THE CHANGING DYNAMICS OF GLOBAL AGRICULTURE

A Seminar/Workshop on Research Policy Implications for National Agricultural Research Systems

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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 that focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on research policy, organization, and management issues, [illegible] assistance agencies.

ISNAR has active advisory service, research, and training programs.

ISNAR is supported by a number of the members of CGIAR, an informal group of approximately 43 donors, including countries, development banks, international organizations, and foundations.

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Toward a Global Agricultural Research System[1]

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In this chapter I address the task that remains of designing and implementing the global agricultural research system that will need to be in place by, at the very latest, the first decade of the 21st century. I will give particular attention to the special problems of the smaller countries in the emerging global system.

The International Agricultural Research System

It is useful to remind ourselves of what has been accomplished over the last several decades. The architects of the post-World War II set of global institutions included meeting world food needs and reducing rural poverty as essential to their vision of a world community in which all people could be assured of freedom from want and insecurity. They sought to achieve this vision by the creation of a set of global bureaucracies – the United Nations (UN) specialized agencies. The establishment of the Food and Agriculture Organization of the United Nations (FAO) was the initial institutional response to this concern (Hambridge, 1955).

In spite of limited efforts by the FAO and several regional organizations, it was not until the late 1950s and early 1960s that a combination of

- concern about meeting world food needs,
- experience in advancing technology in food grain production in the tropics,
- a more adequate analysis of the role of advances in agricultural technology in the development process

converged to provide the impetus for a major effort by several bilateral and multilateral assistance agencies and national governments to build the research capacity needed to sustain agricultural production in the poor countries of the tropics.

Organization and impact

One of the most remarkable institutional innovations of the last two decades was the establishment of a new system of international agricultural research institutes (Ruttan and Pray, 1987: Chapter 2, Table 2.1). The organization of these institutes drew on two historical traditions. One was the experience of the great colonial commodity research institutes that played such an important role in increasing the production of a number of tropical export commodities. There is a substantial body of literature in the English language on the development of British Colonial research institutes and botanic gardens (Masefield, 1972; Brockway, 1979). There is no comparable history of French colonial research, but it is clear that research stations developed and maintained by France, during both the colonial and post-colonial period, made important contributions to oil palm, coconut, and a number of other tropical export crops in West Africa (Eicher, 1984). The Dutch made important contributions to the improvement of rice, sugarcane, and a number of other tropical crops in Indonesia and Surinam. One of the greatest tropical research institutes during the colonial period was at Yangambi in the former Belgian Congo. In spite of its rather short colonial history, Germany initiated important research programs in Cameroon, Togo, and former German East Africa (now Tanzania).

The second tradition was the experience of the Rockefeller Foundation in Mexico and the Ford and Rockefeller Foundations in the Philippines (Stakeman et al., 1967). The first four institutes in the system were the products of the joint efforts of the privately endowed Ford and Rockefeller Foundations. The system is now funded by a consortium of bilateral and multilateral assistance agencies and private foundations, and operates under the oversight of the Consultative Group for International Agricultural Research (CGIAR).

An important innovation in the management of the CGIAR system is that each institute is governed by an independent board of directors and operates as an autonomous institution. This structure combines decentralized decision making (with respect to scientific program) with centralized oversight and judgments (with respect to funding, program direction, and system design and strategy).

Relations with developed countries' research institutions

The initial years of the new international institutes were characterized by a tendency to keep relationships at arm's length between the institutes and the developed countries' universities and research institutions. This relationship has changed over time. As the institutes have identified problems in which lack of knowledge in areas such as physiology, pathology, and other fundamental or supporting areas of science has constrained their ability to expand yield frontiers, they have taken steps to

institutionalize their relationships with developed countries' research organizations.

Examples include the relationship between the Centre Internacional de Mejoramiento Maiz y Trigo (CIMMYT) and several Canadian institutions for work on triticale. The International Potato Center (CIP) has used contract linkages with institutions of developed countries for work on fundamental problems related to its mission more extensively than any of the other international centers. At the time of the 1977 quinquennial review mission, CIP identified 12 such contracts with developed countries' institutions and seven with those of less-developed countries. In a number of cases, CIP's contracts induced additional effort and expenditure on CIP-related problems by the developed country's contracting institution.

There are clear dangers in the growing relationships among the international centers and the centers of fundamental research in the developed countries. If the less-developed countries are to establish a viable base for self-sustained scientific effort leading to productive growth in agriculture, it is important that they establish a capacity to work on the fundamental problems that are of particular significance in tropical environments.

System impact

Evidence regarding the productivity of the international system is fragmentary and incomplete, yet there is little doubt that the rate of return to the investment in the system has been high – even in comparison with the more productive developed country (DC) national systems (Ruttan, 1982: 242-243). As early as the mid-1970s, evidence developed by Robert Evenson and colleagues at the University of the Philippines and the International Rice Research Institute (IRRI) indicated that the supply of rice in all developing countries was approximately 12% higher than it would have been had the same total of resources been devoted to the production of rice using only the varieties that were available before the mid-1960s (Evenson et al., 1978). More recent studies by Nagy (1984, 1985) suggest that the gains to Pakistan alone from the wheat research conducted by CIMMYT would have been more than enough to cover the cost of the entire CIMMYT wheat program from its inception to 1980. Stated another way, for the same amount of money, Pakistan could have profitably invested in a wheat research program of its own comparable in capacity and cost to the entire CIMMYT program.

In 1983, the CGIAR commissioned an independent study group to assess the productivity and distributional impacts of the technology developed at the CGIAR centers and at collaborating national centers. The study was directed by Jock R. Anderson (1985), a distinguished Australian economist, and the study group's staff was drawn from several social science disciplines from both developed and developing

countries. The results of this study are summarized in Ruttan and Pray (1987: Chapter 2).

The international system is particularly important for enhancing and sustaining the productivity of the smaller national agricultural research systems. Personal observation, evidence presented at the Wageningen symposium on research in small countries, and the evidence from the impact study (Anderson, 1985: Chapters 4 and 5) indicate that the international system has provided a mechanism by which many smaller developing countries with only limited national research capacity obtain access to research results from the larger developing countries as well as the international agricultural research centers (IARCs). The infrastructure for this function simply was not in place two decades ago, in spite of efforts by organizations such as the FAO and the Inter-American Institute for Cooperation on Agriculture (IICA).

As the capacities of the less-developed countries' (LDCs) national research systems improve, the relative contributions of the IARC system to the generation of knowledge and technology will decline. One possible outcome of this process is the loss of the institutes' distinct leadership roles. A viable model for the future of the institutes is an expanded role as centers for the conservation and diffusion of genetic resources and of scientific and technical information, relative to their role as producers of new knowledge and new technology. If they are careful to select staff members for their leadership capacities as well as for their scientific and professional competence, they will be able to continue to play a strategic role in establishing research priorities.

There is, however, what might be considered a natural history of research institutes (Ruttan, 1982: 7). A new institute that is able to bring together a team of leading scientists tends to go through a period of high productivity that often lasts a decade or longer. After this initial period of creativity, there is a tendency for the institute to settle down to filling the gaps in the scientific literature and to fine-tuning incremental changes in technology. It is possible that the system of governance adopted – program autonomy at the individual center level combined with centralized oversight – will enable the CGIAR centers to retain and enhance their vitality over a longer time. But the difficulties experienced by the Technical Advisory Committee (TAC) and the CGIAR in attempting to reform management and programs at several "problem" centers do not lead to great optimism about the capacity of the individual centers to avoid cycles of creativity and stagnation.

A second factor that could make an important contribution to future vitality would be the incorporation of stronger LDC representation in both the governance of the system and, at the operational level, in research planning and collaboration. If the international institutes are able to strengthen their capacity to link the national systems to a carefully articulated international system, they will assure their own continued

viability. If they become viewed as being competitive with national research systems, they could fade away into mediocrity.

A continuing need for international support

When the system of international centers was being established by the Ford and Rockefeller Foundations in the early and mid-1960s, there was a general perception that over a period of several decades the foundations would withdraw and transfer the management and support of the institutes to the host countries. The two foundations have now withdrawn from anything more than token support of the system, but responsibility for oversight and support has been assumed, as noted earlier, by the CGIAR and its member institutions. Yet one still hears comments from both staff members of the DC donors and the LDC national research system that at some time in the future the responsibility for the system can be transferred to the LDCs or that the major units of the system (excepting the International Board for Plant Genetic Resources) will eventually be phased out.

I find such discussions unrealistic! The system should be viewed as a permanent component of the global agricultural research system. This should not mean that every unit in the present system should be regarded as permanent. It is not difficult to visualize circumstances that would lead to the de-emphasis of some programs and the initiation of new programs, but the international system itself should be regarded as permanent. The funding for the system should become part of the permanent commitment of the more developed countries to the agricultural development of the poorer and smaller countries in the system. In this respect there is a similarity between the national funding of a system of regional research centers in larger countries such as China, Brazil, India, and the United States, even though the individual states or provinces also support state or provincial experiment stations.

An incomplete system

The international system remains incomplete. There is a need to rationalize the managing and overseeing of a number of international agricultural research centers that have grown up outside the CGIAR system (Table 1). I also see the need for greater capacity to conduct research on some of the difficult resource problems that continue to inhibit the development of agriculture in tropical environments. It also seems apparent that the lack of basic scientific knowledge represents a serious constraint to the development of viable and sustainable technologies in many areas of the tropics.

The establishment of the International Fertilizer Development Center at Muscle Shoals, Alabama, in 1974 was an initial step in the development of an international capacity for research on resource development and management problems. The recent

Table 1. Some International Agricultural Research Activities Outside the CGIAR

Center	Primary focus	Location	Year of initial oper.	Budget US$ (mill.)	Budget Year	No. of senior staff	Programs
ICIPE	Insect physiology and ecology	Nairobi, Kenya	1970	4.77	1982	46	Crop borers, livestock ticks, tsetse fly, plant resistance, medical vectors, insect pathology, pest management
AVRD	Tropical vegetables	Shanhua, Taiwan, China	1972	3.60	1983	32	Tomatoes, Chinese cabbage sweet potatoes, soybeans, mung beans
ICLARM	Living aquatic resources	Manila, Philippines	1973	1.70	1983	14	Aquaculture, traditional fisheries, resource development and management, information services
INTSOY	Soybeans	Urbana, Illinois, USA	1973	0.95	1983	8	Soybeans

IFDC	*Fertilizer*	*Muscle Shoals, Alabama, USA*	*1974*	*6.70*	*1982*	*60*	*Nitrogen research, nutrient interaction, phosphate research, sulfur research, potassium research, economics research, national programs, technical assistance, training*
ICRAF	Agroforestry	Nairobi, Kenya	1978	2.20	1983	18	Agroforestry systems, agroforestry technology, information, training, collaborative research
IIMI	Irrigation management	Kandy, Sri Lanka	1984	5.00	(When operational)	10-12 in HQ, 3-4 per unit	Collaborative research, training, information dissemination
IBSRAM	Soils	Not fixed	1985	4.54	(When operational)	5-10	Headquarters, soil management networks
INIBAP	Banana and plantain improvement	Not fixed	1985	1.75	(Initially)	Small	Headquarters regional networks

SOURCE: Personal communication from Consultative Group on International Agricultural Research, World Bank, Washington, DC, 1985.
NOTE: Activities currently using CGIAR meetings or in some other way related to CGIAR activities in 1984 (totaling about $30 million).

establishment by a group of CGIAR donors of an International Irrigation Management Institute (IIMI) in Sri Lanka and an International Board for Soils Research and Management (IBSRAM) in Thailand represents more recent initiatives. The establishment of an International Council for Research on Agro-Forestry (ICRAF) in Nairobi reflects a growing concern about the need for research capacity in the tropics on the development, management, and utilization of fast-growing trees to sustain the demand for biomass for fuel and other uses.

A beginning has been made in providing international support for the development of the capacity to work on some of the problems where lack of basic knowledge acts as a constraint to technology development. Within the CGIAR system, the International Laboratory for Research on Animal Diseases (ILRAD) has been forced to direct much of its research to basic investigations. The International Centre for Insect Physiology and Ecology (ICIPE), initially established in 1970, has gradually evolved into an institution with a very substantial research capacity.

The United Nations Industrial Development Organization (UNIDO) has sponsored exploratory studies leading to the establishment of an International Centre for Genetic Engineering and Biotechnology. It is doubtful, however, that it will devote adequate attention to the work in molecular biology that will be most relevant for animal and plant protection in developing countries. In my judgment, there is also a very strong need for research to overcome the lack of knowledge about problems of fertility maintenance and enhancement of tropical soils. In many parts of Africa this lack puts a serious constraint on the ability to design viable short-rotation systems to replace the more extensive slash-and-burn or other long-rotation systems now in use.

Finally, there are serious deficiencies in the knowledge needed to develop economically viable technologies for the control of the parasitic diseases that inhibit the development of more intensive systems of agricultural production. In many cases, the relationship between disease and development appears to be symbiotic. Intensification of agricultural production enhances the environment for parasitic diseases, and parasitic diseases reduce the capacity of rural people to pursue more intensive systems of cultivation (Desowitz, 1983; Walsh and Warren, 1979).

It is not too difficult to generate agreement, at least in principle, on the need for greater international support for research on problems of resource development and management. But there is considerable skepticism among donor agencies about the need for international support for a series of basic research institutes in the tropics. The argument is frequently made that the basic research can be done in DC institutes, particularly in countries such as France, the United Kingdom, and the Netherlands, that have a tradition of tropical research and are now seeing that capacity erode as support adjusts to the disappearance of colonial responsibilities and to budget

exigencies. Part of my answer is that the experience of the present IARCs indicates that intellectual commitment to the solution of even scientific problems is enhanced when the scientists working on a problem are located in the environment in which the problem exists. Basic research capacity in the tropics will also facilitate more effective dialogue with the basic research community in the developed countries.

Considerable thought will also have to be given to the appropriate governance for the emerging system of natural resource and basic science research centers. The present CGIAR system is already approaching severe strains on its financial and managerial capacity. There is a pervasive view among donors to the CGIAR system that it will be extremely difficult to push funding for core or base programs at the CGIAR centers much beyond $200 million (in 1985 US$), yet subsets of the same donors have funded the new centers that have emerged outside the CGIAR system.

It would be a serious mistake if new natural resource and basic science institutes were to continue to emerge on an ad hoc basis. One of the great strengths of the CGIAR system is its planning and supervisory role in welding the set of autonomous institutes into an international research system. The CGIAR and TAC secretariat infrastructure could perform the supervisory functions for a much larger system than at present with only a modest expansion in staff. Nevertheless, donor funding considerations may make it desirable to consider the establishment of a new supervisory body, perhaps a consultative group for natural resource research, to govern the new natural-resource-based institutes. It may also be desirable to establish a separate governance system for any new system of basic research institutes – a consultative group for biological sciences for tropical agriculture. As new internationally supported basic research units are established in the tropics, more attention should be given to the training role, particularly advanced training at the Ph.D. and postdoctoral levels, than was the case when the present international commodity institutes were established.

A global system

Finally, I would argue that an effort should be made to ensure that the international system becomes a truly global system. The new international system has been effective in building communications between LDC national research systems. The linkages of the international centers with DC research institutions are, however, generally filtered through the bilateral development assistance agencies. Direct linkages with the national research systems of the developed countries remain underdeveloped. The linkages between the national research systems of the developed countries are even less developed. It is my impression, for example, that there has not yet emerged any institutional capacity to rationalize or coordinate agricultural research between European Economic Community (EEC) or Organization for Economic Cooperation and Development (OECD) member countries. There is a modest program of

information exchange between EEC and OECD countries, but these activities appear to be more symbolic than substantive (FAO, 1984). And we have barely begun to build effective linkages between either the national research systems of the developed countries or the international systems with agricultural research systems of the centrally planned countries.

National Research Systems

By the late 1960s, many of the bilateral and multilateral aid agencies were recognizing serious shortcomings in the results of their efforts to support the development of national agricultural research systems. Most national systems in the less-developed countries were unprepared to effectively absorb large amounts of financial, material, and professional assistance. The capacity for scientific management and entrepreneurship of the newly trained scientific community was often underdeveloped. Many systems were plagued by cyclical sequences of development followed by erosion of capacity as budgetary priorities responded to changes in political regimes (Ardila et al., 1981).

Impatient staff members at aid agencies were often unaware of the history of their own national institutions. They had forgotten that the national agricultural research systems of the United Kingdom, Germany, the United States, and Japan had taken decades, not years, to acquire the research and training capacity required to generate the new knowledge and technology needed to sustain agricultural development (Ruttan, 1982: 66-115). Furthermore, the political support available to many national and international aid agencies was often so fragile that support for institution building was difficult to sustain unless a short-term payoff could be visualized. In addition to a sense of frustration with efforts to strengthen national research systems, there was a growing conviction of urgency about the problem of meeting food requirements in the poor countries. The initial success of IRRI's rice program and CIMMYT's wheat program combined to create a conviction that the international agricultural research institute, which could operate independently of the vagaries of the local political environment and could draw on the global agricultural science community for its staff, represented an effective instrument for the management of research resources and for the generation of new technology.

By the mid-1970s, it had become increasingly clear that the productivity of the international agricultural research system was severely constrained by the limited capacity of many national systems, and that the adaptation and dissemination of the knowledge and technology generated at the international institutes were dependent on the development of effective national systems. It became widely accepted that the ability to screen, borrow, and adapt scientific knowledge and technology requires essentially the same capacity as is required to invent new technology (Evenson, 1977a).

Capacity in the basic and supporting biological sciences is at least as important as capacity in applied science. But the outreach programs of the international institutes, even when working through networks such as the international wheat research network, the inter-Asian corn program, and others, did not have the capacity to take on the role of strengthening national systems.

The bilateral and multilateral assistance agencies had no alternative, therefore, but to place the strengthening of national research systems high on their assistance agendas. Both FAO and the Rockefeller Foundation played important entrepreneurial roles in this development. After a series of consultations with the leaders of national research systems, the International Agricultural Development Service (IADS) was established, with initial funding from the Rockefeller Foundation, to provide contract research management and development services to national research systems.

FAO, through its Research Development Center, took steps to strengthen its capacity to support training in the field of research organization and management.

The initiatives of the Rockefeller Foundation and FAO influenced the CGIAR to intensify its own deliberations. In 1977, the CGIAR organized a task force to explore the possibility of establishing an international service for the strengthening of national agricultural research within the CGIAR's systems. These deliberations led to the establishment of the International Service for National Agricultural Research (ISNAR) in 1979. There had been some expectations that, in establishing ISNAR, the CGIAR might absorb IADS, much as it had incorporated IRRI, CIMMYT, the International Institute of Tropical Agriculture (IITA), and the Centre International de Agricultura Tropical (CIAT) under its umbrella in 1971. By 1979, however, the CGIAR had become somewhat sensitive about absorbing activities initiated before the CGIAR/TAC assessment and evaluation process. Some European donors were also sensitive about the fact that staffing patterns at the institutes had not drawn effectively on European professional capacity. FAO, one of the CGIAR's sponsors, expressed strong concern that the new service was infringing on an area of traditional FAO responsibility.

IADS (recently merged into Winrock International) has now acquired substantial experience in managing projects designed to strengthen national agricultural research systems and funded by agencies such as the US Agency for International Development (USAID) and the World Bank. ISNAR has acquired considerable expertise in diagnosing the problems that have inhibited the effectiveness of national research systems and in assisting national agencies in planning for research system reform and development. It is clear, however, that the strengthening of national research systems is only partially, and perhaps only marginally, amenable to the efforts of the assistance agencies. External funding agencies have often inhibited the development of national

systems as a result of lack of sensitivity in their assistance efforts to the difficulties faced by a national research system in achieving political and economic, in addition to scientific and technical, viability.

As the efforts by the bilateral and multilateral assistance agencies to strengthen national agricultural research systems got under way, it became apparent that the 1970s were witnessing a remarkable expansion in agricultural research capacity in a number of important developing countries (Ruttan and Pray, 1987: Chapter 1, Table 1.1).

When one examines the details of the individual country, however, it becomes clear that most of this growth has occurred in relatively few countries, such as Brazil, the Philippines, India, China, and Nigeria. In 1980, there were only slightly more agricultural research scientists in all of Latin America and Africa combined than there were in the US federal-state system – and fewer than in the Japanese national-prefectural system. Even in those countries that have made substantial progress, the ratio of research expenditures to the value of production remains low – and it remains lowest for those commodities produced and/or consumed primarily by the poorest farmers and consumers.

During the last several years, I have been involved in a series of studies of agricultural research systems in Asia (Ruttan, 1981; Evenson et al., 1986). The concerns about the development of national agricultural research systems that have emerged out of my own research and experience have been reinforced by the series of very useful reviews conducted by the World Bank (1983), USAID (1983), and UNDP-FAO (1984). Although the literature on the performance of national agricultural research systems is much more adequate for Latin America and Asia, the concerns expressed in this section impinge with particular force on many African agricultural research systems (Eicher, 1984; Lipton, 1985). Let me summarize some of these concerns.

Excessive facilities. Excessive investment in research facilities relative to development of scientific staff – there are too many facilities without programs. Many of the premature facility developments are the direct result of the multilateral and bilateral assistance agency programs that find it easier to invest in facility development than in human capital development or program support. Premature facility investment represents a burden on the research system rather than a source of productivity.

Excessive administration. An excessive administrative burden that stifles both routine investigations and research entrepreneurship – a major challenge to any national research system is how to achieve consistency between the personal and professional objectives of individual researchers, research teams, and research managers, and the social objectives of the research system. In many respects the individual scientist can appropriately be viewed as an independent contractor who makes his or her services

available in return for professional and economic incentives. Bureaucratic efforts to achieve consistency between the objectives of the individual and the objectives of the system (or simply fiscal responsibility) are often carried to the point where they become an excessive burden on research productivity.

Poor location. The failure of location decisions for major research facilities, often made with the advice of assistance agency consultants, to give adequate weight to the factors that contribute to a productive research location. These factors include:

- location in a community that includes related educational and professional infrastructure;

- location in an agroclimatic environment that is representative of an important part of the area in which the particular commodity is grown or that is representative of a major resource (soil, water) problem area;

- selection of a site with appropriate resources (soil, water) and infrastructure (electricity, transport, amenities).

Differential between importance of budget and commodity. There is often a lack of congruence between research budgets and the economic importance of major commodities or commodity groupings. If new knowledge and new technology were equally easy (or difficult) to come by in each commodity area, a good rule of thumb would be to allocate research resources roughly in proportion to the value (or value added) of commodity output or resource input. It is easy to think of good reasons for departure from such a rule. In a small research system, critical mass (i.e., scale economies) implies the desirability of focusing resources on commodities that account for a large share of output (such as wheat in northern India) or on a commodity where very large gains can be made in a short time (such as lowland irrigated rice in the 1960s). But extreme lack of congruence often suggests that little careful thought has been given to the allocation of research resources or that particular interest groups have biased research allocation to their own benefit.

Research without scientists. The apparent presumption in some national systems that it is possible to do research in agricultural science without scientists – in too many national research systems, commodity program leaders often have neither the training nor the capacity to direct either scientific research or technology development. Salary structures and noneconomic incentives are frequently so unattractive, relative to other national and international alternatives, that potential leadership is eroded, research programs become routine, and returns to research investment are low.

Cyclical nature of national research systems. The cycles of development and erosion

of capacity that have characterized a number of national agricultural research systems – periods of rapid development have often been followed by the erosion or collapse of research capacity when external support has declined. Martin Pineiro, Eduardo Trigo, and their colleagues have documented this pattern most thoroughly in a number of Latin American countries such as Argentina, Peru, and Colombia (Ardila et al., 1981; Pineiro and Trigo, 1983). But such cycles are also familiar to anyone who has followed the progress of agricultural research in developing countries in other areas of the world.

Establishing research priorities. Research priorities may be established with little information and analysis. In research planning that has successfully struggled with the problem of allocating resources for research, it has become increasingly obvious that effective research planning requires close collaboration between natural and social scientists and between agronomists, engineers, and planners. This is because any research resource allocation system, regardless of how intuitive or formal the methodology employed, cannot avoid making judgments about two major questions:

- What are the possibilities of advancing knowledge or technology if resources are allocated to a particular commodity problem or discipline? Such questions can only be answered with any degree of authority by scientists who are on the leading edge of the research discipline or problem being considered. The intuitive judgments of research administrators and planners are rarely adequate to answer such questions.

- What will be the value to society of the new knowledge or the new technology if the research effort is successful? The intuitive insights of research scientists and administrators are no more reliable in answering questions of value than are the intuitive insights of research planners in evaluating scientific or technical potential. Many of the arguments about research resource allocation flounder on the failure of the participants to recognize clearly the distinction between these two questions and the differences in expertise and judgment needed to respond to them (Ruttan, 1982: 262-264).

The perspectives and concerns that I have expressed about agricultural research in LDCs are not the exclusive problems of new and growing research systems. Don Hadwiger (1982) has provided evidence that in the United States the "pork barrel" approach to the location of agricultural research facilities resulted in 44% of all US Department of Agriculture (USDA) research facility construction between 1958 and 1977 occurring in states represented by members of the Subcommittee on Agriculture of the Senate Appropriations Committee. He noted that this practice has forced "the federal Agricultural Research Service to operate a 'traveling circus', opening up new locations in current Senate constituencies, while closing some locations in states whose senators are no longer a member of the subcommittee."

Small Country Agricultural Research Systems

We are confronted with a remarkable paucity of data and analysis on the relationship between scale (or size) and productivity in agricultural research. And what evidence there is, even in the way of casual observation, often lacks precision as to whether the size-output relationship being referred to is with respect to the size of the individual research unit (team, laboratory, department), the individual research institution (center, institute, faculty), or the national or international research system. The views that "small is better" or that "big is better" have often been advanced with considerable heat, but with relatively little precision in concept or definition and with even less empirical evidence. The issues discussed in this section represent an important opportunity for research to bring better theory, method, and data to bear in order to advance our understanding.

Size and productivity in research

What little knowledge we do have suggests that the optimum scale of the research is affected by factors both external and internal to the research process. The optimum level of resources devoted to a commodity research program is positively related to the area planted to a commodity in a particular agroclimatic region (Binswanger, 1978). Therefore, determining the optimum scale of a research unit or program involves balancing the increasing returns associated with the area devoted to the commodity (or problem) on which the research is being conducted against the possible internal diseconomies of scale of the research process or system.

The data that we do have suggest that industrial research and development productivity, measured in terms of patents per engineering or scientific worker, is lower in the large laboratories of the largest firms than in the smaller firms in the same industry (Schmookler, 1966; Kamien and Schwartz, 1975). There is similar evidence for agricultural research (Pound and Waggoner, 1972). There also are a number of case studies that suggest very high rates of return to individual public, philanthropic, and private research units, often with fewer than 20 scientific or technical staff members per unit (Evenson, 1977b; Sehgal, 1977). However, many of these small "free-standing" agricultural research units are engaged primarily in technology screening, adaptation, and transfer activities that depend only minimally on in-house capacity in such supporting areas as physiology, pathology, chemistry, and even modern genetics.

Evenson (1977b) also noted that during the early stages in the development of national research systems, experiment stations tend to be widely diffused, to utilize primarily technical and engineering skills, and to be characterized by a strong commodity orientation. In the Chinese system, for example, decentralization includes not only a provincial research system but also autonomous prefectural and county research

institutions that are financed and governed at the local level. Evenson also pointed to a trend toward hierarchical organization and consolidation into a smaller number of larger units at later stages in the development of agricultural research systems. These centralizing trends are apparently motivated in part to take advantage of economies resulting from research activities in the basic and supporting sciences and to use the laboratory, field, communications, and logistical facilities economically.

The urge for consolidation can easily be overdone, however. In the United States, for example, there is now rather strong evidence supporting the value of decentralization, even within individual states. For a given level of expenditure, a state system that includes a strong network of branch stations gets more for its research dollar than a state system that is more concentrated. What decentralization gives up in lower costs seems to be more than compensated for by the relevance of the research and the more rapid diffusion of results. There are, of course, limits to the gains from decentralization. Disagreement about the relative gains from centralization and decentralization, and about the relative emphasis that should be given to basic science, applied science, and technology development, has been the basis for much of the recent argument about the organization and funding of the US federal-state agricultural research system (National Research Council, 1972; Workshop on Critical Issues in American Agricultural Research, 1979).

A minimum national system

One of the most difficult issues related to size and productivity in agricultural research is the problem faced by the smaller countries in the development of their agricultural research systems. Most of the smaller countries – those in the population range of 4-10 million – do have the resources, or have access to donors' resources, that would permit them to develop, over a 10- or 20-year period, an agricultural research and training capacity capable of staffing the nation's public- and private-sector agricultural research, education, planning, and service institutions.

The 50 or so smallest low-income countries must, however, think of research systems that will often be little larger than a strong branch station in a country such as the Netherlands or Denmark, or in a state such as Texas or Minnesota.

But how can the government of a small country decide on the appropriate size and organization of its national agricultural research system? For countries like Sierra Leone or Nepal, even the financial and professional agricultural research resources of a small American state or a Japanese prefecture are probably at least a generation in the future. The time required to achieve viable research systems for many of the smaller national systems must realistically be calculated in terms of more than a

generation rather than the 5- or 10-year project cycles used by most development assistance agencies.

One major focus of the research effort in these smaller research systems must be the direct support of agricultural production and rural development programs. This means a primary focus on applied research and technology development fields such as agronomy, plant breeding, animal production, crop production, farming systems, and agricultural planning and policy. Trigo and Pineiro (1984) have estimated that a minimum research module for one product requires a team of four researchers trained at the MSc and PhD levels, complemented by eight specialists with graduate-level training, plus a complement of support personnel. They estimate that the total cost of such a program would run in the range of US$ 250,000 (in 1984 dollars) (Table 2). For a small country with six to 10 major commodities and several important agroclimatic regions, this implies a research budget of US$ 5-8 million. When this effort is complemented by the noncommodity-oriented research in areas such as soil and water, pest management, cropping systems, and socioeconomic aspects of agricultural production, marketing, and policy, the implications run into the range of US$ 12-15 million.

The viability of even a small nation's agricultural production also requires capacity for higher education in agriculture, at least through the master's level, to support national programs of technology in transfer, rural development, and regulatory and service activities. When these activities are aggregated it is not difficult to arrive at a minimum level of professional capacity, with training at the MSc and PhD levels, of around 250 and with budget support somewhere in the range of US$ 20-30 million for even the smaller (but not the smallest) countries. For the very smallest countries, even this investment is not feasible in the foreseeable future. Any serious attempt to solve the problem of agricultural research and technology development in the smallest countries must face up to the difficult problem of designing a viable system of regional research collaboration (Wilson, 1984).

Interdependent systems

The idea of reducing or eliminating technological dependency generates strong emotional appeal. Yet even larger countries with advanced agricultural research systems – the United States, the Soviet Union, Japan, India, and Brazil, for example – are not self-sufficient in agricultural science and technology. An effective national agricultural research system must have the capacity to borrow both knowledge and materials from the entire world. The problem of how to link effectively with an increasingly integrated and interdependent global agricultural research system is difficult for the state and provincial research units in the larger national systems. It is

Table 2. Estimated Cost of a Minimum Research Module for One Product (in Thousands of Current US$)

Direct Research Costs (60% of total budget)	306
Personnel	245
Four chief researchers, MSc or PhD, three persons per year in plant breeding, agronomy, and insect pest and disease control and one person–year equivalent in socioeconomics and other specializations, according to requirements (soils, physiology, etc.). Total cost per person per year, US$ 30,000[a]	120
Eight specialists, university graduates. Total cost per person per year, US $12,500	100
Training. Calculated on the basis of 2 x 1 rate of retention; total rotation every 15 years; cost of US$ 100,000 per PhD (MSc 60%). Total annual cost for a permanent team of three PhDs and one MSc (approximately)	25
Services and materials calculated as 12.5% of direct costs	
Equipment calculated as 7.5% of direct costs	
General Costs and Administration (40% of total budget)	204
Includes direction, support, and services (administration, laboratories, library, communication, field, etc.)	
Personnel	122
calculated as 60% of general and administrative costs	
Services and materials	51
25% of general and administrative costs	
Investments and equipment	31
15% of general and administrative costs	
Total budget	510
Percent summary by broad budgetary items (approximate):	
Personnel	72.5%
Services and materials	17.5%
Equipment	10.0%

SOURCE: Trigo and Pineiro (1984).
NOTE: The estimates were made using the budgetary structure of the international agricultural research centers as a guideline for determining the percent of each expenditure item.
a. US$ 30,000 was used as an average of the case for the different countries of the region. The sum includes salaries plus benefits. A variation of US$ 1,000 above or below this average figure implies an increase or decrease of US$ 4,250 in the total budget.

even more difficult for the national agricultural research systems in the smaller countries.

One approach to this problem has been to attempt to establish cooperative regional research programs – for example, the West Africa Rice Development Association (WARDA) and the international crop research networks that are linked to the international agricultural research institutes. Other regional institutions not directly linked to the international (CGIAR) system include the Centro Agronómico Tropical de Investigación Enseñanza (CATIE), the Caribbean Agricultural Research and Development Institute (CARDI), and the Southeast Asian Fisheries Development Center (SEAFDEC). Networking has become the most recent theme in assistance agency jargon, but it is hard to find many outstanding success stories among these efforts. Program activities and cooperative efforts often appear stronger in the glossy pamphlets issued by the organizations than they do in practice (Venezian, 1984). Experience suggests that such regional programs can succeed only with the commitment of long-term external support and with the participation of the external donors in the governance of such centers. Some of the most effective collaborative regional efforts have been organized around the research programs of the international research centers (Plucknett and Smith, 1984).

The international crop research networks, centered around the international institutes, have not been without problems. When the institutes have had confident and effective leadership, they have often played an exceedingly useful role in creating opportunities for productive professional interaction and collaboration. But the institute research networks tend to be selective. At times they have found it hard to bend institute priorities to meet national priorities. Collaborative efforts tend to involve the strongest institutions and the leading scientists rather than those who have the greatest need.

A richer institutional infrastructure is needed to strengthen and sustain the capacity of the smaller national agricultural research systems. In spite of ideological considerations, many small countries have found it advantageous to encourage the transfer and adaptation of technology by the private-sector genetic supply industry or by the multinational firms engaged in commodity production, processing, and trade (Pray, 1983). Firms engaged in the production of crops grown under plantation systems and independent growers producing under contract arrangements with processors have at times provided their own research and development facilities. In other cases, associations of producers have been willing to tax themselves to support commodity research stations. Such arrangements have often been associated with discredited systems of colonial governance. A strong case can be made for reexamining and strengthening the legal institutions and financial incentives for private-sector research, development, and technology dissemination in the developing countries.

The perspectives outlined in this section are highly tentative. Although they are drawn from considerable experience, they should be treated as hypotheses to be tested by further research rather than as conclusions. Institutions such as IADS, ISNAR, and IICA should devote a reasonable amount of analytical effort to attempts to understand the problem of developing and sustaining effective agricultural research in the smaller national research systems.

Some generalizations

In spite of the limited available knowledge, there are a few generalizations about smaller agricultural research systems that can hardly be avoided. One is that the research investment per acre or per hectare will have to be higher in a small system than in a large system to achieve an equal level of effectiveness. This is because the cost of developing, for example, a new millet variety that will be grown on a million acres is not likely to be substantially greater than one that will be grown on half a million acres.

A second generalization is that the cost of developing productive farming systems for a small country with great agroclimatic variation will be greater than for a small country that is more homogeneous. For example, the cost per hectare of developing an effective agricultural research system for Sri Lanka is likely to be much larger than developing one for Uruguay. The issue of guns versus butter in national budgets is also likely to cut more sharply in a small country than in a large country.

Finally, there is no way that a small country can avoid being dependent on others – on the international agricultural research system, on the research systems of large countries in the same region, on multinational firms – for much of its agricultural technology. Furthermore, a small nation with a strong research program but a limited agricultural or industrial base cannot capture as high a proportion of the benefits from its investment in basic research as can a large nation with a diversified economic base. Much of the benefit will spill over to other countries. If it has a weak agricultural research system, it will lack the knowledge needed to capture the benefits of research in other countries or to choose a technological path consistent with its own resource and cultural endowments. Even a strong agricultural research system cannot assure autonomy. But small countries do need to develop sufficient capacity in the agricultural sciences to enable them to draw selectively on an interdependent global agricultural research system. They need to be able to choose what is useful to borrow from other national systems and from the international system.

Toward a Reform of Agricultural Research Support

What can be done to replace the deficiencies that characterize assistance for the support of agricultural research, extension, and rural development programs in poor

countries? A solution to the problems of "aid effectiveness" in support of research is particularly important at this time. I anticipate that the next decade will experience a decline in the real flow of aid resources and increasing competition among the several claimants on aid resources.

The basic thrust of the needed reforms is to move away from primary reliance on narrow project approaches. In supporting agricultural research, the project system should be largely replaced by a "formula-funding" or "revenue-sharing" approach (Ruttan, 1984). There have been many criticisms of the project approach followed by the major bilateral and multilateral development assistance agencies. The criticism most frequently heard is that the assistance agencies exert undue influence on the content of the national development programs (Faaland, 1980; Salmon, 1983). This criticism is partly justified. It is not too difficult to identify cases in which close patron-client bonds have been established between particular officers in the aid agencies and the leadership of favored national program agencies. Such relationships have often appeared to give particular national programs a degree of stability and continuity that would be difficult to achieve in the unstable political environments that characterize many developing countries.

In my judgment, cycles of development and erosion are inherent in the traditional project approach. The reason for this inherent contradiction is that external assistance provides an alternative to the development of internal political support. National research system directors have frequently found that the generation of external support requires less intensive entrepreneurial effort than the cultivation of domestic political support. Domestic budget support required by donors is often achieved by creative manipulation of budget categories rather than by increments in real program support – particularly when donor representatives are under pressure from assistance agency management to "move resources." Most existing project systems thus have built-in incentives for national research system leadership to direct entrepreneurial efforts toward the donor community rather than toward the domestic political system.

Any effective alternative should attempt to reverse the perverse incentives that characterize existing development assistance instruments. The system should be reformed to provide incentives for national research system directors to redirect their entrepreneurial efforts toward building domestic political and economic support for agricultural development.

I am increasingly convinced that the long-term viability of agricultural research systems depends on the emergence of organized producer groups that are effective in bringing their interests to bear on legislative and executive budgetary processes. The support of finance and planning ministries for agricultural research is undependable. Their tenure in office is often short. And their support tends to fluctuate with the

perceived severity of food crisis and foreign exchange demands.

A formula-funding model

What alternatives to the existing system do I suggest? I do not want to be interpreted as completely negative with respect to traditional development assistance instruments. Project aid is often quite appropriate for physical infrastructure development projects. Program aid can be an effective way to provide macroeconomic assistance for structural adjustment or for sector development in a country with substantial capacity for macroeconomic policy analysis and program management. But neither the traditional program aid nor project aid instruments are fully effective in countries that have little financial or professional capacity for providing support for long-term institution-building efforts. New methods of combining the flexibility of program support, effective technical assistance, and sustained financial support for long-term development efforts must be sought.

One innovation that might be used effectively is for the donor community to move toward an approach in which the amount of external support is linked to growth in domestic support. An example of how such a system might work is presented in Table 3. This implies the development of a "formula" approach in which the size of donor contribution would be tied to the growth of domestic support. The formula should include a factor that adjusts the ratio of external to domestic support to take into account differences in domestic fiscal capacity. Given the political considerations that

Table 3. Three Funding Models of Program Support and Assistance Level for Agricultural Research (millions of US$)

National fiscal capacity	Low		Medium		High	
	National support	Donor assistance	National support	Donor assistance	National support	Donor assistance
Low (40% assistance)	20	8	50	20	100	40
Medium (20% assistance)	20	4	50	10	100	20
High (10% assistance)	20	2	50	5	100	10

impinge on the allocation of bilateral donor resources, implementation of the formula-funding model is probably unrealistic in the immediate future.

Country-level research support group

A second alternative might take its lead from the experience now accumulated with the CGIAR model and the various donor consortia that have been organized to coordinate assistance to some of the larger aid recipients. This could involve country-level research support groups, chaired by the chairman of the national agricultural research council or the director of agricultural research. The support group will need to have available to it relatively long-term program plans for the development and operation of the national agricultural research system. To produce and continuously update this program, the national research system may require external assistance, but in general the program should be the product of the national agricultural and general science policy system. Its focus, to help protect the program from the vagaries of political change, would be on long-term agricultural research needs and goals and on the incremental steps required for implementation.

It is expected that long-term program development and priority setting would be done through an interactive process with the support group. Once the program has been accepted, donor members of the support group, it is hoped, would collectively agree with the host country to help provide the components essential to the execution of the program as a whole. The host country, in turn, would assume the responsibility for moving its national research program along the agreed-upon development path. Initial commitments might be for three to five years, subject to annual review and the course corrections suggested by the analysis and feedback from actual experience.

Use of an institution such as a support group has the potential of helping the country involved avoid many of the pitfalls of the project mode while retaining several of its desired attributes. Donor identity could be retained by relating grants to components of the agreed-upon overall program. These could even be called projects if, for administrative purposes, it were so desired. The support group, like the CGIAR, would be likely to involve bilateral grants developed in the framework provided by the forum of multiple donors and the host country. The impersonal process of contributing to a common fund is not envisioned. However, this would not preclude "incentive funding" of a formula type. At the same time, the danger that a single donor would dominate the priority-setting process or that essential program components would be ignored would be minimized.

The research support group has several other potential advantages:

1. It could contribute to building a national constituency by focusing from the onset on

this essential ingredient for viability. The donors, for example, might agree to increase their contributions by some fraction of the rise that occurred in the real support provided by the nation involved. Other matching provisions might be agreed upon to provide incentives for nurturing and cultivating national constituencies.

2. It could provide reasonable continuity in support. Commitments should be fairly long term and subject to review and extension well in advance of termination dates to avoid the risk of the excessive program fragmentation that is frequently associated with narrowly defined project funding.

3. It could reduce the administrative and management load on the host country through the planning and review process the RSG would follow.

4. It could place donors in a position of genuinely complementing and supplementing one another and the national program rather than competing for "good investment opportunities."

That such a support mode is often discussed but little used is evidence that implementation is not a simple, trouble-free task. The method has, however, been used successfully in Bangladesh and, somewhat more informally, in several other countries. An important element in its success in Bangladesh was that the support group meetings were chaired by the director of the Bangladesh Agricultural Research Council rather than by a donor representative.

A dialogue on donor assistance to national agricultural research programs was initiated by the World Bank in 1981. The dialogue has been continued by ISNAR in a series of meetings with directors of national agricultural research systems. It is imperative that these dialogues be continued. The issue of reform of agricultural assistance should be recognized as one of the most urgent items on the agenda.

Notes

1. This paper is also published in Ruttan and Pray (1987). A more complete version was published in Research Policy (Ruttan, 1986).

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