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ORGANIZATION AND STRUCTURE IN NATIONAL AGRICULTURAL RESEARCH SYSTEMS

H.K. JAIN

isnar

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 that focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on research policy, organization, and management issues, thus complementing the activities of other assistance agencies.

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SUMMARY

Important policy decisions have been taken in the past 25 years to strengthen the national agricultural research systems (NARS) in many developing countries to harness science and technology as an instrument of increased food production and agricultural growth. The paper discusses the organization and structure of these systems in different parts of the world. They include the newly created agricultural research councils of Asia, the national institutes of Latin America, and the ministry and university-based research services. The emerging NARS of sub-Saharan Africa and those found in the Arab world have been reviewed in this context. The discussion has been organized in relation to the potentials which have been created for the improved performance of the research and governance functions of these systems. Many of the reorganized systems have already made considerable impact as a result of their newly created potential. Many others are in early stages of their evolution and would need further strengthening before making an impact of this kind. It has been argued that the process of reorganization must continue for all of them so that they become better equipped for the new challenges which will arise from continued population pressures and needs of economic development. The nature of this new reorganization has been considered. It involves, among other things, creation of greater capacity for planning so that the NARS leaders move away from routine administration to policy-making. Some of the other important issues discussed in this context are the need for stronger links between development and research and the structural changes which will be needed to forge these links; decentralization and regional research; and inter-institutional coordination at the national level. It has been stressed that the heavy investments made by the governments in the 1960s and 1970s may not continue and the demand in future will be for greater returns from investments already made through better planning and greater efficiency in the management of resources.

The organization of research station networks has been considered in the wider context of the organization of NARS. The rationale for the different types of stations and their number has been examined. Finally, the internal structure of the research stations has been discussed as a function of their mandate.

Defining National Agricultural Research Systems

In considering the organization and structure of the national agricultural research systems (NARS), it is important that we begin to define them more clearly. In a broad sense a NARS consists of all those organizations and institutions in a country carrying out research in various fields of agricultural sciences. These institutions are often diverse and may be distributed in the various ministries of the government, parastatal bodies, faculties of agriculture and other science faculties in the universities, and in the private sector having close links with agribusiness.

For practical purposes, however, the core of the NARS is more restricted. The core consists of the organizations and institutions created and/or funded by the governments to generate improved production technologies to provide support for the national programs of agricultural development. The government (through its ministry of agriculture and other ministries) is the promoter of the interests of the farmers -- their largest constituency in most developing countries. As guardian of their interests and recognizing the crucial place of agriculture in the process of economic development, the governments have a deep interest in making science and technology an important instrument of social and economic advance. For this reason, most governments create their own research infrastructure or support other institutions for the development of agriculture, and it is this research service created or supported by the government which forms the core of the national agricultural research system.

The research apparatus consisting of experiment stations may function under the ministry of agriculture and/or other ministries. In some cases the governments prefer not to create research institutions of their own but hand over responsibility for agricultural research to the faculties of agriculture in the universities, to which they extend funding and other support. These core groups of institutions often link up with other research institutions in the country, which may not be directly involved in terms of their commitment to development, but all of which have the potential to make a significant contribution. A good national research service is able to mobilize this support from peripheral institutions for its research work. This is often done through a system of contract research or joint research for specific and specialized activities, while the most pressing problems of agricultural development requiring technological support are addressed by the research service organized by the government.

It is important that we make this distinction between the national agricultural research system of a country in its wider sense and the research service specifically created by the government as an instrument of its policy for agricultural development. The distinction was first clearly made by Lord Rothschild, Scientific Advisor to the British Prime Minister, in the 1970s. In a Report on the organization of agricultural research in Britain, Lord Rothschild spoke of a contractor/client relationship. He suggested that the head of the national research system (in this case the head of the Food and Agricultural Research Council in Britain), should see himself in the role of a contractor with the Minister of Agriculture as the spokesman for the farmers as his client. The Food and Agricultural Research Council should be conducting only that kind of research which leads to improved technologies most needed by the farmers for increasing their yields and profits. Here, then, we have a developed country laying down a policy that the government-funded research service will have no other purpose than to serve the needs of farmers and contribute to economic development.

In retrospect, it is clear that Lord Rothschild's report did have a great deal of influence on Britain's policy in organizing its national agricultural research system. Many of the institutional changes which have taken place recently in that country have been influenced in part at least by the Rothschild Report. It follows that the linkage between the national agricultural research system and the national programs of agricultural development should be even stronger in the developing countries, for many of which agriculture constitutes the mainstay of their economy.

Rationale for Reorganization of Research Systems

World agriculture entered a new phase in the 1960s. For most of its 10,000 years since the first domestication of plants and animals, agriculture in most parts of the world has been of a traditional kind, characterized by low yields. The 1960s saw a massive increase in population pressures in the developing countries in the wake of major advances in health care and hygiene. Also, the 1960s saw a far greater emphasis on improved nutrition, with the newly independent countries striving to improve the standard of living of their people. The increased demand on food supplies focused major attention on research for the first time in many of these countries to transform their traditional systems of farming in order to make them more productive and profitable.

It is during this period that many developing countries started to take important policy decisions to reorganize and strengthen their agricultural research services. Looking back over the past 25 years, we may find that more investments have been made in agricultural research in many developing countries during this period than in the entire history of their scientific support for their agriculture. Furthermore, this is only the beginning, and even greater investments in building the national research systems can be expected in the next 20 years. Many of the developing countries have yet to strengthen their agricultural research services to create the needed capacity.

Africa's emerging national agricultural research systems in the background of their post-colonial evolution are beginning to receive a

great deal of attention. Also, the countries of Asia and Latin America have taken only the first steps in laying down the foundations of a more scientific and modern agriculture. They have a long way to go in equipping their research services with improved planning and management skills, tools, and procedures. In this first phase many of them have learned to take better advantage of the international agricultural research system and to forge strong links with it. In the second phase, they must learn to be more self-reliant and to solve some of the more difficult problems of their agriculture in areas like soil and water management and productivity in the stress environments. They must also learn to develop renewable resources of energy so that their agriculture in the coming decades will not have such heavy dependence on costly energy-intensive inputs like chemical fertilizers and pesticides. The emergence of biotechnology in relation to agriculture has opened up altogether new possibilities. Many developing countries, with their limited resources of non-renewable energy, have greater compulsion to exploit the new possibilities that genetic engineering and advances in molecular biology offer.

Basic Components of NARS

A successful national agricultural research system requires many resources, but some are particularly important. First, it must have the needed experiment station infrastructure, and this means:

i) qualified scientists and technicians;
ii) field and laboratory facilities in the form of well-equipped experiment stations;
iii) stable budgetary support consistent with the needs of the evolving research programs.

Second, it must have the organization, structure, and planning mechanisms to use these resources effectively. Organization and structure help to create the potential for a NARS to be effective. Once we have created this potential for effectiveness, we can build on it the additional dimension of efficiency. We can do this by giving it the management techniques and tools which the NARS leaders and the professional staff can use in the course of their work. Some national agricultural research systems, both in the developed and developing countries, are quite effective, but they are not particularly efficient in the use of their resources. Conversely, there are NARS which may have an efficient management but fail to achieve much because of structural weaknesses.

The purpose of this paper is to discuss in practical terms what organization and structure mean in the context of NARS and what is their significance for these systems. It describes the different types of research organizations that have evolved in the developing countries in the recent past, some as a result of a reorganization process, and discusses their potential for greater effectiveness. Before we proceed with this discussion, however, it should be useful to consider some of the more important governance and research functions of the national agricultural research systems.

In order to facilitate the research process and maximize returns from the investment, the research service should be able to take major

initiatives. Further, a good research system should have access to administrative norms and decision-making processes which lead to efficient use of resources without creating a stifling management culture. The governance functions of the system refer to these administrative norms and mechanisms of decision-making. Similarly, the research system, to be effective in its primary task of doing good research, must perform some functions that are particularly important. They help to give a sense of direction to the research process. What are some of these governance and research functions and how can the process of reorganization help in making the system more efficient and effective? We consider them here briefly.

Governance Functions

The governance functions relate to the administrative procedures and decision-making processes in the working of the national research systems. Scientific institutions are not expected to have too much of administration. The basic idea is that scientists should be able to feel free to pursue their creative work without too many distractions from the management. Even so, a minimum of administration is necessary if the work of the organization is to proceed smoothly. Budgets must be made and defended, and financial discipline must be maintained where public funds are involved. Personnel policies have to be evolved and implemented. Thus, while the need for administration is not questioned, the nature of the administrative framework and procedures becomes important, as discussed below with the help of a few examples.

Budget allocation and management

Traditionally, agricultural research services have had their budgetary support incorporated in the overall budget allocation of the department of agriculture. In times of financial crisis the research services were the first to suffer a cut. Agricultural research, by its very nature, has a long-term perspective, and few major programs can be planned on a year-to-year basis. It, therefore, becomes extremely important that the research service should have a budget of its own and should be able to operate it according to the best judgment of its managers, which is not to say that the audit procedures of the other public-funded institutions would not apply. Again, it is not uncommon to find in many countries that a large proportion of the budget goes into staff salaries, and very limited funds are left for operating costs, with the result that the field and laboratory work suffers. The NARS leaders managing a budget of their own should be able to correct this imbalance and take initiatives as opportunities arise. Also, they should be the best judge of how to reduce the size of the research program if a cut in funding becomes inevitable. The problems often arise not from the small size of the budget but from its instability and from the arbitrary nature of the budget-making process.

Resources and their management

Experiment station network. The NARS must organize or support a network of experiment stations keeping in view the agroecological diversity of the country for generating appropriate technologies. There are major issues with regard to the structure and organization of these stations,

which have important implications for the effectiveness of the system. The relationship of the NARS senior management with these experiment stations, especially in the determination of their mandate and program, is a key governance function.

Supplies and procurement procedures. Many a research service forming an integral part of a government department is required to make use of a centralized stores procurement and maintenance service. In other words, purchase of scientific equipment, laboratory chemicals, farm machinery, fertilizer, and all the other store items which the scientists need for their work is linked to the overall purchase operations of a government department, whose staff have little expertise in responding to the timely and specialized needs of scientists. An important governance function of a research service is to organize its own stores procurement operations, and equally important, to arrange maintenance of its scientific and field equipment without having to go through the larger bureaucracy of the government. In the absence of this, tractors, harvesters, threshers, and other farm equipment may lie in an unserviceable condition during the peak of the experimental work in the field when they are needed most.

Personnel policies

As long as the research service forms an integral part of a government department, its recruitment and personnel policies are generally determined by the civil service code which applies uniformly to all the other ministries. Increasingly, however, it has been recognized that in order to attract highly talented persons for a career in scientific research, NARS need a different set of personnel policies which the civil service commission cannot provide, with its preoccupation with so many other government departments, where the work is primarily of an administrative nature. It has been observed that the rapid turnover of scientists in the agricultural research systems of many developing countries, especially in sub-Saharan Africa, is a major problem in the implementation of their program. An effective research service needs staff policies that make it possible to attract the kind of people it needs and to retain them.

Centralization

Most agricultural research systems, with their long tradition of work as part of a government department, tend to be highly centralized. This may make the task of the field stations difficult, with the need to approach the headquarters repeatedly for release of funds and for other purposes in relation to the implementation of their program. The degree and nature of the administrative control which the head of the research service exercises over the field stations has become an important governance issue in recent years, especially in the larger research systems. Similarly, at the level of the experiment stations much of the decision-making may be limited to the director of the stations making it difficult for the scientists to implement their research programs in a creative environment.

Research Functions

The research functions relate to the management of the program. A national research system is only as good as its scientific program in terms of its relevance and quality, and the potential for impact. The NARS leaders and the professional staff must be able to make sure that certain norms and procedures are followed in pursuit of these objectives. Some of the research functions are discussed below.

Research policy and resource allocation

The national research system should be able to establish close links with the policy-making level in the government and with the farmers if its work is to have a strong sense of purpose, commitment and focus on the country's programs of agricultural development. The system's research priorities and programs should derive from a clear understanding of the country's agricultural development policy and farmers' needs for new technologies. Also, the research service should be able to contribute to the formulation of such a policy. While many decisions have to be taken on the basis of the overall economic strategy of the government, the NARS leaders should be able to inform the policymakers about the country's production potential in relation to its agroecological diversity and natural resources, its comparative advantage, and the opportunities research offers to realize this potential. An important outcome of this kind of interaction with the policymakers is a carefully thought out plan of resource allocation for the different research programs covering the different commodities and regions, and their production resources.

Program formulation

Assuming that the NARS managers, working in close collaboration with the development planners and policymakers, have identified the research priorities, there is still the all-important task of translating these into a national research program. This is a highly interactive process involving different groups of scientists at the experiment stations, for technical considerations become important in evolving a potentially effective and viable research program. The ability of the NARS to formulate and implement the different research programs determines whether the farmers will be having the right kind of technologies for increasing agricultural production.

The process of program formulation could take a different route, with the scientists generating mostly disciplinary knowledge which has its own value but may not be particularly relevant to the current needs of a developing country in terms of increasing agricultural production.

Program implementation, monitoring, and evaluation

Many programs of agricultural research may take several years before new technologies become available and recommendations could be made to the farmers. The development of an improved variety of maize or wheat, for example, may take ten years. The NARS should be able to monitor and evaluate the progress of their research work for possible mid-course correction and modification. Also, new problems may arise which require a change of emphasis. For example, a disease or pest may assume epidemic

proportions with the occurrence of a new biotype. The question then becomes important whether the national research system has the planning mechanisms to redeploy its resources. The fundamental issue here is one of the capacity of a national research system to monitor the implementation of its research programs for their effectiveness and continued relevance.

Research coordination

Much of agricultural research designed for generating new technologies for increasing agricultural production calls for a multidisciplinary approach. This is particularly true of commodity research programs, where plant breeders, agronomists, pathologists, entomologists, and others have to be brought together in a highly complementary relationship. In addition, there is the problem of coordination at the inter-institutional level. Most countries may have a great deal of agroecological diversity, and they find it highly cost-effective to mobilize their limited scientific and other resources by setting up a limited number of national stations, which do the more advanced technology-generating research, and a chain of regional stations in the different parts of the country, which are mainly involved in adaptive research working in close collaboration with the extension service. An important function of the national research system is to coordinate the work of these two types of stations and forge inter-institutional links.

Links with extension

The new technologies developed by the NARS scientists, with all of their potential for an impact, must be communicated to farmers if they are to serve their ultimate purpose. The research service is obviously not equipped to reach the farmers in a big way -- a job which in most countries belongs to the extension service organized by the department of agriculture. The question then is: can the research service develop the needed institutional links with the extension service for a two-way flow of information? This is often described as the first-line extension. The research service should be able to communicate its new technologies to the extension staff and should be able to receive feedback from them on farmers' reactions, needs, and problems. It is particularly important for the scientists to verify their technologies on farmers' fields, working in close collaboration with the extension service before final recommendations are made. Even those national systems which manage both the research and the extension service need to organize effective institutional links between them.

Organization and Structure in NARS: The Four Entities

Social scientists[1)] define organizations as the instruments by which public policy is implemented. Two fundamental issues involved in every organization are accomplishing goals while utilizing resources efficiently and providing a climate that enhances the well-being of

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1) Richard H. Hall and Robert E. Quinn (1986) in Organizational Theory and Public Policy. Sage Publications, London.

participants. In an organization decisions and actions are taken within an institutional and environmental framework in which there are actors with different positions and agendas, but at the same time judgments are made and paths followed.

In the context of national agricultural research systems we may define organization as the institutional framework and entities created for generating technological support to the country's agriculture. The relationships and linkages of the different entities and actors and their reporting and decision-making processes as part of the governance mechanisms help to define the structure of the system. These

institutional entities and their relationships can be recognized at four different levels. First, there is that component of the system which is responsible for the formulation of the national research policy and program by interpreting the government's strategy for the development of the agricultural sector. The executive head of the national agricultural research system, often a director general, and the supporting senior staff in his secretariat constitute this entity. It is best described as the headquarters of the system, where most of the strategic planning is done. The head of the system and his/her deputies form the senior management of the system and, depending on the degree of decentralization in the system, they may exercise considerable administrative powers.

Closely allied to the headquarters of the organization is the second entity (or should we perhaps call it the first, reversing the order) in the form of a governing body variously called the governing board, governing council, or advisory council. This body, generally made up of farmers' representatives, members of the academic and political communities, and officials of the ministry of agriculture, including the extension service, is the least well-defined in terms of its functions and the control it exercises. Its most important function is to advise the director general and to lay down the research and management policy of the system. The problem is that in may cases it is reactive rather than proactive. It receives proposals and policy statements from the director general and approves them with or without modification. Its greatest concern is the relevance of research to the farmers' problems and with the transfer of technology. It approves the budget proposals prepared by the secretariat and in the process determines research priorities.

The governing boards of different systems show a great deal of variability. Some, meeting three or four times a year, remain largely advisory in character. Some others, however, have a much stronger profile and make a more definitive contribution in the formulation of management and research policy and in their implementation. In all systems these two entities, the governing body and the headquarters, with the director general and his secretariat, work closely together.

The third institutional component of the system is the experiment station network, where research activities are carried out based on the policy formulated and the mandates defined at the headquarters of the NARS. The directors of the experiment stations have their primary responsibility in the organization and management of research programs and in the

management of personnel and resources. They also contribute to the process of policy formulation as technical advisors to the director general.

The fourth institutional entity takes the form of the national research programs which help to integrate the efforts of the different experiment stations into a coordinated framework. The national programs have an institutional identity of their own, for they cut across different disciplines and different experiment stations. They provide the focus for a concerted and focused approach to technology generation in relation to some of the high-priority commodity or natural resources research programs. The coordinated national research programs are a relatively recent innovation for the mounting of a highly focused national research effort, and their organization and structure merit a consideration of their own.

Organizational Types in NARS

What are the different kinds of institutional models characterizing the organization of NARS in the developing countries? The system may take the form of a national research council or a national research institute, or a research department or division in the ministry of agriculture or ministry of science. In recent years many countries have come to the conclusion that agricultural research is so vital for the development of their agriculture, often the primary industry in most developing countries, that it should be placed squarely in the ministry of agriculture, where its most important clients, the farmers, have their dealings with the government and where other service organizations like extension are located. However, in many other countries, the research service continues to be located in the ministry of science, giving rise to problems of linking it with farmers, the extension service, and the other user departments in the government. In some other countries it is the universities which generate most of the technology and are the dominant institutional entity in the system. Within these broad types there is a great deal of diversity, some of which will be considered in this paper.

We would consider the different institutional models -- first at the system level, and later, in terms of the organization of the research stations. And finally, we would consider the organization of national research programs. At the system level the different kinds of NARS organizations which can be observed currently in the developing countries are as follows.

The Agricultural Research Council (ARC)

The response of the larger Asian countries in terms of reorganization and strengthening of their agricultural research has been to set up semi-autonomous agricultural research councils. These councils have increasingly taken over responsibilities which earlier belonged to the research division of the ministry of agriculture.

The basic concept underlying this transfer has been to free the research service from the constraints of the larger government bureaucracy, the civil service, and from operational procedures designed more for built-in

checks and counter-checks in the use of government funds, rather than for taking major initiatives, and at times some risk, for generating new technologies. The new philosophy has been to hand over much of the managerial responsibility to the scientists themselves, recognizing that research requires a different kind of administrative culture. At the same time the governments have attempted through various devices to ensure that the councils do not become independent of them in terms of their commitment to development. They must remain fully committed to the governments' policies of agricultural growth and must provide technological support for these policies. It is autonomy combined with dedication to the technological needs of the farming community.

An important point which should be recognized is that not all the ARCs have taken the same route in evolving their organization and structure. It is already possible to recognize at least three types of councils in terms of their mandates, and correspondingly, in terms of their organization. We would call them: managing councils, coordinating councils, and funding councils.

Managing councils

The managing councils are all-embracing - they organize, manage, and direct most of the government-funded research station network. In other words, they have responsibility for the planning, management, and conduct of all government-funded research. In the larger countries where there are two separate streams of research, federal and regional, the councils fully manage the federal stream and, in addition, coordinate the work of the regional institutions, which they partly support, with that of the federal stations. This coordinating role of the councils helps to link up the federal and the regional experiment stations through a series of national programs. The Indian Council of Agricultural Research, the Pakistan Agricultural Research Council, and the Agency for Agricultural Research and Development in Indonesia basically belong to this institutional type, although they are by no means identical in their organization and structure.

Coordinating councils

The coordinating council, as its name suggests, has its primary responsibility for coordinating research for the country as a whole, but the experiment stations and institutions maintain their administrative and budgetary independence. They are not linked to the council or in a hierarchy. One of their most important functions is to develop national research plans based on strategic and economic considerations and, in this way, they are in a position to influence the research programs of the different experiment stations in the country. They are also charged with the responsibility of carrying out periodical reviews of the experiment stations. The Bangladesh Agricultural Research Council, which is in an early stage of its evolution, belongs to this type. Sri Lanka is at present in the process of creating a coordinating council (Council for Agricultural Research Coordination) that will help to integrate the work of institutions in eight different ministries, which are currently involved in different aspects of agricultural and livestock research. The new council will also extend funding support to inter-institutional research projects.

Funding councils

The funding council has control over the disbursement of the research funds of the government and is, therefore, in a position to define the research priorities and give a sense of direction to the national research effort. Even though it has no research stations of its own and must look to others for translating its priorities into effective research programs, it enjoys considerable leverage in doing so. The scientists must come to it with programs it considers relevant to the priority needs of the country before these can be supported. The Philippines Council for Agricultural and Resource Research and Development (PCARRD) provides a good example of a funding council. Much of the research in the Philippines is done by scientists in the universities, who submit their proposals to PCARRD. The Ministry of Agriculture and Food, which has its own experiment stations, must also submit its research proposals to the Council for funding support.

National Research Institutes (NRI)

Many of the Latin American countries have reorganized their research services in recent years, prompted by considerations similar to those of the Asian countries. Their newly set-up national research institutes, which have increasingly taken over the research function of the ministry of agriculture, are fundamentally not very different from the agricultural research councils of the large Asian countries. Perhaps they enjoy even greater autonomy, and they have better links with the private sector. Unlike some of the research councils of Asia, the national research institutes in Latin America almost invariably control, direct, and manage all of the publicly funded research station infrastructure in the country. There is less decentralization of research in Latin America than in Asia. In the larger Asian countries the provinces or the states have their own regional research services over and above the federal institutions. In the Latin American countries, on the other hand, most agricultural research outside the private sector is managed by federal institutions, and decentralization and regional research in recent years have become major issues.

Two kinds of national institutes can be broadly recognized - semi-autonomous and autonomous. The autonomous institutes receive strong direction in terms of their research policy and management from a governing board; the director general of the institute reports to the president of the board, which is quite powerful, with good representation from the producer organizations. The minister of agriculture, however, appoints the board, and in this way the government makes sure that the development program of the government and the producers receive the needed technological support.

The semi-autonomous institutes also have a governing board whose powers, however, tend to be limited. The board of the semi-autonomous institutes is basically advisory in character, and the institutes are much more directly linked with the ministry of agriculture, which is able to exercise considerable influence in having its own policy implemented. Thus, the director general of the semi-autonomous institutes has much greater access to the senior officials of the ministry and the minister

of agriculture than in the case of the fully autonomous institutes. Another major difference is that the autonomous institutes have complete control over their research budget, and they are able to operate it in accordance with the policy laid down by the board. The semi-autonomous institutes, on the other hand, have greater dependence on the ministry of agriculture for their budgetary support. It should be stressed, however, that neither the autonomous nor the semi-autonomous institutes are completely independent of the financial norms and discipline laid down by the government for publicly funded institutions. They must satisfy the audit requirements, and they must be seen to follow procedures which, while permitting flexibility, ensure at the same time that there is no wastage of public funds and that rules and regulations have been evolved which provide safeguards against irregularities of various kinds.

An important difference between the national research institutes of Latin America and the research councils of Asia is that the former have much greater involvement with the extension service. INTA, the national institute in Argentina, for example, combines both the research and the extension function. There is no separate extension service in the ministry of agriculture. In many other Latin American countries, however, the extension service continues to be located in the ministry of agriculture. In these countries, the national institutes have strong departments of transfer of technology which work closely with the extension service and, in some cases, substitute for them in varying degrees, depending on the strength of the latter. INIA, the national institute in Chile, for example, has a Department of Transfer of Technology, which is as strong as its Division of Research. It works very closely with the Extension Service of the Ministry and with the producer organizations.

Table 1 lists the autonomous and semi-autonomous national institutes created through a process of reorganization in the different Latin American countries, mostly in the 1960s and 1970s.

Structure of Research Councils and National Institutes

Some of the Councils and the experiment stations network which they manage can be quite large. The Indian Council of Agricultural Research, with its headquarters in New Delhi, for example, manages 43 federal research institutes located in different parts of the country. The Council, in addition, manages 25 national research centers which may be described as mini-research institutes built around a specific program. The Council also partly supports 26 state agricultural universities developed on the land-grant pattern, which constitute the country's regional stream of agricultural research. These institutions work closely with the departments of agriculture and extension in the state (provincial) governments, which provide their core budgets. The federal institutes and the state agricultural universities have been linked with a high degree of complementarity in their research efforts through a series of nationally coordinated programs on important commodities and production resources. The Council has full responsibility for this inter-institutional coordination. There are 71 such nationally coordinated research programs accounting for more than 25 percent of the research budget of the Council. The Council employs more than 6,000 scientists with postgraduate qualifications, with another 18,000

Table 1: National research institutes created in the Latin American countries

ACRONYM	NAME AND YEAR OF CREATION	COUNTRY	TYPE
INTA	Instituto Nacional de Tecnología Agropecuaria (1957)	ARGENTINA	Autonomous
INIA INIFAP	Instituto Nacional de Investigacion Agropecuaria (1961) Instituto Nacional de Investigaciones Forestales y Agropecuarias (1986)	MEXICO	Semi-autonomous
ICA	Instituto Colombiana Agropecuario (1962)	COLOMBIA	Semi-autonomous
FONAIAP	Fondo Nacional de Asistencia y Investigación Agropecuaria (1973)	VENEZUELA	Semi-autonomous
INIA INIPA INIAA	Instituto Nacional de Investigación Agraria (1978) Instituto Nacional de Investigación y Promoción Agraria (1981) Instituto Nacional de Investigación Agropecuaria y Agroindustrial (1987)	PERU	Semi-autonomous
INIA	Instituto de Investigación Agropecuario (1964)	CHILE	Autonomous
CIAAB INIA*	Centro de Investigaciones Agrícolas "Alberto Boerger" (1961) Instituto Nacional de Investigación Agropecuaria (1987)	URUGUAY	Autonomous
IBTA	Instituto Boliviano de Tecnología Agropecuaria (1975)	BOLIVIA	Semi-autonomous
INIAP	Instituto Nacional de Investigación Agropecuaria (1959)	ECUADOR	Semi-autonomous
ICTA	Instituto de Ciencia y Tecnología Agrícolas (1973)	GUATEMALA	Semi-autonomous
INTA**	Instituto Nacional de Tecnología Agropecuaria	NICARAGUA	Semi-autonomous
IDIAP	Instituto Nacional de Investigación Agropecuaria de Panama (1975)	PANAMA	Semi-autonomous

* Law creating INIA is under discussion at the Uruguayan Congress level.
** Research activities went back to the central administrative system of the Ministry of Agriculture since 1979.

Source: C. Valverde (1987), Internal Program Review, ISNAR.

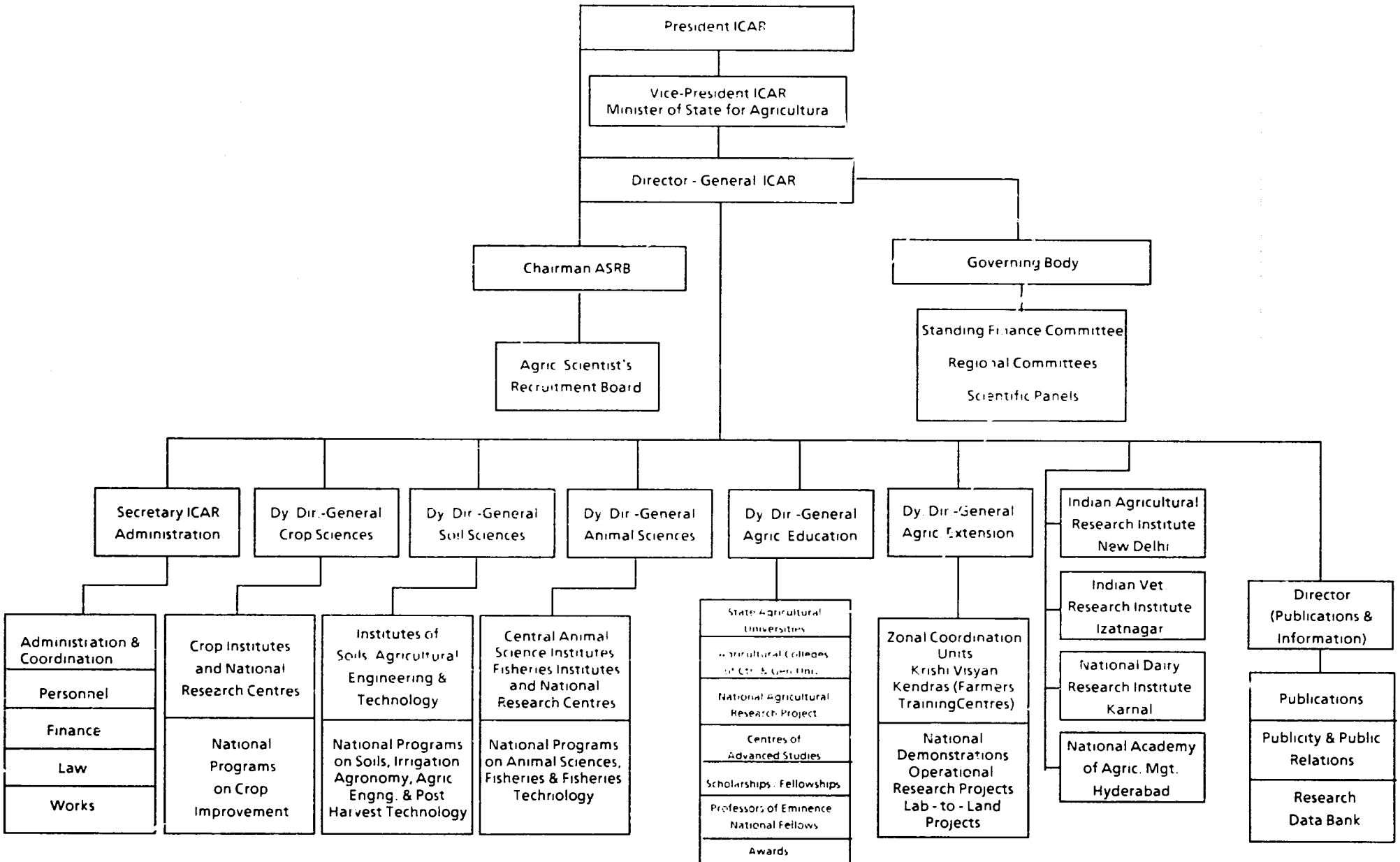
scientists employed in the state agricultural universities. Many of the latter, however, do both teaching and research -- some doing more teaching than research.

Figure 1 shows the organization and structure of the Indian Council of Agricultural Research. The important point to note is that the Minister of Agriculture is the President of the Council, even though it has the legal status of a non-government registered society. Also, it should be noted that many of the directors of the institutes report to the Deputy Directors General at the headquarters of the council, and the senior staff of the Council, thus, have considerable administrative responsibilities. This has important implications for their other role in planning and policy-making.

INTA, the Instituto Nacional de Tecnología Agropecuaria of Argentina, provides a good example of a national institute which is such an important feature of the agricultural research scene in Latin America today. The institutional framework and structure of INTA can be seen in the form of its four different entities. First, there is the INTA Council, which is the top policy-making and governing body. The composition of the INTA Council reflects the importance which the government attaches to it. The President of the INTA Council, as well as its Vice-President and another member, are all appointed directly by the Secretary of State for Agriculture to act as his representatives. The other members of the Council include a representative of each of the four main producer unions of the country and the representatives of the University. The Government obviously wanted to make sure that INTA will always maintain a sharp focus on programs and problems of agricultural development in the country, working closely with the planners and policymakers in the Ministry and representatives of the producers. The second institutional entity of INTA is its Directorate, the main executive body responsible for the overall direction and management of the experiment station network. The highly centralized nature of INTA can be seen from the fact that the Director General and his deputies exercise complete administrative and scientific control over the research station network, which is the third institutional entity of INTA. This network consisting of 40 experiment stations and sub-stations extends all over the country, covering 19 of the 22 provinces. On the face of it the experiment stations would appear to have a regional character, distributed as they are in the different provinces. However, they have few links with the provincial governments, regional institutions, and the local farmers' organizations. The research strategy in the past has been to organize most of the scientific activities in the form of a large number of national programs on different commodities or groups of commodities so that much of the decision making is centralized.

The fourth institutional entity of INTA is to be seen in the form of its 225 rural extension agencies distributed all over the country, with more than 500 extension workers. This activity, too, was centralized until recently through the office of the Assistant Director of Extension, who reported to the Director General in the Secretariat. The result was that the direct relationship of the extension workers in the field with the staff of the experiment stations in the region has been rather limited.

Figure 1: Organization of the Indian Council of Agricultural Research (ICAR)



Source: Based on FAO Research and Technology Paper 3, 1987.

Of all the national institutes in Latin America, INTA probably has been more conscious of the need to decentralize some of its functions, and in the past four years it has taken a series of steps in this direction. The reorganization of INTA which is currently in progress involves several major changes. Perhaps the most important of these is the creation of regional research centers. These centers have been created by grouping the existing experiment stations in the provinces under the management of a regional director, who works closely with a Regional Council. The unit of research organization and management in the provinces following this reorganization is, thus, at a higher level of aggregation than the individual experiment stations. The management of regional centers is the responsibility of a Regional Director, a new position created for this purpose. The Regional Director, in exercising his powers, works closely with the Regional Council, a new institution created for the first time. It is the Regional Council which has become the main instrument for providing a client-oriented input in the process of research planning in the regions, by mobilizing and articulating the views, concerns, ideas, and initiatives of local producers and institutions. Its membership is drawn from the producer organizations, universities, provincial government, and other institutions in the region. The Regional Director reports to the INTA Council through the Director General at INTA Headquarters. Figures 2 and 3 show the structure of INTA in the pre- and post-decentralization phase.

A recent analysis by ISNAR of the decentralization process in INTA shows that it has helped to create an important forum in the form of Regional Councils for discussion of problems of agricultural development in the regions in the context of the needed technological support, and it has succeeded in generating very useful interactions among the different interested groups. It has also created a great deal of consciousness about the need for planning of research at the regional level and has raised many expectations. Above all, it has promoted a closer relationship between the extension service, the regional research stations, and the farming community they both seek to serve. The decentralization process obviously needs to continue so that the regional director and the regional council will have greater power in determining their research priorities and programs and in the use of their resources.

Structure of NARS in sub-Saharan Africa

The national agricultural research systems in sub-Saharan Africa continue to be in an interesting stage of evolution with regard to their organization and stature. The progress they have made in the past 15 years is in many ways very impressive. This progress must be viewed against the background of their past colonial history. Agricultural research in most countries of sub-Saharan Africa was carried out through a number of regional research organizations. In the anglophone countries, regional research organizations like EAAFRO - East African Agriculture and Forestry Research Organization (for Kenya, Tanzania, and Uganda) and the Empire Cotton Growing Corporation, provide two of the examples. There were others, including those built around specific commodities; table 2 lists some of these regional research organizations of the colonial period.

Figure 2: Organizational structure of INTA (Argentina)

(Pre-decentralization period)

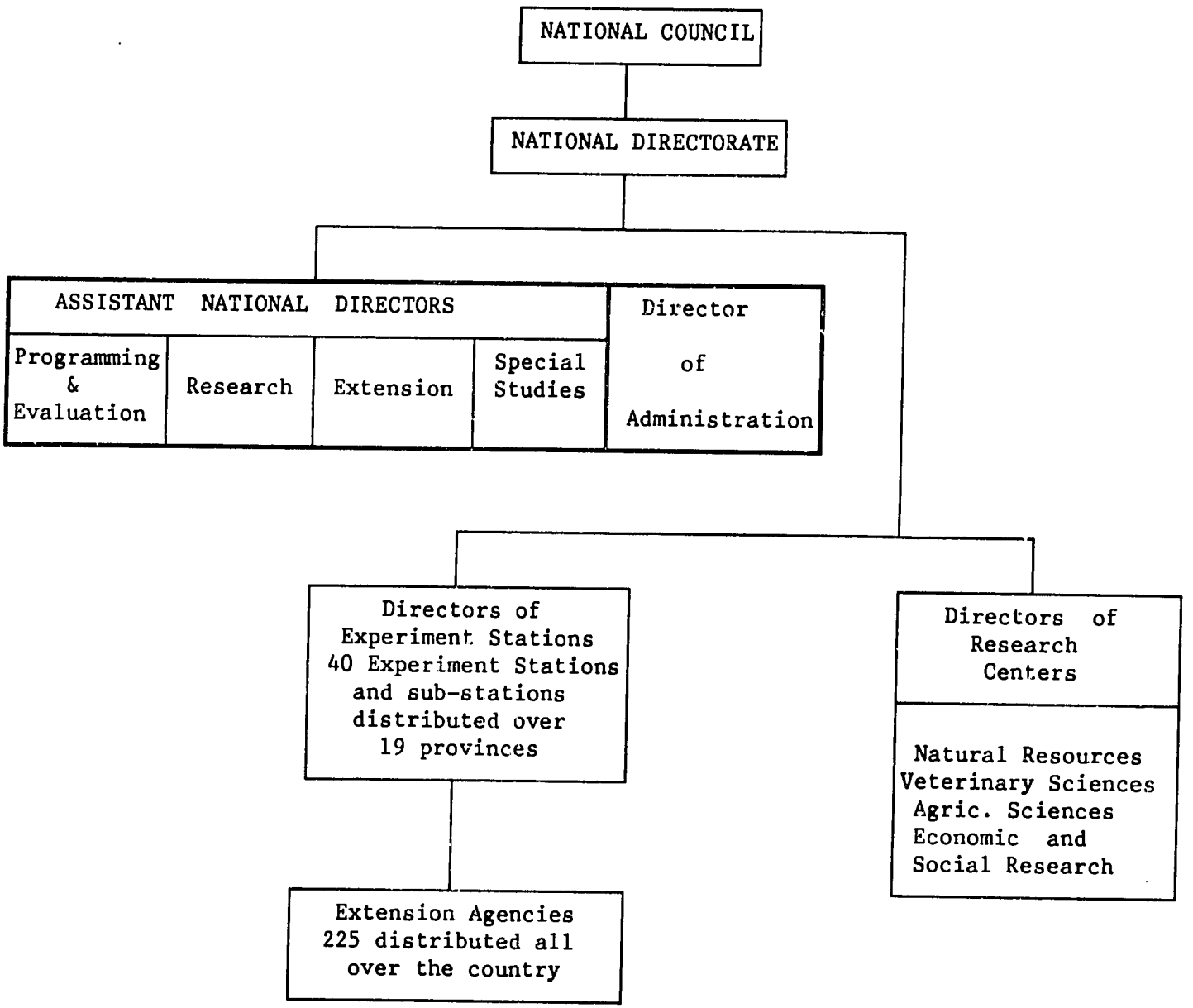


Figure 3: Organizational structure of INTA (Argentina)

(Post-decentralization)

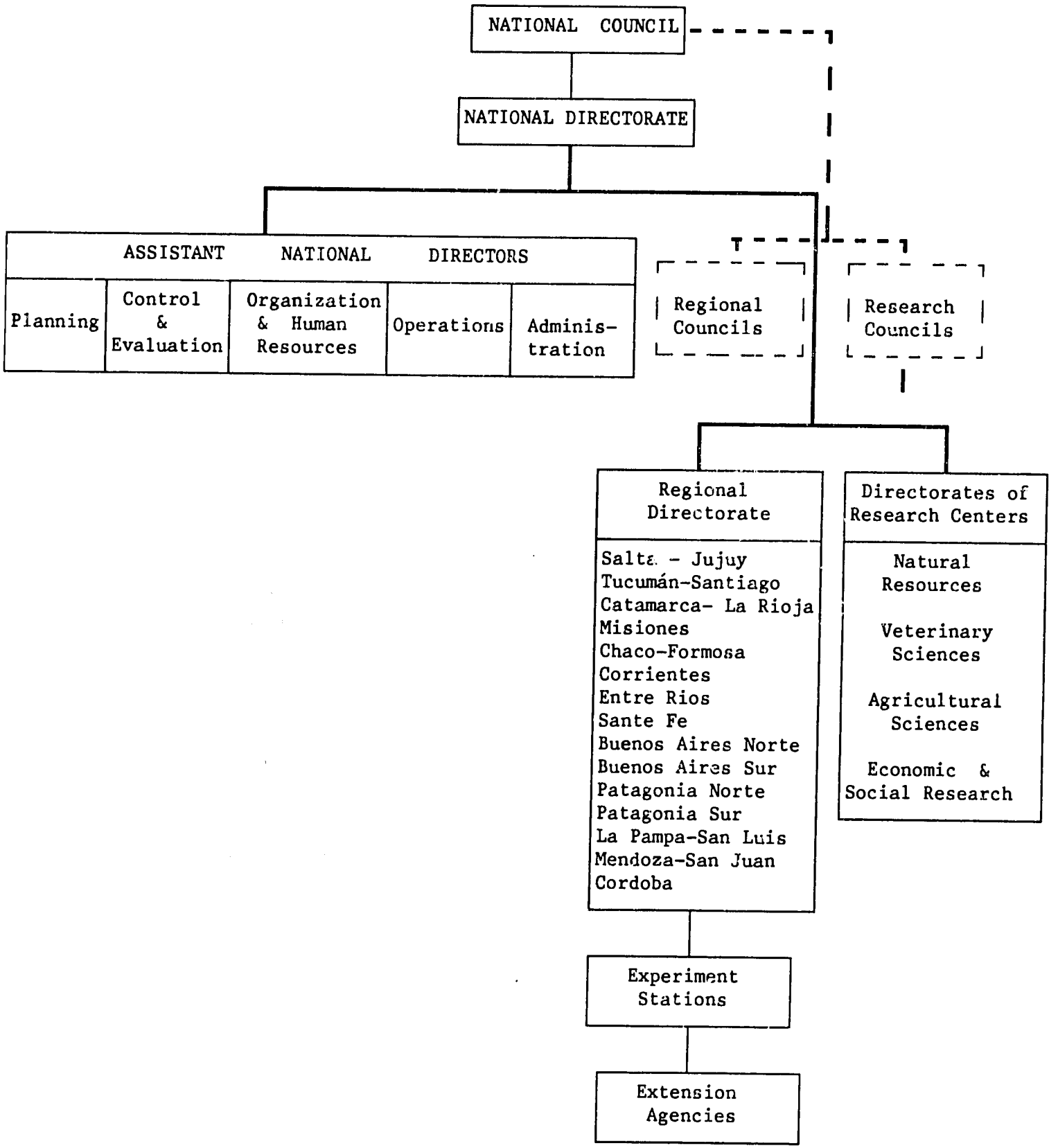


Table 2: Regional institutions for agricultural research in the sub-Saharan African countries during the colonial period

East African Agricultural and Forestry Organization, Kenya (EAAFRO)
East African Freshwater Fisheries Research Organizations, Uganda (EAFFRO)
East African Veterinary Research Organization, Kenya (EAVRO)
East African Trypanosomiasis Research Organization, Uganda (EATRO)
East African Virus Research Organization, Uganda (EAVIRO)
Tropical Pesticides Research Institute, Tanzania (TPRI)
West African Institute for Trypanosomiasis Research, Nigeria (WAITR)
West African Cocoa Research Institute, Ghana (WACRI)
West African Institute for Oil Palm Research, Nigeria (WAIFOR)
West African Maize Rust Research Unit, Nigeria (WAMRRU)
West African Stored Products Research Unit, Sierra Leone (WASPRU)
West African Timber Borer Research Unit, Ghana (WATBRU)
West African Rice Research Institute, Sierra Leone (WARRI)

In the francophone countries, an extension of the national agricultural research system of France to the colonies became the main instrument for providing technological support to the agriculture of these countries. In this highly centralized system ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer), with its headquarters in Paris, carried out basic research, while eight other specialist French institutions with a common board of management had their overseas units in the colonies for applied and adaptive research.

Following independence in the 1960s and 1970s, many of the sub-Saharan countries have taken important initiatives to create national agricultural research services of their own. Some of the new

institutions that have been created in the last 20 years are small compared to their counterparts in many of the Asian and Latin American countries. Table 3 shows the number of scientists to be found in the reorganized research services of the sub-Saharan countries. The new institutions combine some of the features of the Asian research councils and the Latin American national research institutes, but in other ways they tend to be different. In general, they differ in two respects. First, many of them have a semi-autonomous status within the ministry of agriculture or the ministry of science. The affiliation with the ministry of science is more common in sub-Saharan African than in Asia or Latin America, where these institutions are more directly linked with the ministry of agriculture. Second, much of the policy-making and management of the system rests with the director of the institution and not so much with the boards of management, which tend to have a limited role.

The diverse kinds of research systems which are currently found in the anglophone countries of sub-Saharan Africa have been classified by Taylor.[1] If we exclude the research services which continue to form an integral part of the government's departmental structure or are university based, three different types can be recognized.

Semi-autonomous research councils. These councils come closest to the funding and coordinating councils of Asia. Examples are to be found in the Council of Scientific and Industrial Research in Ghana and the Agricultural Research Council of Nigeria, which was created in the late 1960s but was later disbanded, and in the Agricultural Research Corporation of the Sudan.

Semi-autonomous research institutes. These, unlike the councils, have a board of management designated by the government. The board lays down the general policy and direction of the research program, but the management of the system rests largely with the director general of the institute. Examples of semi-autonomous organizations of this kind are provided by the Kenya Agricultural Research Institute (KARI), the Tanzania Agriculture Research Organization (TARO), the Tanzanian Livestock Research Organization (TALIRO), and the Cameroon Institute of Agricultural Research (ISAR).

Advisory and coordinating councils. These councils have little direct involvement with the agricultural research system. Their main function is to lay down the science policy of the country and ensure that this policy is reflected in the programs of the agricultural research organizations. Examples of this are provided by the National Council for Science and Technology in Nigeria and Kenya, the National Research Council in Uganda, the National Council for Scientific and Industrial Research in Zimbabwe, and the National Council for Scientific Research in Zambia.

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[1] T. Ajibola Taylor (1988). Organization and Structure of National Agricultural Research Systems in Anglophone Sub-Saharan Africa. ISNAR Staff Note No. 88-19.

Table 3: Semi-autonomous national agricultural research institutions in francophone West African countries, 1987

Country	Year	Institutions	Mandate	Affiliation
Mali	1960	Institut d'Economie Rurale (IER)	Crop production	Department of Agriculture*
Mali	1960	Institut National de la Recherche Zootechnique, Forestière et Hydrobiologique (INRZFH)	Animal production	Department of Agriculture
Senegal	1961	Institut de Technologie Alimentaire (ITA)	Food technology	Department of Agriculture
Togo	1965	Institut National de la Recherche Scientifique (INRS)	Botany, social sciences	Department of Science
Togo	1968	Direction Nationale de Technologie Alimentaire (DNTA)	Food technology	Department of Agriculture
Ivory Coast	1971	Centre Ivoire de Recherches Economiques et Sociales (CIRES)	Social sciences	Department of Agriculture
Mauritania	1973	Centre National d'Etudes et de Recherches Vétérinaires (CNERV)	Animal production	Department of Agriculture
Niger	1974	Institut National de la Recherche Agronomique (INRA)	Agricultural production	Department of Agriculture
Cameroon	1974	Institut de Recherche Agronomique (IRA)	Crop production	Department of Science
Cameroon	1974	Institut de Recherches Zootechniques (IRZ)	Animal production	Department of Science
Cameroon	1974	Institut des Services Humaines (ISH)	Social sciences	Department of Science
Senegal	1975	Institut Sénégalais de Recherches Agricoles (ISRA)	Agricultural production	Department of Agriculture
Togo	1976	Direction de la Recherche Agronomique (DRA)	Crop production	Department of Agriculture
Mauritania	1977	Laboratoire d'Entomologie Agricole (LEA)	Agr. entomology	Department of Agriculture
Burkina Faso	1981	Institut d'Etudes et de Recherches Agricoles (INERA)	Crop production	Department of Science
Burkina Faso	1982	Institut de Recherche en Biologie et Ecologie Tropicale(IRBET)	Tropical ecology	Department of Science
Ivory Coast	1982	Institut de Développement des Savannes (IDESSA)	Food crop production	Department of Science
Benin	1984	Direction de la Recherche Agronomique (DRA)	Agricultural production	Department of Agriculture

* Department of Agriculture also stands as a proxy for other government departments having main responsibility for development of agriculture.

In the case of francophone countries, too, the trend is for the research services to be created within the framework of the science ministry or the ministry of agriculture, with considerable autonomy on the operational side. These institutions remain closely affiliated with the ministry. Table 3 lists some of these newly created research organizations in a number of francophone African countries.

Ministry of Agriculture Model

The agricultural research services in most developing countries have traditionally formed an integral part of the ministry of agriculture, and in many of them this position continues, especially in the smaller countries. While some of the larger research systems have found it increasingly difficult to cope with the government bureaucracy, and for this reason have reorganized themselves with varying degrees of autonomy, many other countries continue to find this model quite useful for their situation. They find it unrealistic or unnecessary to think of large research councils and institutes in their context. Their concern has been to introduce reforms within the existing framework. Also, some of the larger research systems of this kind have sought to gain flexibility without severing their links with the government structure. The Department of Research and Specialist Services in the Ministry of Agriculture and Land Development in Zimbabwe, for example, has its own line budget and enjoys considerable autonomy in managing its affairs.

An important variant of the ministry of agriculture model is the organization of agricultural research in several ministries. A good example of this is provided by Sri Lanka, where eight different ministries dealing with one or the other aspect of crop or animal production have organized their own research services. The multiplicity of institutions is also a common feature of research organizations in many countries of North Africa and West Asia. In many of these countries the research organizations continue to be closely linked with a departmental structure of the government.

Organization of NARS in North Africa - West Asia

The Arab NARS, according to Hariri[1)], can be recognized in five different types on the basis of their structural diversity. First, there is the pluralist model characterized by considerable fragmentation of the different institutions. These institutions in the different departments of government, and even in the same department, are fairly independent in the determination of their research programs, and there is not a great deal of interaction between them. The second group of NARS is those where the instrument of budgeting is used to bring about some degree of coordination between the institutions of the same ministry. The ministry decides upon a common science budget from which allocations are made to the different research institutions it manages. Even so, there is not a

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1) Ghazi Hariri (1988). Organization and Structure of Arab National Agricultural Research Systems (NARS). ISNAR Staff Note No. 88-9.

great deal of coordination in terms of the research programs of the different institutions, which work more or less independently of one another. The third group of NARS shows a much greater degree of coordination in the work of their different institutions, brought about primarily through the mechanism of advisory bodies. These bodies help to link up institutions in the different ministries by helping to formulate a national science policy for agriculture. The different institutions are expected to respond to these policies in the formulation of their research programs. The fourth group of NARS shows an even greater degree of coordination, and this is achieved through the creation of a formal coordinating body. This body helps to achieve a consensus on the basis of research proposals received from the different institutions and presents them to a ministerial committee for approval. Finally, there is the fifth group of NARS, characterized by a high degree of centralization in the allocation of budgetary resources on the basis of detailed planning of national priorities and resource allocation corresponding to these priorities. These NARS, responding to a national research policy, have the advantage of a decentralized functioning once their mandate and research resource allocation have been determined by the central authority. Table 4 shows some of the institutional diversity of the national agricultural research systems in the different countries of North Africa and West Asia.

The University Faculties of Agriculture

Some developing countries, recognizing the ready availability and concentration of highly trained scientific manpower in their universities, have found it more realistic to mobilize their colleges and faculties of agriculture to provide technological support to their agriculture. Agricultural education and research are fully integrated in these systems. These university-based research services are highly variable in their organization and commitment. Some of them derive their inspiration from the land-grant colleges of agriculture in the United States of America, the country which, during the last century pioneered one of the most successful experiments in the development of agriculture through public-funded scientific research. The land-grant colleges in the United States have evolved a very definitive pattern of organization in response to the mandate given to them by the Congress. Within a period of 25 years of the establishment of the first land-grant college, the United States Congress had enacted legislation in the form of the Hatch Act of 1887, which called for the establishment of at least one agricultural experiment station in each state and a decision was taken to locate these stations in general in the land-grant colleges. The Hatch Act, thus, helped to transform the basic character of the colleges of agriculture. They were no longer primarily academic institutions. They became at the same time major agricultural research centers of the country, with additional investment of large resources in scientific manpower and experiment station facilities.

Several developing countries in recent years have adopted this model with some modification. India's 26 state agricultural universities, constituting the regional stream of research, for example, have been set up in the past 25 years on the general pattern of the land-grant institutions. In the Philippines, we have a research Council, PCARRD, acting mainly through the colleges of agriculture, which it has helped to strengthen for increased research capability in the past 15 years. In

Table 4: Number and type of agricultural research institutions in the North African and West Asian countries

Country	Institution		Affiliation
Algeria	INRA	Institut National de la Recherche Agronomique)	
	INRF	Institut National de la Recherche Forestière)	
	TI	Technological Institutes)	Ministère de l'agriculture
	NI	National Institutes)	
Libya	ARC	Agricultural Research Centre	General Authority for Agricultural Production
Mauritania	CNRADA	Centre National de Recherche Agronomique et de Développement Agricole)	Ministère du développement rural
	CNERV	Centre National d'Elevage et de Recherches Vétérinaires)	
	CNROP	Centre National de Recherche Océanographie et de Pêche	Ministère des pêches et de l'économie maritime
Morocco	INRA	Institut National de la Recherche Agronomique	Ministry of Agriculture and Agrarian Reform
Tunisia	INRAT	Institut National de la Recherche Agronomique de Tunisie)	
	CRGR	Centre de Recherche du Génie Rural)	
	INRF	Institut National des Recherches Forestières)	
	IO	Institut de l'Olivier)	
	IRA	Institut des Régions Arides)	Ministère de l'agriculture
	DRS	Division de Ressources en Sols)	
	BIRH	Bureau de l'Inventaire des Recherches Hydrologiques)	
	IRVT	Institut de Recherche Vétérinaire de Tunisie)	
	INSTOP	Institut National Scientific et Technique d'Oceanographie et de Pêche)	
Djibouti	DA	Department of Agriculture Research Service	Ministère de l'agriculture et développement rural
	ISERST	Institut Supérieure d'Etude et Recherche Scientifiques et Techniques	Ministère de l'éducation
Egypt	ARC	Agricultural Research Centre	Ministry of Agriculture
	WRC	Water Research Centre	Ministry of Irrigation
	DRI	Desert Research Institute	Ministry of Land Reclamation
	NRC	National Research Centre (ASRT) Academy of Scientific Research and Technology	Ministry of Education
	IOF	Institute of Oceanography and Fisheries (ASRT)	ASRT, Ministry of Education
Somalia	DAR	Directorate of Agricultural Research	Ministry of Agriculture
	LR	Livestock Research, MLFR	Ministry of Livestock, Forestry and Range
Sudan	ARC	Agricultural Research Corporation	Ministry of Agriculture and Natural Resources
	APRA	Animal Production Research Administration)	
	VRLA	Veterinary Research and Laboratories Administration)	Ministry of Animal Resources
	NCR	National Council for Research	Prime Minister
Iraq	SBAAWRR	State Board for Applied Agricultural and Water Resources Research	Ministry of Agriculture and Irrigation
	CSR	Council of Scientific Research	Prime Minister's Secretariat
	AWRRC	Agriculture and Water Resources Research Centre)	
	BSRC	Biological Sciences Research Center)	Council of Scientific Research
	SERC	Solar Energy Research Center)	
Jordan	NCARTT	National Centre for Agricultural Research and Technology Transfer	Ministry of Agriculture
Lebanon	ARI	Agricultural Research Institute	Ministry of Agriculture

Table 4 (contd.): Number and type of agricultural research institutions in the North African and West Asian countries

Country	Institution		Affiliation
Syria	DASR	Directorate of Agricultural Scientific Research	)
	DS	Directorate of Soils	) Ministry of Agriculture and Agrarian Reform
	DCB	Directorate of Cotton Bureau	)
	TRI	Tobacco Research Institute	
Bahrain	DAR	Directorate of Agricultural Research	Ministry of Economy and External Trade
	BCSR	Bahrain Center for Studies and Research	Ministry of Trade and Agriculture
Kuwait	KISR	Kuwait Institute for Scientific Research	Autonomous public institution
	AAFRA	Agricultural Affairs and Fish Resources Authority	Autonomous public research institute with a board of trustees
Oman	DAR	Directorate of Agricultural Research	Ministry of Public Works
Qatar	DAWR	Department of Agriculture and Water Research	Ministry of Agriculture and Fisheries
Saudi Arabia	RAWRC	Regional Agriculture and Water Research Center	Ministry of Industry and Agriculture
	DAR	Directorate of Agricultural Research	) Ministry of Agriculture and Water
	NCST	National Council for Science and Technology	)
U.A. Emirates	ARC	Agricultural Research Centre	The Prime Minister
Yemen AR	ARA	Agricultural Research Authority	Ministry of Agriculture and Fisheries
Yemen PDR	DRE	Department of Research and Extension	Ministry of Agriculture and Fisheries
			Ministry of Agriculture and Agrarian Reform

some of the African countries, the universities play a dominant role in the national research effort, and they virtually constitute the NARS. A good example of this is provided by the University in Sierra Leone. The University of Ahmadu Bello in Northern Nigeria is the main source of technology generation for the whole of Northern Nigeria, with a population of nearly 60 million people. In other African countries, like Kenya and Zimbabwe, the role of the university scientists is rather limited at present. In sub-Saharan Africa as a whole, the university scientists constitute the largest highly trained scientific manpower in agriculture but remain an under-utilized resource.

Organization of Experiment Stations

The national agricultural research systems, as we saw, show considerable diversity in their management and institutional framework. Some of this diversity is further reflected in the organization of their experiment stations. First, the number of experiment stations in the different countries may vary greatly and not always as a function of the size of the country and its agroecological diversity. Second, the size of the experiment stations may differ greatly - some with as many as one hundred or more scientists, others with as few as 10 or less. Third, the organization of the experiment stations may be built around commodities, disciplines, production systems, or a combination of two or more of these.

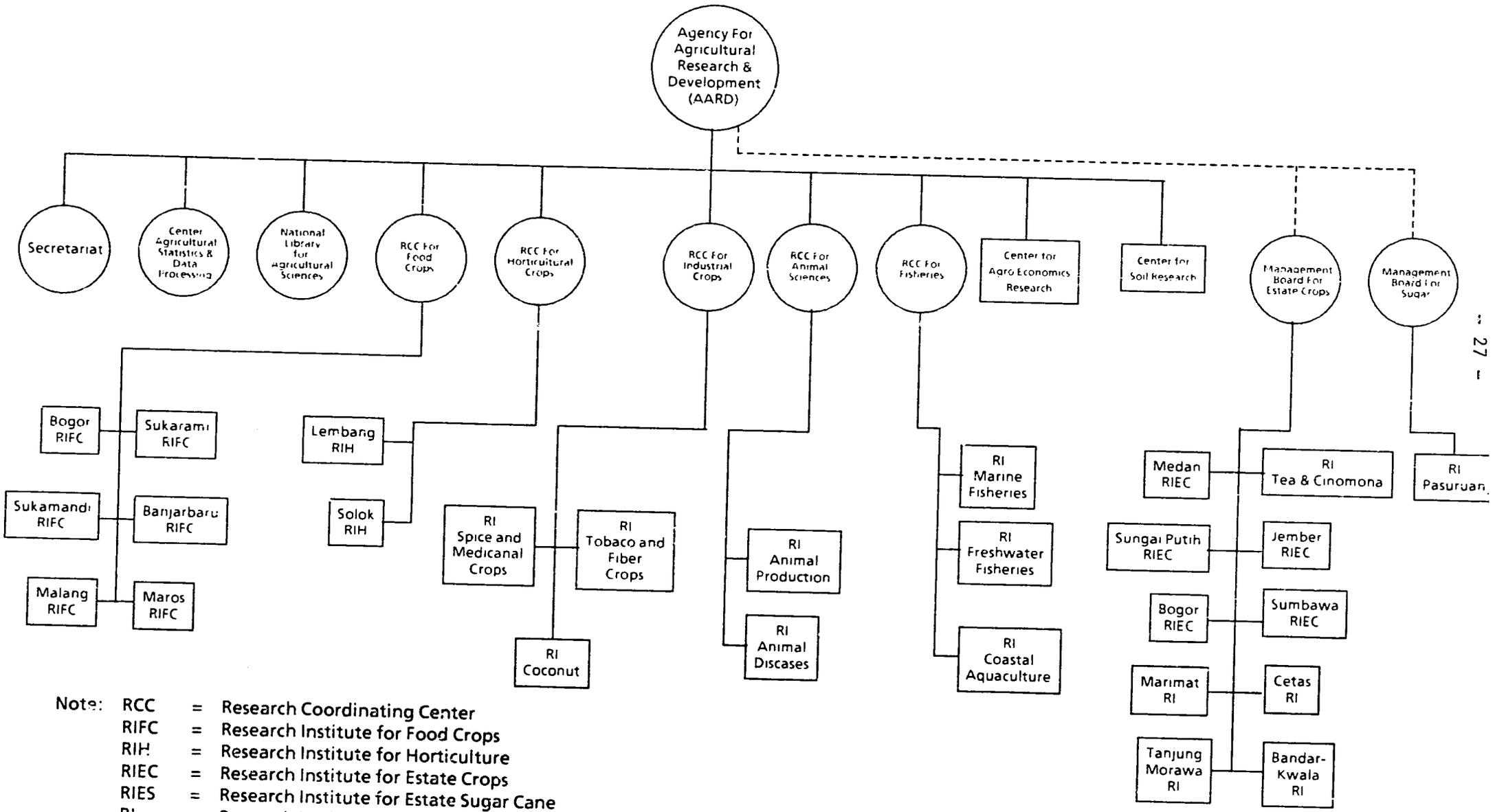
Single-commodity stations

The simplest type of experiment station is perhaps the single-commodity station (or institute) with all the scientists focusing their attention on a selected crop or livestock commodity of strategic importance to the country, e.g., tea, coffee, rubber, or an important cereal crop like rice, wheat, or maize, or an important livestock like beef cattle. They have the obvious advantage of fostering a strong multidisciplinary approach. This approach is particularly strong when the internal structure of the station is built around programs rather than discipline-based departments. International agricultural research centers like CIMMYT favor a program structure. CIMMYT, for example, has a wheat program and a maize program, and the plant breeders, agronomists, pathologists, entomologists, and all others report to a program director with no position of heads of department for the different disciplines.

Multi-commodity stations

An extension of the single-commodity experiment station is to be seen in the multi-commodity experiment stations; they are obviously needed, since few countries can afford to have a large number of single-commodity stations. In these, multidisciplinary teams are built around a number of commodities. The Indian Agricultural Research Institute (the largest of the research centers of the Indian Council of Agricultural Research), for example, carries out research on more than ten different commodities or groups of commodities, including wheat, rice, maize, sorghum, pearl millet, pulses, oilseeds, cotton, fruits, vegetables, and ornamental plants. The Indonesian Agency for Agricultural Research and Development has a network of 25 research institutes or experiment stations working on a wide range of crop plants and animals, as can be seen from Figure 4. Unlike some of the single-commodity experiment stations, the

Figure 4: Organizational Structure of The Agency for Agricultural Research and Development (AARD), Indonesia August 1986



Note: RCC = Research Coordinating Center
RIFC = Research Institute for Food Crops
RIH = Research Institute for Horticulture
RIEC = Research Institute for Estate Crops
RIES = Research Institute for Estate Sugar Cane
RI = Research Institute

multi-commodity experiment stations are almost always organized in the form of a number of disciplinary departments, whose heads report to the director of the station. The main advantage, of course, is that the discipline-based departmental structure helps to foster the professional growth of scientists through their close interaction of their own fraternity. If suitable mechanisms for program formulation can be invoked, a multidisciplinary approach to research is still possible in such stations. Figure 5 shows the organization of a typical multicommodity experiment station.

Pure disciplinary form

The third type of experiment station is organized around disciplines. The National Agricultural Research Station in Zimbabwe, for example, has Institutes of Plant Breeding, Agronomy, Plant Pathology, and Soil Science, in addition to a number of other experiment stations. Institutes or experiment stations of this type are more commonly found in the developed countries which invest considerable resources in basic research. If the mandate of the institute is to promote the growth of a particular discipline or to carry out a survey of an important production resource, e.g., soils, the concentration of scientists which these stations provide to foster close interaction and a concerted approach is obviously of great value. However, if the mandate is primarily research of an applied and adaptive nature, experiment stations of this kind may present serious problems in fostering a multidisciplinary focus so essential for the generation of an integrated production technology.

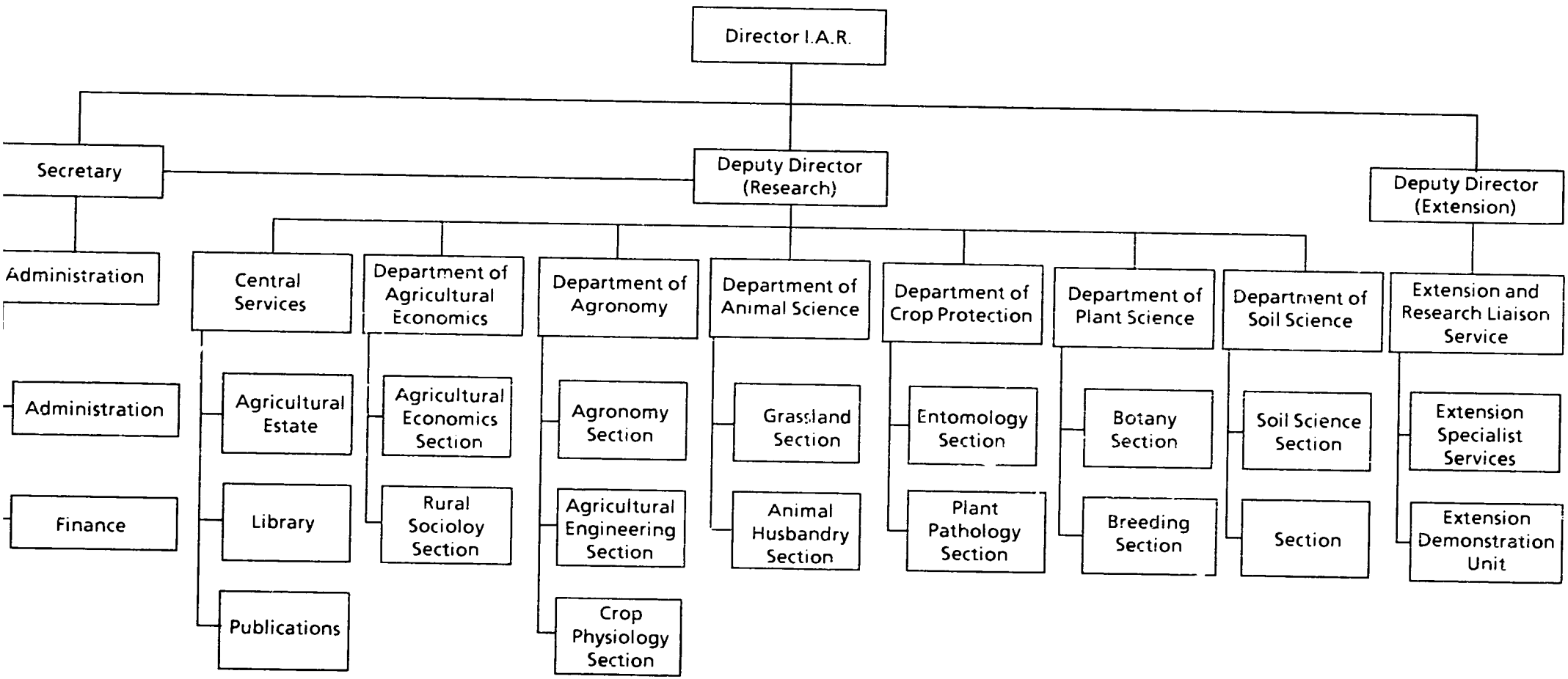
Systems-based stations

Another group of experiment stations has the major research focus on production systems rather than individual commodities. An experiment station for dryland agriculture, for example, can hope to achieve success only when genetic manipulation of crop plants for their improvement is combined with agronomic manipulation of the production environment through improved techniques of moisture conservation and soil management. Far too often the emphasis is on genetic improvement alone in the hope that the "miracle" seeds will solve the problem of these stress environments. Experiment stations of this type, more than all others, are generally organized around a program structure with scientists from different disciplines working together in a highly complementary manner.

National Research Programs

The national research programs, which in recent years have received considerable attention, are a new institutional innovation in the organization of NARS. They can be recognized as a separate institutional entity because they help to link up scientists from the different experiment stations and have a management structure of their own. These programs help to ensure that some of the country's major priorities in agricultural development receive the needed technological support in a

Figure 5: Organization of Ahmadu Bello University, Institute for Agricultural Research, Nigeria.



Adapted from brochure on Institute of Agricultural Research, Ahmadu Bello University.

highly focused and organized manner and that the funds available for research are not thinly distributed over too many programs and projects. A common failure of many national research services is that they have a very large research agenda, and no effort is made to identify priorities for allocation of resources and the opportunity to maximize impact. The organization of national programs helps to rectify this situation. The national programs, to be successful, need a coordinating mechanism which provides a great deal of inter-institutional and inter-disciplinary interaction. The national research programs are, therefore, best described as nationally coordinated programs which help to ensure a great deal of complementarity in the work of the different stations around a commodity, production system, or natural resource of strategic value to the country. They help avoid duplication by mobilizing the resources of the different research stations for a common purpose.

The structure of these national research programs is built around a coordinator, whose job it is to create a network of scientists from the different stations for the implementation of the program. The coordinator's unit is located in one of the stations closely related to the mandate for that particular research program, but it should be stressed that it has an identity of its own. The national coordinator has a role quite different from that of the director of the research station. The director's main responsibility is to provide managerial and scientific leadership for the station's program. The national coordinator's main responsibility is to bring about close cooperation of the concerned scientists from the different experiment stations, national and regional, in the implementation of the national program. The national coordinator reports directly to the head of the national research system, i.e., the director general. The coordinator has authority and status consistent with this responsibility. The coordination unit has a budget of its own to support the work of the coordinator and the associated staff in the coordination unit.

The more important responsibilities of the national program coordinator are expected to be as follows:

* help to define the objectives and technical content of the nationally coordinated program;

* recommend allocation of resources to the different cooperating stations for the implementation of their part of the program;

* monitor the progress of work at each center;

* organize multi-location trials of improved varieties and other technologies emerging from the program and consolidate the findings from these trials for presentation, review, and recommendations;

* organize annual workshop of all the participating scientists to review the past year's results and to plan the next year's work at each of the centers; the workshop would provide an opportunity for interaction with the senior staff of the extension service for identification of technologies to be recommended to farmers;

* prepare and present annual progress report of the program to the national director;

* liaise with the international agricultural research centers for introduction of new genetic materials and technologies for induction into the national program;

* organize training of young scientists from the different cooperating centers.

Reorganization: The Next Phase

The reorganization of agricultural research in the developing countries in recent years has taken several different forms. This was only to be expected, and no one has ever suggested that all countries should end up having similar types of institutional structures and administrative frameworks for the organization of their agricultural research. For one thing, the size of the research systems, their mandates, and their resources may vary considerably in different countries. For another, the past history of the country's administrative, educational, and social institutions may impose some limits on the options to be explored in reorganizing the research system. And finally, the reorganization process would be influenced to some extent by the past history of the system itself.

For these reasons a comparative analysis of the different types of institutions which have emerged during the past 15 to 20 years in the different developing countries does not serve a particularly useful purpose. These institutions obviously differ in their potential for the different governance and research functions considered earlier in this paper. Many of them have been able to make a significant impact on agricultural production with their newly found flexibility and management culture.[1] The question we should be considering is how these different types of institutions can use their enhanced potential to become even more effective and how they should be evolving in the future. It is in this context that we may consider the different kinds of national research councils and research institutes and other organizations which have appeared on the agricultural scene of the developing countries in the past 20 years.

Continued evolution of NARS

The reorganization which took place mainly in the 1960s and 1970s had one major objective -- to create a potential for effectiveness in the short

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[1] H.K. Jain (1988). Role of Research in Transforming Traditional Agriculture: An Emerging Perspective. Proceedings of the Seminar "Food and Nutritional Strategies: Concepts - Objectives - Application". Royal Academy of Overseas Sciences (Brussels), pp. 335-355. (Eds. R. Delleré and J.J. Symoens).

term. The prime need was to make an impact on production by making science and technology an instrument for the transformation of traditional agriculture. The new organizational structures, with their newly found sense of confidence and freedom from a stifling administrative culture, did make it possible for the research systems to take major initiatives and to move with speed in generating new technologies, both through their own efforts and by working in close collaboration with the international agricultural research centers (IARCs) of the Consultative Group on International Agricultural Research (CGIAR). They provided a vast amount of improved genetic material which made it possible to widen the gene pool of the locally available genetic resources in some of the important cereal crops.

The need today is different. The potential for effectiveness in the new organizations has been exploited for responding to some of the more urgent needs. Now they must equip themselves to make a more wide-ranging impact on a continuing basis. Most of the countries have had their greatest success in major cereal crops like wheat and rice and to a lesser extent in maize, sorghum, and millet. In the sub-Saharan African countries, where many of the research services had their origin in regional institutions during the colonial period, the impact, with some exceptions, has been limited. The high-yield technology must be diversified and, above all, the technology must be generated for the more difficult agroecological situations - the dry lands and lands with problem soils, where a very large part of the farming community in developing countries, more particularly in sub-Saharan Africa, is located.

The strategy in the 1970s was to take advantage of the more favorable environments to tide over the immediate shortages and to create reserve stocks of foodgrains so that in years of drought, there was no large-scale distress and the food prices could be brought down for the poor people. In the closing years of the century, the social problems of the bulk of the farming community must be addressed, with equity considerations receiving greater attention.

Creation of planning capacity

What kinds of organizational change are further needed to achieve these objectives? First and foremost, the headquarters of the new councils and national institutes must be reorganized to place greater emphasis on planning and policy-making than on administrative work. The NARS need to create a strong planning capacity, with appropriate blends of skills for this purpose. The NARS leaders should be spending more time on issues of policy; e.g., the relative resource allocation to different commodities, production systems, and production resources, on monitoring and evaluation of research programs; and on establishment of closer links with the extension service, the producers, and the policymakers in the government. They should also help the system to link more effectively with the world knowledge system, including the centers of the CGIAR. The fundamental question is what kind of planning units should be created within the headquarters of the council and the national institutes so that the director general and the senior staff are able to devote more time to issues of this kind.

The systems as organized at present use their high-level scientific expertise more on routine administrative matters in managing the

experiment stations from a distance than on issues of policy and planning. In other words, we seem to have substituted one kind of bureaucracy for another. The management of the experiment stations should be left in the hands of the directors of the stations, with a great deal of delegation of responsibility.

The creation of planning capacity is important if the potential for effectiveness is to be combined with efficiency in the use of resources. The new councils and institutes have not been particularly efficient in the use of their limited resources. The governments in the past have been extremely generous with their budgets, but increasingly questions will be asked about the efficient use of these resources. It would be unrealistic to expect that their budgets will continue to increase as in the past.

Decentralization

The other kind of structural change is dictated by the need for decentralization, especially with increasing recognition of the role of regional research. Agriculture in the larger countries by its very nature is a highly dispersed activity practiced by millions of farmers distributed in different agroecological regions. Organization of agricultural research to provide technological support to these diverse groups of farmers cannot and should not be a highly centralized activity. The need obviously is for a national as well as a regional focus in research planning, responding to the broader national priorities and the more specific problems of the regions. In many large countries, a large part of responsibility for the development of agriculture rests with the provincial or the state governments. These countries, therefore, are expected to have two major streams of research, a federal stream and a regional stream, linked closely through the institution of a number of nationally coordinated programs. This division of responsibility becomes all the more important for the organization of the extension services -- a grass-roots activity which normally belongs to the provincial or state governments.

Inter-institutional coordination

A key problem is one of coordinating the work of the federal and regional research institutions and building a great deal of complementarity in their work. The nationally coordinated programs discussed earlier provide the institutional mechanism of such linkage. Some of the countries already recognize this and, as noted earlier, have promoted the growth of a strong regional research service managed directly by the state governments, with partial federal support. Others, especially the larger countries of Latin America, have yet to take major initiatives in decentralizing some of their research functions to the provincial governments and in helping them to set up their own research services. With a large network of research stations spread all over the country employing hundreds of scientists, the research system presents many problems if the process of decision making remains highly centralized. In centralized systems of this kind the management is often overwhelmed with routine administrative work, leaving the senior staff little time for planning and policy-making. There is a good rationale for a division of responsibility between the federal and the regional institutions in terms of their research mandate and for coordination of their work.

Commitment to development

The organizational changes that have taken place in the last 20 years need to be reviewed in the context of the central function of the national agricultural research systems, which is to organize highly relevant and effective research programs in support of the development of the country's agriculture. While giving them greater autonomy, the paramount need has been to combine it with commitment. The contractor-client relationship proposed by Lord Rothschild implies that the newly created councils and institutes must think of themselves as contractors appointed by the government to help meet the improved technology needs of the farmers for increasing agricultural production and for making it a major instrument of the country's economic and social transformation.

The experience of the last 25 years shows that some of these newly created bodies may have distanced themselves from the ministry of agriculture and from other government departments responsible for the development of the farm sector.

In the case of the Indian Council of Agricultural Research, the Government of India was so concerned with this aspect of the Council's functioning that it took two major precautions to make sure that the reorganized research system does not waste its resources on research which is not relevant to the needs of the farmers and the country. First, the Minister of Agriculture acts as the President of the Council, so that the Director General, who acts as chairman of the Governing Body, reports to him directly. In this way the power of the Governing Body to act independently has been curtailed. More important, a special device was found to link the Director General, but not the Council, more closely with the Government. This was done with the creation of a symbolic Department of Agricultural Research and Education (DARE). The Director General of the Council has a dual position; he also acts as the Permanent Secretary of DARE. This mini-department was specially created for the sole purpose of ensuring Government control over the research policy. The management of research, on the other hand, is carried out in the Council, which remains a non-government organization and can operate outside the civil service procedures and the Government rules and regulations.

The gap between the newly created national research institutes and the ministry of agriculture has tended to widen in some of the Latin American countries. Some of the institutes may have become increasingly isolated from the government. Their autonomy makes it possible for them to do many things without having to report to the government on some of their major decisions.

A good example of an autonomous national agricultural research institute in Latin America, as we saw earlier, is the Instituto Nacional de Tecnología Agropecuaria (INTA) in Argentina. INTA is widely regarded as one of the more successful of such national institutes in Latin America and, indeed, it enjoys the reputation of being one of the more effective national agricultural research systems in the developing world as a whole. Even so, the perception is that the INTA Council is so powerful

that it is able to formulate the country's national agricultural research policy without a great deal of interaction with the Ministry of Agriculture. One consequence of this is that in spite of some very outstanding work, the members of the INTA Council and the senior scientists in the system may have failed to evolve national research priorities through a wider process of consultation involving, among others, the senior government officials and policymakers.

A good example of a reorganized institution isolating itself from the government is provided by the Kenya Agricultural Research Institute - an autonomous research organization which was created by the Government of Kenya in 1979 by transferring to it all the research responsibilities of the Division of Scientific Research of the Department of Agriculture. A review of the national agricultural research system of Kenya carried out by ISNAR in 1981 showed that the Board of Management of KARI rarely met and, indeed, the new organization hardly functioned. Recognizing this failure, the Government decided to create a new KARI, which is now beginning to function very effectively. The new KARI incorporates major changes in its Board structure, with the senior officials of the Department of Agriculture, among others, represented on it. Also, the research station infrastructure has been consolidated, with fewer experiment stations and with their mandates clearly defined.

It is concerns of this kind that have made some of the governments cautious about transfer of the research function from the ministry of agriculture to semi-autonomous or autonomous organizations. Indeed, a few of the governments are now proposing that research should be brought back to the ministry of agriculture after their perception that the creation of the semi-autonomous research organizations has not helped much. A case in point is that of Tanzania, where the research function was transferred from the Ministry of Agriculture to a number of parastatal organizations in the 1970s. The Ministry of Agriculture and Livestock Development in Tanzania has now proposed that this function should be transferred back to the Ministry under a reorganized Division of Agricultural Research and Training. Another case in point is that of the Instituto Nacional de Tecnología Agropecuaria of Nicaragua, which was created in the early 1970s. The Government decided in 1979 to bring the research function back to the Ministry of Agriculture. The lesson we learn from this is not that autonomy is bad but that it must be combined with commitment. The experience with many of the new institutions, more generally, has been extremely favorable.

Improvement in the Board structure

We may ask what has gone wrong with some of the newly created research councils and national institutes, which undoubtedly have a great deal of potential to be effective and many of which, indeed, have done some very good work. The answer in a word is: nothing is wrong, but they need to evolve further. One problem lies with the institution of the governing board or the governing council, which lays down the policy framework for these reorganized research systems and monitors their work. The composition of these boards and councils in this context becomes particularly important.

If autonomy is to be combined with commitment, the obvious need is to give much greater representation to those who are directly concerned with the promotion of agricultural production programs in the country, working closely with the farmers. This means that the producer organizations should be fully represented so that they are able to project their technological support needs to the research systems. This also means that the senior officials of the federal ministry of agriculture and of the departments of agriculture in the states, who have a direct responsibility to provide support to farmers in the implementation of the different production programs, should be represented on these governing bodies.

For example, the director of agriculture, the director of extension, the director of irrigation, and officials of the planning ministry, commission, or board should sit on these boards. They are the clients of research on behalf of the farmers and the poorer sections of the rural and urban populations, who suffer most in the event of food shortages. Their own performance is evaluated by the impact they are able to make on the development of agriculture in the country and, for this reason, they have a vested interest in the output of the research service. They are strongly motivated to place demands on the research service for the highly relevant technologies the country needs.

The experience of the past twenty years shows that in many cases the governing boards and the governing councils have been filled with persons who may be very distinguished in their own fieids but who have little aptitude for, knowledge and understanding of, and responsibility for the development of agriculture. They simply have no experience of agriculture, and they have no particular interest in it.

Even more important is the reporting relationship of the director general of the system. The councils and the boards could become a mechanism for preventing a close contact and working relationship between the minister and permanent secretary of agriculture on the one hand, and the director general of the research system, on the other. It is clear that if the director general is to come out with a highly relevant research program he should be able to monitor the government's development policy closely, and for this purpose he must maintain close contacts with the minister of agriculture and the senior officials of the ministry. He should be able to report directly to the minister and/or to senior officials of the ministry of agriculture.

Linkage with the private sector

An important structural weakness of NARS in many developing countries is that they have limited links with agribusiness and the private sector. The history of agricultural development in the industrialized countries in the past 50 years shows that they have increasingly transferred some of their responsibility for research and research-related services to the private sector. Also, the private sector invests heavily in public-sector research and collaborates with the public-sector institutions in research programs in which it has a specific interest. In countries like the USA, the private-sector investment in agricultural

research is as high as or even higher than that in the public sector. The developing countries over a period of time will have to follow the same evolutionary route for reasons of economy, greater accountability and, above all, for building a greater degree of relevance in their research programs.

In the developed countries most of the adaptive research is carried out by the agribusiness companies as part of their promotion programs for the sale of seeds, fertilizers, pesticides, farm machines, and other modern farm inputs. This frees the public research services to concentrate their resources on strategic and applied research. It also helps to reduce the size of the research stations, leading to a more efficient management. In many developing countries, especially in Latin America, a similar trend is now beginning to emerge. Carl Pray and Ruben Echeverria[1)] have reviewed the role of private-sector agricultural research and technology transfer in the developing countries. The need now is to accelerate, through conscious policy decisions, these collaborative processes.

There is no good reason, for example, why production of certified seed should not take place in the private sector, making use of the breeders' seed produced in the public-sector institutions. Many of the industrialized countries have reached a stage where a large part of work on varietal improvement is carried out by private seed companies. The latest development in this regard is the privatization of the world-famous Plant Breeding Institute at Cambridge, a large part of which was recently sold by the government to a private company. Similarly, public-sector institutes have very little hope of introducing improved farm implements without close collaboration with the private sector. The government-funded research stations in most developing countries are simply not equipped for the production of prototypes and their modification and improvement based on continued testing on farmers' fields, through years of painstaking work. Their role should stop with the production of the first workshop model when it can be handed over to a private entrepreneur.

The other kind of links with the private sector relate to the funding of research. The NARS should be able to receive funds from the private sector for development of specific products, e.g., a particular type of tomato variety which may be more suitable for processing, sugarcane varieties with higher recovery of sucrose, improved farm machines, or new vaccines for animal diseases, to name only a few. The scope of such collaboration will expand as biotechnology research gets under way and a wide variety of commercial products begin to be available for marketing. In the industrialized countries, this is already beginning to happen. The Agricultural and Food Research Council (AFRC) in Britain, for

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1)Carl E. Pray and Ruben G. Echeverria (1988). Linkage between private-sector Agricultural Research and Technology Transfer in Developing Countries. ISNAR Staff Note No. 88-33.

example, has promoted in recent years the formation of an Agricultural Genetics Company in collaboration with a number of private industries. The understanding is that in lieu of the funding support which these companies provide to the scientists of the AFRC-supported institutes in the public sector, the first options to commercially exploit the products coming from such research will rest with these companies.

In some developing countries the NARS already receive funds for research in the form of an export tax on agricultural commodities like sugarcane and tobacco. In Argentina, for example, INTA receives its budget from the government through the imposition of a 1.5 percent tax on the export of agricultural commodities. In Pakistan and India a cess is levied by the government at the manufacturing stage on a number of crop commodities, which is added to the research budget of the national agricultural research system. The need now is to institutionalize some of these funding mechanisms.

Research foundations

The NARS in Latin America, in general, have been more successful in developing links of this kind with the private sector. Apart from the joint ventures with individual companies, a major concept in some of these countries in the past ten years has been to create foundations that would extend funding support to institutions both in the private and public sectors. These foundations, encouraged with funding support from USAID and the private sector, are in different stages of evolution in the different countries. Margaret Sarles[1], of Rutgers University, in a recent paper has analyzed the experience of USAID in helping to set up a number of such research foundations. The foundations were set up largely in response to the difficulties of various kinds which were found to be associated with the public-sector institutions. Thus, it was noted that in many cases these institutions suffered from administrative and leadership weakness, that they failed to give advice to the farmers and agribusiness groups who were their clients, and that their weak financial position was made worse by burdensome budgeting and fund dispersal mechanisms. The foundations were conceived to provide an institutional model which would be more flexible administratively and free from public-sector over-regulation, offering a technical rather than a political orientation, as developing formal leadership roles for farmers and agribusinesses, and as capable of developing linkages between the national agricultural research system and the technology transfer systems, international sources of technology, and new outside sources of funding.

Analyzing the functioning of these foundations retrospectively, Sarles came to the conclusion that for the present they do not seem to have done too well. While the new approach was intended to circumvent serious

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[1] Margaret Sarles (1988). A.I.D. Experiment with private-sector in Agricultural Research, Agricultural Technology Management Workshop, Rutgers University.

institutional problems of the existing systems, the integration of the foundations into the rest of the agricultural technology system must be systematically worked out. In summary, while the foundation idea seems excellent, a great deal remains to be done to make them an integral part of the existing research system, supporting and complementing its work rather than competing with it. There is little doubt, however, that such foundations have the potential to link public-sector research much more effectively with its clients in the farming community and in the business sector.

The future direction of coordinating and funding councils

The funding and coordinating types of council set up in some of the Asian countries clearly represent only the first step in the process of research system reorganization. The future government initiatives in strengthening the councils clearly depends on their performance; in establishing their credibility and in demonstrating that research has the potential to become a powerful instrument of economic growth. The governments can be expected to strengthen them in a variety of ways. The funding councils are in a more fortunate position, as they have used their power with good effect. An outstanding example of this is provided by the Philippines Council for Agriculture and Resource Research and Development. Since its establishment in the early 1970s, PCARRD has made an important contribution in the development of a national research strategy - evolving priorities and programs and in coordinating research efforts of different agencies and institutions around selected priorities. Agricultural research in the Philippines today has a strong national focus in relation to development, which was missing in the earlier years. PCARRD's success can be attributed directly to its strong planning capacity.

The limitation of councils like PCARRD is that they have no research infrastructure of their own, and they must always depend on others for translating their priorities into effective research programs. Councils of this kind need to link up with a more dependable research station infrastructure for greater sustainability and continuity of the research effort.

The coordinating councils would receive greater recognition from the government if they succeeded in their primary tasks of preparing strategic national research plans for the institutional development of the system, and in monitoring and evaluating the work of the different experiment stations. Further, they are expected to organize a series of nationally coordinated research programs involving inter-disciplinary and inter-institutional collaboration. They would be expected to have a more direct administrative link with the different experiment stations in the country once they demonstrate their preeminent position in the area of research planning and policy-making. In short, the coordinating councils must evolve a research strategy which makes sense to the governments and to the scientists in the different experiment stations, the donors, the academic community in the country and, above all, to the farmers.

Harnessing the Ministry of Agriculture model

Agricultural research in many developing countries continues to be organized within the framework of a departmental stature in the ministry of agriculture.

With all of its bureaucracy, which may make decision-making and program implementation difficult, the ministry of agriculture model of research organization does offer one great advantage. In these systems the linking of research programs with the development policy of the government is greatly facilitated. The research service is expected to function as the technical wing of the government in support of its overall economic policy. Also, the transfer of technology to farmers is greatly facilitated because both research and the extension services form part of the same ministry. It should be stressed that the bureaucratic constraints may not be so stifling when the countries are small. Indeed, in many of these countries, where the research services are a relatively recent innovation, they may need the prestige and protection which comes from their close association with the government.

The best strategy for the future evolution of these systems would be for the government to nurse them to greater maturity and consider their special needs for operational autonomy. Some African countries have already done so. In Zimbabwe, for example, the Department of Agricultural Research and Specialist Services in the Ministry of Agriculture and Land enjoys a large amount of autonomy in the management of its various operations and budget. The Department also participates in the selection process of its senior staff.

Transformation of the university-based research services

There are not many countries in which universities play a dominant role in the organization and management of agricultural research in the country. Some of the African countries use their universities to provide research support of this kind for the country's agriculture. A good example is provided by countries like Sierra Leone and Nigeria. In many countries, however, the federal stream of agricultural research is strongly supported by a regional stream based in the universities. In some of these the university-based regional institutions may, in fact, be the major source of improved technologies for the farmers, with the federal institutions doing more of strategic research.

The inspiration for a deep involvement of the university scientists in generating technologies for the country's agriculture comes from the land-grant institutions first established in the United States during the last century. The land-grant institutions, however, must now be regarded as a historical phenomenon, and it may not be realistic to think that the experiment could be replicated at this stage in many developing countries. At the same time, the land-grant philosophy itself remains highly valid, and some countries have already taken full advantage of it in recent years in reorganizing their research systems.

The 26 state agricultural universities established in India during the past 25 years to strengthen the country's regional stream of agricultural research have been fashioned on the concept of integration of higher

education, research, and extension education. These institutions have taken over the experiment stations which earlier formed a part of the Department of Agriculture. In the Philippines, the government has gone a stage further. Following the policy decisions of the early 1970s to reorganize the research system in the Philippines, the government decided to down-grade the role of the Ministry of Agriculture in the organization and conduct of research; they handed over much of this responsibility to the colleges of agriculture in the universities. There is no fundamental reason why faculties of agriculture in many other developing countries should not be similarly harnessed to provide support for the development of the country's agriculture. This is particularly true of sub-Saharan Africa. In these countries some of the best-qualified scientists are to be found in the faculties of agriculture, while the research services of the ministry of agriculture are often very short of highly qualified staff. However, the concept of a trilogy of teaching, research, and extension requires a great deal of supporting infrastructure for research and a built-in budgetary mechanism to put it into practice.

The faculties of agriculture in most countries have evolved in response to the needs of teaching. Their future development lies in equipping them with experiment station facilities, some additional scientific staff, and budgetary mechanisms if they are to provide research support of the kind the land-grant institutions in the United States provide. Here is a tremendous resource that could be harnessed for the benefit of the country's agriculture with a minimum of investment, complementing and not competing with the national research effort.

Rationalization of the Research Station Network

Organization at this level merits a consideration of its own. The very first issue here is one of the size of the network: how many research stations? This will be determined in the first place by the availability of scientific and other resources in the country. The tendency generally is to have too many stations with a sub-critical mass of scientific and other resources. Many of these stations tend to become isolated from the national system as a whole, and their productivity suffers. Consolidation of the research station network should receive far greater attention in most countries than it normally does. The emphasis most of the time is on growth.

The second factor determining the number of stations and their location is obviously the size of the country and its agroecological diversity. Ideally, and consistent with the availability of resources, the needs of the different agroecological regions should be met. If a country does have a great deal of such diversity and must have a number of research stations, then two other issues become important. First, there is the question of division of responsibility between the different research stations, and second, there is the issue of inter-institutional coordination at the national level.

National and regional research stations

The experience of many developing countries with a limited number of qualified scientists and other resources suggests that there is considerable merit in having two different types of stations -- national

research stations and regional research stations. They will have quite different mandates, combined with a strong complementary relationship. The national research stations will be developed as the country's main research centers for advanced research for the generation of improved genetic materials and technologies for a particular commodity or group of commodities, or for a particularly important production resource, such as the soils and water. The main concern here is that this kind of advanced technology-generating research, which cuts across the needs of different regions, cannot be easily replicated and must, therefore, be organized on a centralized basis. The national research stations will have the required concentration of resources in the form of a multidisciplinary team of scientists and adequate laboratory facilities. Their research results must have the potential for wider dissemination, transcending provincial or state barriers. The number of such national research stations would vary, depending on the crop and livestock resources of the country, and only the more important priority programs built around commodities or resources of overwhelming importance to the country, e.g., maize in Kenya or rice in Bangladesh and Indonesia, would qualify for stations of this kind.

Complementing the national stations would be a group of regional research stations placed strategically in the different agroecological regions and having a major focus on production-oriented research closer to the needs of the farming systems. The regional research centers should help to improve the productivity of the recommended farming systems, making use of the new genetic materials and concepts developed at the national research centers. Their mandate would be adaptive research, based on the materials and practices developed at the national research stations. They would also be integrating the different components of production technology in response to the specific regional needs.

Countries with very limited scientific and other resources, which cannot afford to set up even a very limited number of national research stations, must make a compromise. They would have a number of regional research stations, with some of them having a lead function for national research on a particular commodity. Thus, some of their experiment stations would have a dual mandate, a national one for one or more commodities and a regional one for the relevant production systems.

Table 5 illustrates the principle of organization of a research station network as a function of country size, its agroecological diversity and resource base.

Structure of experiment stations

Finally, we come to the issue of the scientific structure of an experiment station. The different organizational models of experiment stations have been discussed by Paul Bennell[1)] of ISNAR. He has listed

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[1)] Paul Bennell (1986). Planning and Programming in Agricultural Research in Zimbabwe. Proceedings of a workshop. ISNAR, The Hague.

Table 5: Organization of research station network

COUNTRY SIZE	RESOURCE BASE	TYPE OF STATION	TYPE OF RESEARCH
Large	Excellent resource base	National stations Regional stations	Basic and strategic Applied and strategic
Large	Fair amount of resources	National stations (several) Regional stations	Applied and strategic Adaptive and applied
Medium	Limited resources	National stations (few) Regional station	Applied Adaptive
Small	Limited resources	National stations (one) Regional stations	Applied Adaptive
Small	Very limited resources	Regional stations (some) with lead functions	Adaptive and applied
Very small	Limited resources	National station testing sites	Adaptive

some of the advantages and disadvantages of the different types of structure of experiment stations. Table 6, for example, shows the advantages and disadvantages of two types of experiment stations -- those having a pure disciplinary form and a pure commodity form. The table should be seen to provide a framework for analysis; much depends on the kind of resources available to a particular country. Thus, the discipline-based structure for a research station would be possible only if a critical number of scientists in each of the disciplines is available for being placed in the different departments. Also, single-commodity stations may not be possible to establish in those countries with an extremely limited number of trained scientists. Their scientists must work on a number of commodities and production resources.

The single-commodity stations may have higher costs, but experience shows that they are remarkably effective. In the case of sub-Saharan Africa, where one sometimes hears the comment that agricultural research has not made a substantial impact, the single-commodity institute, like those on coffee, tea, and oil palm provide outstanding examples of research that has made a major contribution to the national economy. Several factors account for the effectiveness of these stations.

In the first place, the mandates of these stations are very clearly defined. Second, in response to this mandate, the scientists generally come out with a highly relevant program. There is not much possibility of the scientists pursuing their own research agenda when the demand from the clients for improved production technology has been so clearly articulated.

Third, the single-commodity stations are highly successful in generating a multi-disciplinary approach to their work. The research work of these stations is basically organized around a program structure, even if the scientists are placed in different disciplinary departments. There is a great deal of complementarity in their work, so that they reinforce one another.

Fourth, the single-commodity stations tend to be small in size - the largest of them having no more than 30 to 40 scientists; the smallest ones may have no more than 15 to 20 scientists. Their small size is a great asset, as it helps to achieve a high degree of efficiency in management. Some of the problems commonly associated with institutes of large size are seldom encountered in the single-commodity stations.

There is no basic reason why the concept of single-commodity institutes should not be extended to some of the more important food and other crops. If rice, maize, or wheat for a country is of overwhelming importance for the diet of its people or for other strategic reasons, a station with a mandate for these crops may be the most effective way of clear identification of commodities or production resources that are of organizing research. It is recognized that countries with very limited resources cannot organize institutes or stations of this kind around a large number of commodities. But this is not the suggestion. The suggestion is that, depending on the availability of resources and a overwhelming importance, the country may choose to have one or two or more of these stations. For a country like Bangladesh, an experiment

Table 6 : A comparative analysis of discipline- and commodity-based experiment stations

THE PURE DISCIPLINARY FORM

Advantages	Disadvantages
Provides effective disciplinary "home for researchers	Not conducive to cross-disciplinary collaborative research (commodity and systems approaches)
* specialization -- particularly for basic, strategic, and applied research	* exacerbates professional rivalries
* critical mass for specific disciplinary areas	* complicates coordination process
* effective supervision and on-the-job training	* excessive specialization and sophistication
* well suited to component research where clients able to clearly articulate their needs	* difficulty in adopting a holistic approach to commodity and/or system improvement
* career development	Strong tendencies (although not intrinsic) towards:
Simple, straightforward management structure	* individualized rather than team work - excessive researcher autonomy
* unity of command	* proliferation of projects, with weak program focus, inefficiencies of excessive dispersion of research activities
Advantages of agglomeration	* remoteness from clientele / lack of understanding of farmer problems
	Excessive centralization: disadvantages of agglomeration

THE PURE COMMODITY FORM

Advantages	Disadvantages
Encourages focused and integrated research	
* holistic approach to commodity improvement	* researcher lacks benefits of disciplinary agglomeration (except in very large commodity organizations)
* cross-disciplinary teamwork (especially during programming and evaluation processes)	* usually only feasible when relatively large number of experienced researchers
* enhances motivation - researchers identify strongly with the commodity	* team-work imposes additional stresses and strains
* with clear objectives and coordinated activities, easier to monitor and evaluate	* excessive reliance inconsistent with systems' perspective and may lead to inadequate emphasis on non-commodity factor and environmental research problems
* in certain situations, can effectively complement or be incorporated with systems research	* locational factors: diseconomies of agglomeration
* locational factor: advantages of agglomeration	* in smaller NARS, only few commodities able to justify commodity teams, and may lead to rigidities and inflexibilities

station for rice (the Bangladesh Rice Research Institute) clearly makes a great deal of sense. The counterpart of the single-commodity stations is stations with a mandate for an important production resource. Their contribution can be equally important in the context of agroecological and other resources of the country having a vital bearing on the country's agriculture.

Table 7 indicates how the internal organization of an experiment station is influenced by the nature of its mandate.

Table 7: Research station organization by mandate

GOAL	ORGANIZATION
Pure research	Individual scientist
Highly focused mission	Multidisciplinary program structure
Commodity development	Multidisciplinary program structure or Research station with disciplinary departmental structure
Commodity development and growth of discipline	Research station with disciplinary departmental structure
Growth of discipline	Disciplinary institute
Farming systems research	Multidisciplinary program with a coordinating unit

Experiment station programs and linkages

Directors of experiment stations with a mandate to carry out applied and adaptive research find their main structural problem in two different

areas. First, they need a mechanism to foster a multidisciplinary approach, and this becomes difficult when the scientists are placed in different departments, as is commonly the case. Second, they need an institutional mechanism to link more effectively with the extension service and the farmers for more effective transfer of technology generated by their scientists.

Ideally, the research projects of most experiment stations doing commodity or production system research should be organized around teams of scientists drawn from different disciplines. The genetic improvement of maize, for example, requires scientific support not only from the breeders but also from pathologists, entomologists, agronomists, and others, working together in a highly integrated team. In reality, projects of this kind are difficult to organize, except perhaps in very small research stations. A more practical approach would be to ensure that there is a great deal of complementarity in the work of the scientists working in the different disciplinary departments so that they reinforce their work. This becomes possible if the process of program formulation by the different groups of scientists in a station has built-in mechanisms for ensuring such complementarity. The director of the station must constitute a program committee which helps to achieve this important objective.

A program committee made up of all the heads of departments, with the director acting as its chairman, serves this important function. It helps to define the main research thrusts of the station, based on its mandate, and communicates them to the different departments so that they can respond with appropriate programs and projects. It then reviews the projects formulated by the scientists in the different departments, scrutinizes them for their relevance and complementarity, and helps to limit their number to match the available resources. A great deal of coordination in the work of different departments in an experiment station is brought out during discussions in the program committee. If maize, for example, is the most important crop for a particular station, the program committee makes sure that the scientists from the different disciplines identify the more important problems of this crop requiring attention. The committee ensures that the program balance in terms of allocation of resources, including scientific manpower from different disciplinary groups, is right and that there are both formal and informal mechanisms of coordination.

Some of the larger experiment stations may like to enlarge the membership of the program committee to include non-staff members; e.g., scientists from the universities and officials of the department of agriculture and representatives of farmers' organizations. They do so to improve the relevance and quality of their research program. It should be stressed, however, that the question of relevance receives greatest attention when research priorities are determined at the headquarters of the national agricultural research system. It is the senior managers of NARS, working with the governing body, who lay down the outline of the national research program and define the mandate of the different stations. The scientists at an experiment station are expected to translate these priorities and broad outlines into technical programs in the form of different research projects to be implemented.

Institutional mechanisms for transfer of technology

The institutional mechanism which the directors of experiment stations need in linking more effectively with the extension service and the farmers should normally take the form of a separate research-extension liaison department or a department of transfer of technology staffed with extension scientists and socioeconomists. Depending on the size of the national research system and its constituent experiment stations, a number of such units have to be created. Each of the larger experiment stations should have one such department, but in the case of smaller systems, at least one such unit. The very small system, in which much of the adaptive research is carried out at one central station, will have a research-extension unit located in it. In some of the very large institutes this department takes a higher profile in the form of an extension directorate, so that there is a director of research and a director of extension, having responsibility for the transfer of technology.

The main function of this department or unit is to liaise between the research scientists of the station and the staff of the extension service. The main activities of the research-extension liaison department or unit in the discharge of this important function would be as follows:

- Mobilizing the available technologies from the different groups of scientists at the station and organizing them into an integrated package that can be recommended to farmers.

- Organizing verification trials on farmers' fields in collaboration with the extension service.

- Rendering scientific information in a form the extension staff and the farmers will understand. The extension service benefits little from the scientific papers published in academic journals. The research-extension liaison department helps the experiment station and the extension service to develop a publication program based on popular farm bulletins and production technology of different crops and livestock, and on management of resources.

- Laying down demonstrations of new varieties and techniques on the research station for visiting farmers, extension staff, and government officials; and assisting the extension service in laying similar demonstrations on farmers' fields.

- Receiving feedback and an assessment of their needs from the farmers and the extension service and helping to place this information on the research agenda of the different groups of scientists through participation in the deliberation of the program committee and other planning bodies.

- Organizing farmers' fairs and field days on the research station in collaboration with the scientists from different groups and disciplines.

- Organizing regular meetings and workshops for the extension staff to meet the scientists for a two-way exchange of information, ideas and knowledge.

- Organizing training programs for the farmers and extension workers in the field.

Finally, it should be stressed that the research extension liaison unit provides the scientists' main instrument for carrying out on-farm research so essential for receiving feed-back from the farmers and extension workers. On-farm research in recent years has received much attention, both in the process of transfer of technology and in receiving valuable information from the field for the determination of research programs at an experiment station.

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