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International Technology Transfer

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International Service for National Agricultural Research

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing and operations.

Of the thirteen centers in the CGIAR network, ISNAR is the only one which focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on organization, planning, manpower development, staff requirements, financial and infrastructure requirements, and related matters, thus complementing the activities of other assistance agencies. Additionally, ISNAR has an active training and communications program which cooperates with national agricultural research programs in developing countries.

ISNAR also plays an active role in assisting these national programs to establish links with both the international agricultural research centers and donors.

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Foreword

This paper by Dr. Nyle C. Brady was presented at a conference on Social and Economic Perspectives on the Transfer of Food Production Technology to Developing Nations, 21 September 1982, held at Auburn University, Alabama, U.S.A. It was subsequently published in a book, *Transferring Food Production Technology to Developing Nations - Economic and Social Dimensions*, copyright 1983 by Westview Press, Incorporated, Boulder, Colorado, U.S.A. Edited by Joseph J. Molnar and Howard A. Clonts.

The International Service for National Agricultural Research expresses its appreciation to Dr. Brady and Westview Press for permission to include the paper in the ISNAR Reprint Series. We believe it will be of interest to many people.

Alexander von der Osten
Director General
ISNAR

Introduction

There is a tendency these days to overlook the strategic importance of technology development and transfer in enhancing national economic growth and to assume that massive resource transfers are all that are required to help our less fortunate Third World neighbors solve their problems. All too often assessments of past economic development have ignored the strategic importance of technology development and transfer as the foundation for much of the progress already achieved in agriculture and health in many of the developing countries.
I am pleased that the agency I serve—the U.S. Agency for International Development (USAID)—includes among its primary goals the promotion of technology and development and is currently placing greater emphasis on these processes than has been the case in the past. There is growing recognition that the development and utilization of improved technologies is essential for long-term progress in every low-income nation with which we deal.

Current Development Process

As we meet today, the world economic situation for both developed and developing nations is less than optimistic. Growth rates in the developed nations have declined in real terms for the past five years. For 1982, their average growth rate is less than one percent. Growth rates in the developing countries, while somewhat higher than those of industrial countries, nevertheless have exhibited a similar downward trend. The low-income developing countries reported an average of 3.9 percent growth in 1981, but this is considerably lower than their growth of 5.9 percent in 1980 and with their longer-term growth of 4.5 percent between 1973 and 1980. These have been difficult times for developing countries.[1]

Population. Assessments of current economic development progress in most developing countries must begin with a consideration of population levels. The dramatic increases in population numbers stimulated by improved health and medical services following World War II have had and are still having significant constraints on economic development of the low-income countries. Today's population of some 4.2 billion people is increasing by 70 to 80 million annually, and four of five of the births occur in the developing world. These newborn babies must be fed, and future economic and social opportunities provided for them. Even though *percentage increases* in population numbers have declined slightly in some developing countries in the past decade, the absolute number of births continues to rise and will likely do so for some time to come. This is because 40 percent of the people in the developing countries are 15 years of age and younger. This 'population bulge' will move into child-bearing ages in the coming decades, giving steadily increasing population numbers. In practical terms it means that for every two people on the globe today, at least one additional person will be added by the year 2,000—compounding the problems of finding food in a world of shrinking resources. Even if moderate success is achieved in population control and overall development, it is likely that the *additional* food that must be produced by the year 2020 will approach the total amount of food that is being produced today.
While the gloomy forecasts of worldwide food deficits made in the 1960s and 1970s have not come to fruition, food supplies remain a critical problem for most low-income countries. Overall, they can look with pride on progress of the past 30 years, during which their food production was about doubled, a remarkable feat. But per capita food production has edged up only slightly worldwide, and in some areas, such as Africa south of the Sahara, it has actually declined. Per capita availability of beef peaked in 1976, grain in 1978, fish catch in 1970, and oil in 1973. The war on hunger is obviously far from being won.

When food requirements cannot be met by national production, the developing countries are compelled to import food with or without outside assistance. For example, since 1975, Mexico has been spending much of its valuable foreign exchange on importing corn, rice, beans, and wheat—the essential elements of the national diet. In 1980, due to a shortfall of the 1980 harvest, the total agricultural trade balance in Mexico was a debit of $700 million.[2] Newspaper reports of the past few months call our attention to similar problems faced by India. Widespread droughts in 1982 forced India to import cereals just one year after its record production of wheat and rice.

In addition to population pressure, another stress on the international food situation is the increased demands due to rapid growth in per capita incomes in several middle-income nations. Included are the major oil exporters, such as Indonesia, Nigeria, and Venezuela, as well as other developing nations which have made rapid economic gains in the recent past, such as Korea, Taiwan, Brazil, Malaysia, and Thailand. As people become more affluent, they not only want to eat more food, but food of better quality, such as meat and poultry. The extra grain and fodder needed to feed the animals must be produced.
Another factor has emerged to further complicate the world food demand pattern. The centrally planned economies, particularly the Soviet Union and China, have stepped up significantly their imports of cereal grains to meet the growing political pressure for more and better quality food. While some of this import demand is in response to low yields due to bad weather, analysts generally agree that the demand may well continue for some time into the future.
All of these factors are influencing current world food

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supplies and the demand for them. Critical analyses suggest that stresses on these supplies will continue at least for the next two or three decades. If the demands cannot be met, world food prices will remain high and will likely go higher, placing in jeopardy the truly poor nations and poor people in those nations unless indigenous food production can fill the gap.

Resource Deterioration. Problems in developing nations of deteriorating soil and water resources, such as desertification and erosion, seriously impede programs designed to improve food production and add to the cost of the food. For example, the centuries-old practice of 'slash-and-burn', which involved cropping the land for two-three years and then allowing it to fallow for eight-fifteen years was reasonably stable. This system depended upon nature to cycle plant nutrients from deep in the soil through trees and underbrush to the surface where they are subsequently available for food crop production. While there is ecological merit to this time-consuming process, population pressures have forced a shortening of the time sequence for the rotations, leaving the land in fallow for only three to five years. This is inadequate time for the soil 'regeneration', with consequent reductions in yield and increases in soil erosion potential.

Over-grazing of grasslands in low-rainfall areas and over-cutting of trees for fuel wood are other practices which are threatening the natural resource base, especially in Africa. The Sahel drought of the seventies called the world's attention to the fragility of the food production system in that area. The problems are not only physical and biological but anthropological and social as well.

Guarded Optimism. Even though the present economic situation of the developing countries is unacceptable, and the demands by the growing world citizenry for food exceeds the capacity of many of the nations of the developing world, overall there is reason for guarded optimism. Progress, to a limited extent, has been achieved. Some countries have had remarkable success, and potentials and plans for further progress for increased food production are in evidence. Because of the adoption and application of improved technologies, practices, and policies, the world's farmers produced twice as much food in 1980 as they did in 1950. Moreover, the world is still capable of meeting substantial increases in global demand for food. The most serious danger is not a global food shortage, but an array of localized problems within Asia, Latin America, and Africa that will require continuing attention.

Two Criteria for Success. One cannot help but be impressed with the increased agricultural production, especially of cereal crops in the developing countries, during the past 20 years. These increases were the inspiration in the late sixties for the term 'Green Revolution' to describe the process of which they were a part. They were based on two major advances. First, new varieties and associated production technologies were made available to farmers and, in turn, were adopted by these farmers. Second, sources of chemical and financial inputs, and government policies, were such as to make it profitable for the farmers to adopt these varieties and associated production technologies. The question can be raised as to why this two-component development process had not surfaced earlier. Failure of governments, both developing and more developed, to focus attention on agriculture is one factor. Likewise, failure to recognize that western temperate-climate technology could not be transferred directly to the tropics with any degree of success is another one. A third is the failure to assess the significance of trained indigenous person power to a successful development process. A fourth is that at no time in the past had technologies been available which were sufficiently superior to the traditional ones as to truly attract the cultivators.

Improved Technologies

When the modern wheat and rice varieties on which the Green Revolution was based first became available, they spread very rapidly to geographic areas for which they were suited. Small-scale low-income farmers who had been described as being too tied to their traditional agriculture suddenly became innovators. They abandoned their traditional varieties and practices and adopted new ones fully as quickly as had the Midwest farmers when hybrid corn became available in the 1930s and 1940s. They soon discovered that it was to their advantage to change. They could make more money by doing so.

The situation just described had not prevailed prior to the late 1960s. When I first went to the Philippines in 1953-55 as a young Cornell professor, I was depressed by the prevailing, but fallacious concept that the development of improved technology through research was not needed. Officially, the U.S. agency which supported us was not permitted to get involved in research. The prevailing concept was that the U.S. and other western nations already had the necessary technology on which development in the tropics could be based. According to this notion, all we needed to do was to transfer our technology to them. My two years in the Philippines in the fifties convinced me that the development of technology suited to the tropics, along with person power development, was the first step to increased food production in these areas.

Let me give you another example. In the 1960s the Ford Foundation encouraged the Indian Government to establish 'intensive agricultural districts', which were provided packages of technology. The assumption was

made that existing technology, along with plenty of fertilizer and financial inputs, and training for farmers, would make India's production really take off. While some notable successes occurred, in general the expected production increases did not take place. It became obvious to all concerned that the technology being sold to the farmer was not greatly superior to that which he/she was already using. They began to understand that development was not a phenomenon utilizing merely the technology coming from outside the developing countries and imported for their use. Rather, development would work only when the technology used was superior to what the farmer was already using and was suited to the physical, biological, and socio-economic environments where the development was to occur.

Further, the leaders realized that while some of the technological components of the development process could be imported and used with little modification, most had to be created in the local environments where they were to be used, and all components had to be tested and molded to fit these environments.

Technology--Mechanical versus Biological. One of the primary motivations for the technological revolution which took place in the 19th and 20th centuries in Europe and the United States was the need to save labor. The result was to replace human power and even animal power with machines. The degree to which output per person per hour was increased was used as a measure of success of the technology. Labor was, and still is, expensive in the more developed countries.

In the developing countries labor is plentiful and cheap. In contrast, machines are expensive both to purchase and to operate. As a consequence, the kind of technology needed for a two-hectare rice farmer in Indonesia is only remotely related to that needed on an Iowa or California corporate farm. The Indonesian cultivator can be helped most by simple technologies suited specifically to his environment. A five-horsepower tiller will take care of most of his mechanical needs. Varieties with built-in resistance to insects and diseases which reduce his dependence on pesticides would be high on his 'want' list. His social and economic requirements must be met, not those of the Iowa farmer.

Increased Emphasis on Research. One of the consequences of the Green Revolution was worldwide increased interest in and support for agricultural research for technology development. This interest was particularly evident in actions of donors, both national and international, and of developing country political leaders, research scientists, and farmers. Problem-oriented science was recognized as an effective development tool. For the first time, an agricultural field scientist was given a Nobel prize. Scientists were honored by their governments for products coming from their research. Farmers began to have confidence in the products of the researchers and were willing to listen to extension personnel as the new technologies were spread. And, perhaps most importantly, additional financial resources were made available to support research by national and international donors and by developing country governments.

Among the international agricultural research efforts, probably the most successful is the network of international agricultural research centers sponsored by the Consultative Group on International Agricultural Research (CGIAR). Some 13 centers, each focusing on one or more specific development constraint(s), have been established. In addition to the research carried out at the headquarters of these institutes, collaborative networks have been established to assure coordination with national research systems. In turn, donors and developing country governments have given increased attention to the strengthening of national agricultural research organizations. Although the process has only gotten well under way, already improved varieties and associated technologies are products of these combined efforts.

The approach of the CGIAR network and that of other successful international science and technology efforts has seven common characteristics:

1. Focus is placed on removing real constraints to development as opposed to research abstracted from practical needs.

2. Funding has been through voluntary donations rather than by assessed contributions.

3. Direct bilateral relationships have been encouraged between donors and recipient nation scientists and research institutions.

4. Decisions have been based on development needs and technical merit.

5. Existing mechanisms were used and strengthened for collaboration between developing countries and donors in the design, implementation, monitoring, and evaluation of projects.

6. A large bureaucracy with functions that overlap those of existing national and international entities was avoided.

7. The needs of the lower-income developing countries received the highest priority.

To complement and enhance technology development by international centers and national research organizations, the United States has passed legislation

which makes possible extensive use of American universities in both agricultural research and extension. In the long run, educators and scientists in the developing countries must take primary responsiblities for providing technologies suited to their national needs. But a serious lack of trained persons, of institutions and of research and extension capabilities, makes it necessary for assistance to be provided from the outside. Over the past three decades U.S. universities have been found to be well suited to provide much of that assistance.

Specifically, U.S. universities have provided three kinds of help:

1. Formal training and research experiences in America for thousands of developing country students.

2. Technical assistance in agriculture to developing nations. This involves overseas participation by U. S. faculty members in collaborative projects of institution building, human resource development, and specific research and extension projects. USAID provides about $300 million annually for support of projects with which American universities are associated.

3. Partnership research efforts between American scientists and counterparts overseas focused on problems which neither partner could solve alone, but which are amenable to solution through joint research.

The U.S. universities have the scientific expertise, sophisticated equipment, and research methodology needed to tackle researchable problems which overseas farmers and, in turn, scientists face. The overseas partners can provide a testing ground for products or research, and through cooperative efforts, can develop their own capabilities to do the more sophisticated research.

Policies and Support Mechanisms

Up to now I have stressed the singular importance of the development of truly superior technologies in enhancing the food-producing capacities of nations. But the facts are that the 'environment' in which these technologies are to be used must be such as to assure benefits for the producer if he/she accepts them. If this condition does not pertain, the technology will not be adopted. It will be of value only to the researcher and his/her colleagues.

The 'system' must enable the technology to work. Government policies and support mechanisms can foster farmer adoption and application of improved technologies. Farmers around the world—in both developed and developing countries—will not adopt new technologies (regardless of how good) under adverse economic conditions. For example, American farmers generally have adopted a new technology on a large scale only when the farmers are convinced it is to their economic advantage to adopt it. The same holds true for farmers of the Third World; they will not adopt improved technologies unless the price they receive for their harvests are set high enough to permit them to make a decent profit.

Additionally, farmers need access to credit, they need adequate roads for bringing their produce to market, they need reliable and affordable supplies of seeds, fertilizers, and pesticides; they also need facilities for storing their surplus crop so that they are not forced to 'sell cheap and buy dear'. Government policies have a strong bearing on each of these aspects of a developing country's food system.

A graphic example of such a situation was described in a recent *Wall Street Journal* article about agriculture and economic conditions in Africa's sub-Sahara countries.[3] It was noted that of the 30 countries classified worldwide as the 'poorest of the poor', two-thirds are African. In seven of these, agricultural output is on the decline. For example, food production in Senegal is not keeping pace with population growth. In discussing the reason for the inadequate food production levels in Senegal, note was made of the fact there was little incentive for Senegal's farmers, who account for 80 percent of the country's employment, to increase their production.

Over the years, government policies in Senegal, and for that matter in most African countries, have resulted in low prices for the farmer. In part, that policy exists to ease the burden for urban dwellers, who increasingly have held the political leverage. Under the government-run agricultural system in Senegal, the low farm prices set by the government offer little real incentive to grow more. Seeds and fertilizer often are not delivered until after the rainy season. The quality of both often is poor. Marketing is undependable. One Senegalese farmer who grows groundnuts noted that years before the state took over the agricultural system 'everybody would try to plant more than the next farmer. Now everyone settles for growing the same.'[3] Government policies obviously play a major role in determining which technologies will be developed and which will be adopted.

Continuing Technology Transfer Constraints

While much progress has been made in developing truly improved technologies which are acceptable to farmers, it is insignificant compared to what is

needed. Even for rice farmers, where a 20-year concerted effort has been made to improve the technologies, truly superior technologies suitable to farmer adoption are available for no more than about half the rice area of the world. While the comparable proportion of the wheat area for which suitable wheat technologies have been developed is higher, even here much progress is yet to be made. Many physical, biological and socio-economic constraints remain.

Physical and Biological Constraints. A major challenge is the development of superior technology to overcome an array of physical and biological constraints on production which continue to limit the amount of food that most Third World farmers can produce with the available resources. First, new seed varieties need to be bred with characteristics that allow the plants to flourish under adverse climatic conditions and to thrive with a minimum of costly inputs. Second, we need to know how to overcome the major constraints to food production in developing countries, including (1) insect pests and plant diseases, (2) rodents and other vertebrate pests, including birds, (3) problem soil conditions, including salinity, acidity, and zinc deficiencies, and (4) water resource problems (whether too much or too little water).

Large geographical areas still remain where no applicable technology exists for raising food production in economically feasible ways. This is particularly true in semi-arid areas like the Sahel and in some humid lowland tropical areas subject to area flooding. Seeds of the Green Revolution—those that are available today and the same ones that permitted much of the production increases of the past few decades—flourish only under the most favorable physical, economic, and biological conditions. Plants selected on this basis are not necessarily the most efficient when confronted with nutrient or climatic stresses.

The challenge now is to breed new varieties that can flourish under adverse climatic conditions and can thrive with a minimum of costly inputs. At the same time, we must learn how to overcome those plant diseases, pests, problem soil conditions, deficiencies and excesses of water, and other production constraints which today hold millions of Third World farmers in subsistence servitude—teetering precariously on the border of abject poverty. These farmers consume almost everything they grow and thus have very little to market.

Social, Economic, and Political Constraints. Certainly with regard to food production, government policies strongly influenced the relation between technological and social change in the countryside. In the case of agriculture, farmers, as mentioned earlier, will not avail themselves of new technology, no matter how accessible and productive and appropriate, unless the prices the farmer receives for his produce are set high enough to allow a reasonable profit. The ability of farmers to increase yields is also determined to a large extent by the nature of the technological innovations generated by agricultural research programs, extension programs, and rural education. Government policies have a strong and sometimes decisive bearing on each of these aspects of the food system in a developing country, and positive policies produce positive results. Land reform issues are pertinent to the successful transfer, modification, and adoption of new technologies. Taiwan and Japan underwent substantial structural changes in the late 1940s. Massive land reform programs in these two countries dissolved traditional near-feudal land tenure patterns. These reforms also expanded agricultural extension services and provided loans for peasants to buy the land they had worked as tenants all their lives. With such assistance, farmers increased the yield per hectare. Such wholesale change, however, has yet to reach the majority of developing countries.[4]

Strong local institutions are crucial to the technology transfer process. The most sophisticated scientific knowledge is of no use to Asian, African, or Latin American farmers unless local institutions can adapt that knowledge to local needs and unless extension workers can show the farmers how to put that knowledge to use on their own fields.

Institutions must be developed to enable the poor to benefit from the new technologies or, if the institutions already exist, to help them function. These institutions may be governmental, such as extension services, or they may be private, such as cooperatives or small-scale rural industries. To the extent feasible, these institutions must respond to specific needs of the poor. The private sector vis-a-vis market mechanisms plays a major role in the creation, adaptation, and dissemination of technologies. However, too often consideration of institutions in development is assumed to be confined to the public sector. While it is true that in most countries public sector institutions must be relied upon to help institute new activities, it is the private sector which will determine the extent of agricultural production. A very important aspect of public policies in the developing nations is the extent to which they encourage rather than constrain the private sector.

The private sector is generally more efficient in providing inputs such as chemicals and credit and in marketing the agricultural produce. The U. S. Agency for International Development recognizes the importance of the private sector and is initiating pilot programs to encourage small private agricultural enterprises in developing countries. These efforts will complement those relating to universities and government agencies.

Constraints of Trained Person Power. One of the

problems of transferring technology to the less developed countries is the shortage of appropriate skills. Providing these countries with technical information does not result in technology transfer if they do not have the necessary skills to interpret it and to put it to use. The transfer of technology to developing countries, therefore, involves the transfer not only of information but also of skill, and preferably in ways that encourage the development of indigenous skills. One way to transfer technology is by person-to-person contact—bring together the people who have the technology with the people who wish to acquire it. When technology is transferred to another country, not only do you have to cross political boundaries, but also boundaries of culture, language, and custom.[5] The most effective means of building the human resource capability of the developing countries is through formal and informal training. American universities played a critical role in the 1950s and 1960s in providing advanced training for hundreds of developing country scientists and educators. They also participated in institution development programs that provided the physical plant and faculty bases for agricultural universities around the world. A noted example is the collaborative effort of a group of universities in helping to establish 10 agricultural universities in India. Not only did hundreds of young Indians receive training in the United States, but more importantly, thousands of Indians have received their entire college education at these now well-established universities. Similar, but perhaps less spectacular, success can be noted for other educational institutions in Asia, Latin America and, to a limited extent, in Africa.

In spite of past success in training of indigenous personnel, inadequacies of trained people remain one of the primary constraints to economic development, especially in Africa, where per capita food production is actually declining. In my judgment, a massive 15-25-year effort is needed to help the countries of that continent train and educate the leaders they need to turn around their agricultural development systems.

Room for Optimism

Today, I believe we have a realistic awareness of both the possibilities and pitfalls of technological change. We know that technology is far from a panacea that can overcome all the problems of underdevelopment, especially ancient patterns of social injustice. At the same time, there is widespread recognition that improved technology not only can facilitate beneficial social change but in many cases is a prerequisite for that change.

Technologies provide political leaders, extension agents, teachers, and most importantly farmers, with tools for raising overall living standards and significantly those of the poor majority. Fortunately, in recent years, political leaders throughout the developing world have been showing increasing concern for raising domestic food production. Clearly, they have come to recognize that their own political and economic survival is closely tied to their ability to do a better job of feeding their own people.

I would like to conclude by emphasizing that technological change will continue to be a prerequisite for expanding food supplies, whatever a nation's policy dilemmas, social needs, or ideology. By substantially increasing the supply of basic food grains, new technologies can help to hold the line on food prices, with corresponding benefits for small producers and for low-income consumers who already spend most of their limited budgets on food. By the same token, technological change is the lifeblood of job creation and economic growth.

Without expecting technology to do the impossible, we must bend our efforts to develop and disseminate the kind of technology that can promote social change on behalf of the world's impoverished people—knowing that without technological advance, succeeding generations of people in the developing world will be no better off than their parents or grandparents.

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