, Bangladesh, Pakistan, and India

Area, Hectares	Indonesia (1963) percent	Bangladesh (1960) percent	West Pakistan (1960) percent	India (1961) percent
.4	45	24	15	-
.4-1.0	26	27	18	39[3]
1.0-2.0	18	26	16	23
2.0-3.0	5	12	12	13
3.0-5.0	3	7	16	15
5.0-10	2[1]	3	15	6
10-20		[2]	6	5
20-60			2	
60			[2]	

[1] Amount is for over 25 acres.

[2] Less than 0.5 percent.

[3] Amount is for all holdings under 2.5 acres.

Source: Falcon, Walter P., "The green revolution: second generation problems." American Journal of Agricultural Economics, Vol. 52:5, 1970, p. 707.

Table 3 World population data by region, 1973 estimates

	No. of Countries	Population (millions)		Growth Rate (%)	Years to Double
Africa		(374)	(530)		
Northern	6	95	140	2.7	26
Western	16	110	155	2.5	28
Eastern	15	106	149	2.5	28
Middle	8	38	52	2.1	33
Southern	5	25	34	2.4	29
Asia		(2,204)	(2,874)		
Southwest	16	84	121	2.8	25
Middle South	10	828	1,137	2.6	27
Southeast	12	313	434	2.8	25
East	8	978	1,182	1.7	41
Americas					
North	2	233	263	0.8	87
Middle	7	75	112	3.2	22
Caribbean	11	27	36	2.2	32
South:					
Tropical	8	165	236	3.0	23
Temperate	4	41	51	1.7	41
Europe	29	472	515	0.7	99
USSR	1	250	287	1.0	70
Oceania	4	21	27	2.0	36
WORLD	162	3,860	4,933	2.0	35

Source: 1973 World Population Data Sheet, Population Reference Bureau, Inc., Washington, D.C.

Table 4 Per capita gross national product of countries in Africa, Latin America, and Asia, 1970

Per Capita GNP (dollars)	Africa	Latin America	Asia[1]	North America Europe Oceania	Total
Less than 100	12	-	8	-	20
100 - 249	25	2	15	-	42
250 - 499	9	11	12	-	32
500 - 749	1	8	2	3	14
750 - 999	2	5	2	3	12
1000 - 1999	1	3	1	6	11
2000 - 2999	-	1	-	13	14
3000 - 3999	-	-	-	4	4
4000 or over	-	-	-	2	2
	50	30	40	31	151

[1] Oil producing countries omitted by authors; Fiji and Papua-New Guinea included.

Source: 1973 World Population Data Sheet, Population Reference Bureau, Inc., Washington, D.C., Original data from World Bank.

Table 5 Populations of United Nations members and of geopolitical entities, 1973[1]

Region	Population in Millions							Number of Countries
	0.1-0.9	1.0-4.9	5.0-9.9	10.0-19.9	20.0-49.9	50.0-99.9	100+	
Africa								
Northern	-	1	1	3	1	-	-	6
Western	3	9	3	-	-	1	-	16
Eastern	3	5	4	2	1	-	-	15
Middle	2	3	2	1	-	-	-	8
Southern	3	1	-	-	1	-	-	5
Asia								
Southwest	7	4	3	1	1	-	-	16
Middle South	3	-	-	3	1	2	1	10
Southeast	1	3	1	2	4	-	1	12
East	1	2	-	2	1	-	2	8
Americas								
North	-	-	-	-	1	-	1	2
Middle	-	5	1	-	-	1	-	7
Caribbean	5	4	2	-	-	-	-	11
South	2	2	2	3	2	-	1	12
Europe, USSR	3	6	8	4	4	4	1	30
Oceania	1	2	-	1	-	-	-	4
Totals	34	47	27	22	17	8	7	162

[1] Includes only those entities having populations in excess of 200,000.

Source: 1973 World Population Data Sheet, Population Reference Bureau, Inc., Washington, D.C.

Table 6 Estimated amounts of cultivated land by region, compared with potentially arable land, 1965, versus amounts outside the humid tropics

Region	Area in Millions of Hectares							Cultivated Land			
	Total	Potentially Arable		Cultivated		Potentially arable not cultivated		As percent of area potentially arable		Per person (hectares)	
		(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Africa	3,019	732	500	158	160	574	340	22	32	0.5	0.5
Asia	2,736	627	465	518	470	109	-	83	101	0.3	0.3
Australia, New Zealand	822	154	120	16	20	138	100	10	16	1.2	1.4
Europe	478	174	170	154	150	20	20	88	88	0.4	0.3
North America	2,108	465	450	239	240	226	210	51	53	0.9	0.9
South America	1,752	679	370	77	80	602	290	11	21	0.4	0.4
USSR	2,234	356	350	227	230	129	110	64	66	1.0	1.0
WORLD	13,148	3,189	2,425	1,388	1,350	1,801	1,350	44	56	0.4	0.4

Sources: (1) "Water and Land" in The World Food Problem, Volume II, Report of the President's Science Advisory Committee, USA, May 1967.

(2) Outside the humid tropics, Revelle, Roger, 1974. Population and Resources. Research Paper No. 5, Harvard Center for Population Studies.

Note: This is a partial list of figures. Totals include areas not represented on table.