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WORKING PAPER No. 4

**AGRICULTURAL RESEARCH  
ORGANIZATION IN THE  
DEVELOPING WORLD:  
DIVERSITY AND EVOLUTION**

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***ISNAR***

**International Service for National Agricultural Research**

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## TABLE OF CONTENTS

	page
I. INTRODUCTION	1
II. THE BASIC OPERATIONAL OPTIONS	4
The Ministry Model	5
The Autonomous or Semiautonomous Institute	5
The University Model	6
The Agricultural Research Council	6
Private Sector Research Organizations	6
III. THE ASIAN AGRICULTURAL RESEARCH COUNCILS	10
IV. THE LATIN AMERICAN NATIONAL AGRICULTURAL RESEARCH INSTITUTES	17
V. POST-COLONIAL AFRICA: IS THERE A PREVAILING ORGANIZATIONAL TREND?	23
VI. COMMONALITIES AND DIFFERENCES AMONG THE PREVAILING FORMS OF ORGANIZATIONAL STRUCTURE	29
The Demand for Research and Institutional Change	30
Country Characteristics and Choice of Organizational Format	34
VII. CONCLUDING REMARKS	38
NOTES	41

# AGRICULTURAL RESEARCH ORGANIZATION IN THE DEVELOPING WORLD:

## DIVERSITY AND EVOLUTION

### I. INTRODUCTION

In the publication "Considerations for the Development of National Agricultural Research Capacities in Support of Agricultural Development", ISNAR has observed that successful research systems result where there exist mutually reinforcing interactions among three groups of variables: the policy environment, the system's organizational structure, and a set of basic operational processes, which include the setting of objectives and priorities, resource acquisition and development - including the development of a critical mass of experienced scientists, program development, the establishment of adequate scientific linkages, assuring the flow of information between research and extension workers, farmers, policy-makers, and the public, and monitoring and evaluating program implementation. Within this three-sided perspective the system's organizational structure provides the framework which links research and the broader social, political, and economic environment, and conditions the implementation of the system's basic operational processes and thus the actual research activities performed.

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The views expressed in this paper are those of the author, and not necessarily those of ISNAR. The author wishes to acknowledge the contribution to the concepts expressed in this paper made by Joseph Chang through his work on the governance of national agricultural research systems in developing countries while he was a Research Fellow at ISNAR, in 1984.

In general terms, the organizational structure has to be seen as the institutional forms and mechanisms, by means of which research objectives and priorities are set, and human, physical, financial, and information resources are mobilized for the operation of the research process. It can thus be considered an additional resource, which can facilitate the functioning of the system and multiply the impact of other available resources or limit the effectiveness with which they are used to achieve given goals. The system's organizational format can critically affect important aspects such as the interaction with the system's clientele, the capacity to mobilize and develop resources, and even the capacity to implement certain types of research or research oriented toward specific topics or areas.

Recognizing the importance of the organizational structure, however, does not imply that any particular format is better than the alternatives in all circumstances. Information from agricultural research (and other fields of activity) shows that there is no one optimum method of organizing a system: a country's agricultural conditions, history, economic characteristics, and socio-political traditions play a key role in shaping the optimum organizational structure. Even within a country, the most effective way to organize research activities will change through time as social, economic, and political conditions change.

This paper attempts to summarize the ways in which national agricultural research systems in the developing world are organized and examines some of the aspects that may have affected their characteristics and evolution. In doing so, it is hoped that certain issues concerning those involved in the institution-building process in agricultural research systems will be clarified; particularly the nature of the relationship

between organizational format and the country's characteristics. It is hoped that this discussion will be a step towards the future development of guidelines for the improvement of organizational structures in agricultural research.

This paper is divided into seven sections. Section II considers the nature of the basic organizational options currently found at the level of the national agricultural research system and how widespread they are in the different developing regions. Sections III, IV, and V consider some of the main organizational trends in Asia, Latin America, and Africa. Section VI tries to point to some of the commonalities and differentiating elements in these trends. Finally, in section VII the main aspects discussed are summarized, and areas for future work are highlighted.

## II. THE BASIC ORGANIZATIONAL OPTIONS

From an analytical point of view, the organizational structure comprises the durable organizational arrangements through which responsibilities and authority are distributed and the reporting relationships among the different organizational components. These relationships correspond to the patterns for division of labor -- single versus multicommodity, basic versus applied research, research and extension -- and coordination among the different units responsible for research. The organizational structure also includes the channels for interaction with the system's environment, which reflect the system's guidance and input mechanisms.

The analysis may begin either at the level of the overall system or at the level of the individual organization. Specific descriptive variables at the system level are the types and numbers of organizations that perform research (degree of decentralization); their mandates (scope of work); their governance and resource acquisition mechanisms and the degree of control they allow over decision-making in regards to operational policies and resource management matters (degree of autonomy); and the patterns they follow in working with each other and with other relevant non-research organizations (planning/coordination and resource allocation mechanisms).

At the level of the individual organization, governance and resource acquisition mechanisms are the main differentiating characteristics. Using these as typological variables, agricultural research organizations can be summarized in five basic organizational types (1).



The Ministry Model. Research is organized in one or more line departments within the bureaucratic structure of a ministry (2). The basic feature of this format is that the unit responsible for research has a low degree of control over decision-making, particularly in matters concerning resource management. Funding usually flows from allocations within the national budget through the ministry treasury, and administrative policies and procedures are subordinated to those of the ministry. Mandates, both in product and functional terms, are highly variable. Research and extension functions are usually located in separate units. There is no predominant base with respect to the product scope.

The Autonomous or Semiautonomous Institute. Research responsibilities are placed within an administratively independent organization. The basic characteristic of this format is a high level of control over decision-making with respect to program and administrative policy and resource allocation matters, which is usually exercised through an independent board of directors or governors. At the funding level, the autonomy allows the existence of an independent treasury, which increases research management control over fund administration. Funding flows as a special budget line within the national budget, and in some cases funds are directly tied to specific sources of revenue (a cess on sales of given crops, export revenues, etc.). As with the ministry model, functional and product mandates are variable. The first experiences with autonomous research institutions were with single commodities. More recently, however, the broad-mandate national research institute type has become quite widespread (3).

The University Model. Research is closely integrated with education within a university context. Extension activities may or may not be part of the same structure. However, the crucial feature of this approach is the integration of applied research activities oriented to technology generation within the educational environment. Because of the very characteristic of the university structure, this model has a high degree of autonomy and decentralization. Funding flows through a variety of mechanisms from both public - national, state, or provincial - and private sources (4).

The Agricultural Research Council (ARC). The agricultural research council model represents a variant of the autonomous research organization, emphasizing the coordination function rather than the direct implementation of research activities. Several different organizational arrangements are usually included under the general concept of the ARC. Autonomy and a high level of control over program policy matters, through an independent board of directors or governors, are the key distinguishing feature of the council model. However, specific functions assigned to them range from those of merely a review and advisory role to responsibility for the consolidation of budgets for all government-sponsored research, funding specific research projects, and even directly implementing research. From the point of view of mandate, the ARC almost invariably has a wide national scope of work and concentrates solely on research activities.

Private Sector Research Organizations. The basic characteristics of research organizations operating in the private sector domain are highly specific and concentrated mandates with program policy subordinate to

that of the parent organization. There are two basic variations of private sector involvement in agricultural research: a) research departments of the firms producing technological inputs such as seeds, agrochemicals, fertilizers, farm machinery, and veterinary products; and b) crop-specific research associated with agricultural producer associations. Autonomy in program and administrative matters tends to be low in the first type, particularly at the applied-adaptive end of the research scale, where research efforts are usually directly integrated into the firms' overall production and marketing strategies. In producer associations, the second type, there is a greater similarity to the autonomous commodity institutes facing comparable conditions.

The types of research organizations described above should be considered in terms of "ideal types"; they are very seldom found in isolation as pure forms. At the national level, it is usual for different types of research organization to coexist. In such cases, the number and type of different organizations that conduct research, and the coordination patterns and mechanisms among them, become the important differentiating features among systems. Two basic types of system can be envisaged: single-organization systems, where most research activities are carried out within one organization; and multiorganizational systems, where a variety of different organizations perform research activities. The first type is generally directed from a ministry or an autonomous research institute with a broad mandate. In the multiorganizational situation, the most important differentiating element is the existence or not of formal coordination mechanisms. Agricultural research councils are characteristic of the multiorganizational framework with formal coordination mechanisms.

Table 1 summarizes the current organizational formats of National Agricultural Research Systems (NARS) for the majority of the countries in Asia and the South Pacific, West Asia and North Africa, Africa South of the Sahara, Latin America and the Caribbean (5). A brief look at the situation highlights the fact that no organizational format can be said to be predominant throughout the developing world; on the contrary, much "variability" exists both within and across geographical regions. In a cross-regional analysis two aspects to highlight are: a) the concentration of the model with formal coordination of research activity (ARC) in the Asian countries; and, b) of the autonomous or semiautonomous national institute model in Latin America. The ministry model (without considering how many ministries are involved, and allowing for some autonomous - mainly commodity-specific - research activities) seems to be present in all three regions; however, it is more common in Africa. In Asia, the South Pacific, Latin America, and the Caribbean there seems to be an association between the size of the country and the prevailing model; the smaller countries tend to carry out research within ministerial structures.

In the next section we discuss the characteristics of these main organizational forms by region and their evolution over the last 20 to 25 years.

TABLE 1: ORGANIZATIONAL STRUCTURE OF THE NATIONAL AGRICULTURAL RESEARCH SYSTEMS IN 81 COUNTRIES OF THE DEVELOPING WORLD

	1*	2	3	4		1	2	3	4
ASIA AND THE SOUTH PACIFIC					AFRICA SOUTH OF THE SAHARA (continued)				
Bangladesh				X	Zaire				X
Burma	X				Zambia		X		
India				X	Zimbabwe		X		
Indonesia	X				Somalia		X		
Malaysia		X			LATIN AMERICA AND THE CARIBBEAN				
Nepal	X				Argentina			X	
Pakistan				X	Bolivia			X	
Philippines				X	Brazil				X
South Korea	X				Chile			X	
Sri Lanka			X		Colombia			X	
Thailand	X				Costa Rica		X		
Fiji	X				Ecuador			X	
Papua New Guinea	X				El Salvador		X		
Solomons	X				Guatemala			X	
Tonga	X				Honduras			X	
Western Samoa	X				Mexico			X	
AFRICA SOUTH OF THE SAHARA					Nicaragua		X		
Benin	X				Panama			X	
Botswana	X				Paraguay		X		
Burkina Faso			X		Peru			X	
Burundi				X	Guyana		X		
Cameroon	X				Belize				X
Cape Verde		X			Peru			X	
Central Africa				X	Uruguay		X		
Chad	X				Venezuela			X	
Ethiopia		X			Barbados		X		
Gambia	X				Cuba				X
Ivory Coast			X		Dominican Republic			X	
Lesotho	X				Jamaica		X		
Madagascar		X			Haiti		X		
Malawi	X				Trinidad & Tobago		X		
Mali	X				WEST ASIA AND NORTH AFRICA				
Mauritania			X		Algeria				X
Mauritius			X		Cyprus		X		
Mozambique			X		Egypt				X
Niger	X				Morocco				X
Nigeria				X	Syria		X		
Rwanda				X	Tunisia				X
Kenya	X				Turkey		X		
Ghana			X						
Senegal			X						
Sierra Leone	X								
Sudan		X							
Swaziland	X								
Tanzania			X						

\* Key: Types of NARS

- 1 Research carried out predominantly by ministries (one or more; there may be one or more autonomous efforts, restricted to specific crops).
- 2 Research carried out predominantly by an autonomous or semiautonomous agency with a broad mandate, both in commodity and territorial terms (there may also be one or more single-crop efforts and some research at universities).
- 3 Research is carried out by several different entities: ministries, autonomous and/or semiautonomous agencies, universities, without the existence of a central coordinating authority.
- 4 Research is carried out in a multi-organizational situation with a central coordinating body (Agricultural Research Council).

Source: Elaborated by the author on the basis of primary and secondary information available at ISNAR.

### III. THE ASIAN AGRICULTURAL RESEARCH COUNCILS

The ARC model has emerged as one of the main features of agricultural research organization in the Asian continent over the last 20-25 years (6).

Historically, ARCs have emerged in response to situations characterized, on the one hand, by a complex network of institutions with overlapping mandates, lack of skilled personnel and scientific critical mass in key organizations, unstable funding levels unrelated to organizational needs, neglect of important research areas, and inadequate responsiveness to national needs as determined by policy-makers; and on the other hand, by an agricultural or food situation severe enough to induce the government to attempt to bring agricultural research under control (7).

The particular characteristics and powers vested in the ARCs vary, but as indicated in the previous section, coordination and planning functions constitute the foundation of the research council idea. Specific functions may be:

- \* review and advisory role in regard to the program and projects of other organizations;
- \* responsibility for developing a long-term research plan;
- \* preparation of a consolidated research budget for all agricultural research organizations for approval by the government;
- \* financing, monitoring, and evaluation of research projects of national interest out of own funds;

- \* final decision on the allocation of all agricultural research funds among executing agencies;
- \* responsibility for coordinating training for agricultural research;
- \* responsibility for coordinating external technical and scientific assistance in agricultural research;
- \* responsibility for coordinating external financial assistance in agricultural research.

In terms of legal status, ARCs are autonomous organizations, with full powers to set administrative policies and procedures. The highest authority is the board of directors/trustees, whose members are chosen, by legal requirement, often according to their role as appropriate representatives of particular institutions or interest groups. They usually operate with an executive office/secretariat which includes permanent technical staff and is complemented by ad hoc members from other organizations in the system mobilized for specific tasks.

Following the creation of the Indian Council of Agricultural Research (ICAR) in 1964, a number of councils have been created; in Pakistan, the Pakistan Agricultural Research Council (PARC, 1964), in the Philippines, the Philippine Council for Agricultural and Resource Research Development (PCARRD, 1972), and in Bangladesh, the Bangladesh Agricultural Research Council (BARC, 1973).

In addition to these, the Malaysian Agricultural Research and Development Institute (MARDI) and the Indonesian Agency for Agricultural Research and Development (AARD) are frequently mentioned as having the ARC's basic characteristics. They differ substantially from the "model", however, since their central mandate is to implement research activities, and

their coordination function is quite limited. For example, AARD exercises no control or coordination over what happens in research outside the Ministry of Agriculture in the National Science Department Board and the Ministry of Research and Technology. Furthermore, the degree of autonomy of AARD is limited, and it does not escape the ministerial structure in administrative and personnel policies (8). MARDI is an autonomous body with a governing board which has participation from both the private and public sectors. But, its functions do not include the coordination of research activities outside the program it implements directly (9).

Each of the aforementioned ARCs (ICAR, PARC, BARC, and PCARRD) constitutes the legal apex of the national agricultural research systems in their respective countries. However, they have varying degrees of formal and de facto power and involvement in research activities per se.

Beyond this there is a tendency to move away from being a body with merely coordinating and advisory powers to one with greater directional, executive control over the actual implementation of the research program. The force behind this trend appears to be the increasing conviction that without at least partial control over funding and the capacity to actually implement certain strategic components of the research program, the coordination function cannot be properly performed.

This trend is clearly present in the Indian case, where the very creation of ICAR in its modern concept in 1964 corresponded to the desire to transform its predecessor organization, the Imperial (later Indian) Council of Agricultural Research, established in 1929, into a more effective coordinating mechanism. In its pre-1964 conception, ICAR did



not operate or control any research facilities and was restricted mostly to making ad hoc grants to the various institutes, ministries, and other research organizations. Under those conditions, ICAR coordination functions were severely restricted. The changes introduced in 1964 included the transfer of control of the commodity research institutes and the central research institutes previously under the Department of Agriculture or the Department of Food to ICAR. An additional institutional innovation was the creation of the Coordinated Crop Improvement Programs as the basic instrument for coordinating the research activities in the country's priority crops at the state level (10).

In its new - and present - format, ICAR brings together two functions. At one extreme ICAR has a self-contained "agricultural research institute," implementing its own programs through its own research infrastructure. At the other, ICAR is intended to mobilize the entire Indian research capacity, and acts as the main linkage between the Ministry of Agriculture, the body responsible to Parliament for the agricultural development effort, and the research community of the states and the agricultural university system. Within this context, the autonomous nature of ICAR has allowed the creation of separate conditions of service for its personnel and the flexible management style necessary for successful research. Accountability is assured through its special relationship with the Ministry of Agriculture and the composition of the board.

The pattern of development of the other councils mentioned has been similar to that of ICAR. However, the degree of control which they exercise over their respective countries' research activities varies.

The Council with broader powers in these terms seems to be PCARRD (originally the Philippine Council for Agricultural Research - PCAR) in the Philippines. According to its constitution, PCARRD functions cover a wide field which includes, among others, the development of objectives and definition of goals for research, the development of a national agriculture and resources program, the establishment of priorities, the development and implementation of a fund-generating strategy and programming. It also allocates all government revenues earmarked for research and controls the incentive mechanisms for researchers and, since 1977, relationships with international funding agencies and technical assistance organizations. The establishment, support, and management of a national network of centers of excellence for the various research programs in crops, livestock, forestry, fisheries, soils and water, mineral resources, and socioeconomic research related to agriculture and natural resources, are also functions formally assigned to PCARRD (11).

To implement its coordination function, PCARRD has the power to review all research proposals in agriculture and natural resources, and to recommend research proposals to the Ministry of the Budget for funding. This power was recently bolstered by a policy of the Ministry of the Budget that only research proposals recommended by PCARRD will be eligible for government funding.

The functions of PARC in Pakistan and BARC in Bangladesh are somewhat more restricted in terms of actual control over the research infrastructure and stay within the coordinating role. However, over the last few years both have gradually increased their powers (12). In 1978, following a catastrophic wheat crop (caused by yellow rust), PARC was reorganized into an autonomous body with representation from various

provincial and national sectors, and with a subcommittee of the council designated as the Executive Board. The strengthening continued throughout 1981, when a World Bank credit was made available for the development of PARC headquarters, as well as the expansion and completion of the National Agricultural Research Center (NARC) facilities. The Pakistan Agricultural Research Council Ordinance of 1981 acknowledged the administrative and institutional advances made by PARC so far, with what could be construed as an enlargement of the mandate. Fully autonomous PARC employees were then placed outside civil service regulations.

In Bangladesh a number of decrees, starting in 1976 and 1979, have placed practically all research activities legally under BARC. However, a number of the research institutes have retained control over their own sources of funding and their administrative councils (such as in the case of BARI, the Bangladesh Agricultural Research Institute).

The trend toward the existing ARCs has continued. In addition, a number of countries are moving toward the creation of similar structures. One example is that of Sri Lanka, where plans and specific proposals are advanced and already at the project preparation stage. Here the intention is to create a coordinating body to facilitate priority setting and coordination among the commodity institutes, units within ministries, and universities currently involved in research activities (13).

The Sri Lankan experience represents an interesting summary of the ARC idea and evolution. The reorganization presently being discussed arises out of a preoccupation with the state of dispersal in agricultural research activities and the difficulty of integrating the present research effort, particularly in those areas that fall between the

jurisdiction of different ministries. The situation is similar to that encountered in neighboring countries when they initially established their ARCs; the response is also similar, favoring coordination and planning functions rather than direct control over research infrastructures and funding. What remains to be seen is whether the Sri Lankan coordinating body will stay as it is or will move toward an increase in control and executive powers.

#### IV. THE LATIN AMERICAN NATIONAL AGRICULTURAL RESEARCH INSTITUTES

National Agricultural Research Systems in Latin America and the Caribbean clearly fall within two main forms of organizational structure: the ministry model and the autonomous or semi-autonomous research institute with broad national mandate (14). As shown in Table 1 these two models cover, in practice, the entire region. There seems to be a correlation between country size and the type of system: all the larger countries have national research institutes, while the ministry structure usually appears in the smaller countries of South America, Central America, and the Caribbean Islands. However, it is necessary to highlight a number of national institutes in countries such as Panama and Honduras, which clearly fall within the small-country category. Moreover, in a number of other countries, such as the Dominican Republic and Guyana, there have been recent developments toward the creation of national institutes (15).

An important feature of the Latin American experience, however, is that these two forms of organization cannot be seen as alternatives since, almost without exception, the creation of the national institute has followed and replaced a structure of research based in the ministry of agriculture.

The early agricultural research efforts in most Latin American countries developed on an ad hoc basis under a number of different, and often unstable, institutional arrangements. The initial experiment stations were usually developed as isolated efforts linked, in some instances, to ministries of agriculture or to their predecessors in the administrative structure (such as in the case of Pergamino and other experiment stations

in Argentina); to agriculture schools (such as Palmira in Colombia); or to agricultural producer organizations (such as La Platina in Chile and Cañete in Peru). During the 1940s and the early 1950s these initial undertakings were streamlined, and essentially all research activities, with the sole exception of some export crop cases, such as coffee in Colombia, were centralized as line activities of varying hierarchy within the ministries of agriculture. This was the predominant institutional model in the mid-1950s (16).

This form of research organization soon came under attack. The criticisms stemmed mainly from the ministries' essentially bureaucratic nature. Some of the most commonly expressed deficiencies were the lack of stable budgetary support; poor expression of the problems and priorities of the producers; lack of coordination of efforts; inadequate communication between researchers, on the one hand, and technical assistance and extension workers on the other; and finally, absence of any coordination between organizations generating technology, and others responsible for implementing different components of agricultural policy, prices, credits, services, and others (17).

The national agricultural research institutes resulted from these preoccupations. The general model is common to them all, entailing the legal and administrative character of an autonomous or semi-autonomous public entity with a broad mandate covering a wide range of products, regions, and types of farming situations. The basic objectives sought were to solve the problems created by the bureaucratic environment of the ministries; to allow for an improvement in the funding situation and conditions of service for research personnel; and at the same time to maintain research in the public domain, closely linked to agricultural

development policy. Organizationally, the model adopted in most cases was one that combined centralized decision-making, with respect to priority setting and resource allocation, and operational decentralization through a network of experiment stations and commodity discipline programs.

The efforts to create the national research institutes had large support from technical and donor assistance, and particularly that originating from what came to be known as Point IV of the US Foreign Aid Policy. This assistance included crucial support for human and infrastructural development. Perhaps more important, however, was its role as a key element in the development of the national research institute model as a Latin American expression of the US experiment station system.

From this process emerged the following institutions: the National Institute of Agricultural Technology (INTA) of Argentina in 1957; the National Institute of Agricultural Research (INIAP) of Ecuador in 1959; the complex CONIA-FONAIAP in Venezuela between 1959 and 1961; the National Institute of Agricultural Research (INIA) in Mexico in 1960; the Agricultural Research and Promotional Service (SIPA) in Peru, which after successive modifications became the National Institute of Agricultural Research Promotion (INIPA) in 1984; the Colombian Agricultural Research Institute (ICA) in 1963; and the Agricultural Research Institute (INIA) in Chile in 1964. This trend continued into the seventies with the creation of the Bolivian Institute of Agricultural Technology (IBTA); the Institute of Science and Agricultural Technology (ICTA) in Guatemala; the Agricultural Research and Development Institute (IDIAP) in Panama in 1975; and the National Institute of Agricultural Technology (INTA) in

Nicaragua. (Since 1980 INTA has been put back under direct control of the Ministry of Agriculture).

All these institutions share the organizational characteristics mentioned above. However, variation exists with respect to some specific aspects covering their governance structure, mandates, and/or sources of funding.

In regards to the governance structure, all the institutes are organizations with a legal status of their own, reporting in most cases to the ministry of agriculture or its equivalent. A differentiating characteristic, however, is the existence or not of a board of directors or trustees responsible for policy guidance and management control. Of the above-mentioned institutes, INTA of Argentina, ICA of Colombia, ICTA of Guatemala, and INIA of Chile have boards; the remaining institutions do not have such a body and the directors general or the chief executive officers report directly to the ministries of agriculture.

Another difference relates to the scope of the mandate. The institute model has tended to bring research and extension together. However, in some instances, such as INIAP in Ecuador, IDIAP in Panama, and INIA in Mexico, the two functions have been kept separate, with extension remaining a ministerial function. Education was generally kept separate from research and extension. However, in a number of cases - Argentina, Colombia, Peru, Uruguay, Mexico, and Brazil - due to the need to develop a minimum critical mass of human resources, ad hoc attempts were made to develop post-graduate training infrastructures in conjunction with universities. With the exception of Brazil and Mexico, most of them have been short-lived and unstable, and have not become integral parts of the institutional model.



Funding is also a differentiating factor. The original concept was to seek as much funding autonomy as possible. While this was seldom achieved as a permanent feature, autonomy as regards financial management has allowed the institutes to attract substantial amounts of donor assistance. However, only INTA of Argentina has had special funding mechanism treatment, receiving its resources through a 2% tax on agricultural exports. Usually, funds flow from direct allocations in the national budgets, with the result that, although some benefits have been derived from greater control and flexibility in budget management, funding instability continues to be a serious limiting factor in many countries (18).

The development of the Brazilian agricultural research system has followed a somewhat different pattern. Chronologically speaking, Brazil is the only major country in the region where the sixties brought no major change. More significant, however, is a difference with respect to the institutional model followed to create the Brazilian Corporation of Agricultural Research (EMBRAPA). EMBRAPA, established in 1973, is an institutional development similar to that of the research institutes in the other Latin American countries: the objective is to set the national basis for linking Brazil to the international system and making research an active instrument of agricultural development policy. As in the cases of INTA in Argentina, ICA in Colombia, and other institutes, it was not an isolated event. It resulted in and remains an integral part of a broader effort to influence agricultural development.

The organizational format adopted is, however, different. EMBRAPA combines two separate sets of functions. On the one hand, there is the

mandate to carry out research, for which it has a substantial research capacity of its own in the national commodity centers. On the other, it has the function of leading and coordinating, as far as objectives and priorities are concerned, a multi-organizational model, involving separate levels of administration in the public sector (federal and state) as well as in the private sector. In this context EMBRAPA is probably closer to the concept of the Agricultural Research Councils than to the rest of the national research institutes in Latin America.

## V. POST-COLONIAL AFRICA: IS THERE A PREVAILING ORGANIZATIONAL TREND?

By examining the information presented in Table 1, one may be tempted to associate the current situation in Africa with the ministerial model of agricultural research organizations. This association is probably correct but should be made carefully, and with a number of qualifications, especially in reference to the subsequent evolutionary trends that may be involved.

The first consideration relates to the colonial heritage. Colonial strategies in Africa varied widely, not only depending on the colonial power involved, but also within any given colonial heritage. Nonetheless, it is pertinent to attempt a summary of the main phases which have marked the evolution of agricultural research organization since the colonial era. Especially if the African experience is to be included in the effort to develop hypotheses concerning the relationships between organizational format and the environment of agricultural research (19).

The second consideration is that in a number of countries the national research institutions are in the early stages of development, often just beginning to develop their human resource base. Consequently, any attempt to generalize trends on the basis of the current situation should be treated with extreme care (20).

The main differentiating element among the colonial experiences (British, French, Belgian) in regard to agricultural research is the way in which research in the colonies and the metropolis were linked, and the type of

relationship maintained after independence. The first affects the starting point of today's structures; the second affects the nature of the changes that have taken place and the level of resources that have been available to national research since independence.

Under British colonial rule each colony was perceived as a distinct entity, to be ruled and developed in accordance with its particular characteristics. This acted against the centralization of research, and in some cases - particularly in food crops - also against the regionalization of research activities, although regional efforts were present in East and West Africa in the post World War II period (21). In line with this approach, general responsibility for research came under the aegis of a department of agriculture in each colony, although a number of commodity-specific efforts were developed outside the ministries.

At the time of independence there was a dual structure in situ, where research in the food crops in departments of agriculture coexisted with a number of autonomous, or quasi-autonomous, efforts servicing specific export crops, where planters or external commercial interests were significant. Since independence, the modifications in the power structure and a very dynamic, and often chaotic, social, political, and economic environment constitute the basic framework for the evolution of the research structures. The main features are the "nationalization" of the structure, with a rapid fading of colonial presence and the substitution of expatriate researchers with national research personnel, and a shift of research emphasis from export to domestic food crops.

Specific changes in agricultural research organization have followed these tendencies in the context of acute shortages of trained manpower and the need to protect some important export crops as sources of external revenue. This sometimes prompted post-independence administrators to leave untouched the organizational arrangements in those commodities. The general trend, however, has been to maintain the preeminence of the ministry or ministries vis-à-vis other types of organization and in recent times to develop a central coordinating capacity, either by combining the different ministerial units involved in research under one roof, as in the case of Kenya or Tanzania, with the Tanzanian Livestock Research Organization (Taliro) and the Tanzanian Agricultural Research Organization (Taro) (22), or by formally assigning the coordination role to a special unit or a ministry of research and scientific development (or similar), as in the case in Nigeria.

Experience in former French colonies has been significantly different. Before independence agricultural research was highly centralized and closely linked to the metropolis through the GERDAT institutes, which had an applied orientation and a worldwide mission covering not only Africa but also the French colonies in other parts of the world (23). The budgets of these institutions, with headquarters in France, were met largely by French taxpayers. The stations abroad were outreach establishments of the specialized institutes. Staffed by expatriates, no consideration was given to creating an independent research capacity in the colonies, either individually or regionally.

The end of French colonial rule in 1960 did not immediately change the characteristics of the French agricultural research presence in the former colonies, with which France maintained close economic, political,

and cultural ties. In most instances the activities of the various French agricultural research organisms in the former colonies continued under formal cooperation agreements with the national governments.

In terms of the organizational structure of the post-independence research system, the most important feature is the growth of an indigenous agricultural research and agricultural administrative capacity within or alongside the agricultural research institutes largely staffed, funded, and controlled by French organizations and nationals. As a consequence of increased national participation, there has also been a shift from export to food crops in the overall focus of the research system. This process has been greatly affected by the political evolution of the relationship with France and by the resource situation in each of the countries. The particular array and distribution of responsibilities between ministries, agencies, and institutes in each case results from shifts in power distribution during the successive alternations of military and civilian rule. Although no clear evolutionary pattern can be identified, it is possible to mention some tendencies. These refer to the creation of the ministries of scientific and technical research (Senegal, Ivory Coast, Cameroon, Central African Republic, Mali) in the 1970s and the development of horizontal linkages among the research institutes working in a country, to substitute for the vertical links that existed between the individual institute and its parent in France, which continued into the post-independence period.

For how long these dual structures, with heavy participation of the former colonial institutes, will last is difficult to say. Three essential issues are: a) the nature of the privileged relationships between the countries and France; b) the evolution of the research

capacities in the local institutions created since independence, particularly with respect to the availability of research staff with proper levels of training; and c) the willingness of a national government to bear the costs of its national research effort.

In the former Belgian colonies the situation is rather different. Again in this case the colonial strategy with respect to agricultural research has played a key role in determining the present situation. The research efforts initiated under Belgian rule were based in the Institut National pour l'Etude Agronomique du Congo Belge (INEAC), which had stations throughout the Belgian Congo, Rwanda, and Burundi. Created in 1933, it was funded primarily by Belgian funds but was highly decentralized in terms of program development and implementation. At the time of independence, or soon thereafter, this infrastructure was transferred to the full and separate control of those independent states, and constitutes the basis of the national agricultural research systems in those countries. The salient feature of the evolution since then has been the inability to use the vast infrastructure inherited (e.g., Zaïre, Rwanda). Political problems and lack of resources - human and financial - to substitute for the Belgian support as it was withdrawn have been the main deficiencies (24).

To summarize, the post-colonial structure of agricultural research in Africa appears to be characterized by the existence of a vast array of organizations, which mostly correspond to what was in place at the time of independence. The "nationalization" of those research structures has undoubtedly been the main task of the last 20-25 years. This process has taken place against the background of different colonial heritages, which has affected the types of institution established in the newly

independent countries and the decolonization strategies, which influenced the nature and pace of the nationalization. The array of agencies, ministries, universities, etc., are still confronted with many of the same problems prevalent in Asia and Latin America, when the processes that led to the national institutes and ARCs were started: namely, too few human resources, unstable funding, and duplication. In recent years efforts have concentrated on the development of an appropriate resource base. At the organizational level the ministry model seems to be widespread, but it would be premature to talk about a well-established trend toward a "dominant" model as in the other regions.



## VI. COMMONALITIES AND DIFFERENCES AMONG THE PREVAILING FORMS OF ORGANIZATIONAL STRUCTURE

The issues discussed in the previous sections highlight evolutionary patterns of interaction between the research institutions and their environment and how at any point in time the existing structures reflect the influence of a complex set of forces. They also provide a good basis from which to approach the discussion of the idea that there is no single "best" way to organize agricultural research and that any particular format is not equally effective in all situations. Without going into a detailed discussion, it is relatively easy to accept that agricultural research in Asia and Latin America over the last 20-25 years has been highly effective and has contributed significantly to the improvement of agricultural production and productivity. It suffices to point out that today India maintains a buffer stock of around 25 million tons of cereals, the significant improvements in rice production throughout Asia and Latin America, the near doubling of grain production in Argentina since the early 1970s, the Brazilian experience with wheat and soybeans. Although a one-to-one relationship is not argued, it is not difficult to associate these successes with changes in the organizational structures that allowed research to address the problems of the farmers. Since the organizational approaches adopted have been quite different, it seems relevant to ask, therefore, "What are the factors that prompted the evolution of the systems?" and "What were the differentiating factors?" Bearing these questions in mind, we will now examine how the environment in which the processes of institutional

change took place and briefly discuss some of the factors that may have affected the particular shape of the institutions that were created.

### The Demand for Research and Institutional Change

The process of institutional change is clearly affected by political, social, and economic forces (25). For the purposes of this paper, a detailed examination of how these function is not pertinent. However, it is postulated that for effective institutional change to occur, a clear need must exist and the decision-makers must see structural change as a necessity to meeting that need. If "effective" change is to happen, there must be political support and commitment to assuming the costs - political and otherwise - associated with that change. The changes that have taken place in Latin America and Asia since the late 1950s-early 1960s are interesting examples of the dynamics of these processes. At the same time they allow us to raise a number of hypotheses about the situation in Africa and its likely evolution. The important aspect to highlight is that, although the countries in the regions differ substantially in terms of resources, and cultural and political traditions, the processes that led to the establishment of the national research institutes and the agricultural research councils have striking similarities.

The emergence of the national institutes and that of the ARCs, and the cases of MARDI and AARD, resulted from situations in which technology, and consequently research, were seen by the relevant political system as a key to solving the problems they confronted.

In both regions the need was made obvious by the poor performance of the agricultural sector and its inability to satisfy the national requirements of food and to provide exportable surpluses. In Latin America, in some instances, such as Mexico, Colombia, Peru, and Ecuador, national production was rising at a rate well below the increase in demand, resulting from population growth and the urbanization process. In others, such as Argentina and Uruguay, the stagnation of the agricultural sector generated balance-of-payment problems, which augured the appearance of even more serious difficulties as the industrial processes began to gain headway. In still other countries, such as Brazil, the situation of the agricultural sector was inextricably linked to both foreign trade and domestic demand problems (26).

In Asia, most countries were confronted by both sets of problems, as they were highly dependent on food imports, which represented a major drain on foreign exchange and a substantial constraint on the overall growth of the economies. In some years, even to meet domestic requirements through imports was not possible, since it was difficult to purchase the grain, irrespective of the prices. There were also logistical problems in transporting the food to where it was needed. Furthermore, there was a political dimension: the poor agricultural performance was a major contributing factor to political instability. In Indonesia, the "rice crisis" of the second half of the 1960s contributed to the fall of the Sukarno regime. In other countries there was an increasing realization of the dangers of depending on other countries for the food supply.

India and Pakistan both experienced difficulties with US PL 480 foodgrain shipments during the 1960s, when the US stopped food aid or threatened to do so in order to force these countries to make certain political decisions. In 1974 the food aid to Bangladesh was delayed in a shortage

year, and the Bangladeshis perceived this as an attempt by the US to force them to break their trading relations with Cuba (27).

At the international level there was, as pointed out above, a growing conviction that these problems could be solved through new technology. Furthermore, by that time it was clear that the soils, climate, and the nature of the dominant crops were amenable to major technological breakthroughs, but institutions capable of producing and disseminating them were needed (28). The existing structures did not meet the requirements. In some cases there was a network of overlapping institutions; in others the existing structure was too dependent on volatile political factors. In almost all circumstances there were insufficient human and material resources.

These conditions set the stage for the domestic demand for research and the reorganization of the existing structures. Foreign assistance played a key role in facilitating the implementation of these changes. It did so in several important ways: first, by helping link the production and productivity problems with research and conceptualizing the need for institutional change; second, by providing foreign scientists and administrators to help identify appropriate institutional forms and adapt them to the local needs; finally, by providing support for the implementation of the new structures. USAID, the Ford and Rockefeller Foundations, together with a number of American universities, participated actively in these processes. In more recent times the involvement of FAO and the World Bank, and in Latin America, IDB and IICA, are other important sources of ideas and support.

In Africa, there are two important factors in the context of the institutional changes that have taken place over the last 20-25 years. The first is the local situation and the demand for agricultural research. At the political level, there was no local demand for research until recently. The changes that took place resulted not from the decision to strengthen research institutions, but as part of the overall nationalization of the public administration that followed independence. The tendency in many countries has been towards policies which discriminated against the agricultural sector, and consequently there was no role for research. It is only in the past few years that some local initiatives have begun to appear.

The second difference is in the role of donor assistance in the region. As stressed above, external agencies have played a crucial role in both the conception and the implementation of the institutional changes that took place in Asia and Latin America. In Africa they have also had an active involvement; but their role has been different. Donor assistance has focused mainly on specific projects rather than on long-term institution-building programs. Furthermore, there is a high level of direct involvement in the implementation of the projects and of research activities proper, often within ad hoc structures and not as part of the local research organization. In a few instances more recently, donors have begun to emphasize institutional characteristics in their assistance efforts. An additional important differentiating feature is that while for the other regions there was - rightly or wrongly - the conviction that the problem was technological and that technologies were available, in the African case there is no general agreement as to the role that technology can play in solving the problems or whether available technologies can solve them (29).

### Country Characteristics and Choice of Organizational Format

The debate as to how essential organizational questions, such as the degree of decentralization, have been dealt with in different situations, provides important additional insights into the relationships between environment and organizational structure.

The centralization-decentralization issue lies at the very center of the discussion about agricultural research organization. Agricultural research has a need for decentralization; not because decentralization is inherently superior from an organization point of view, but because it is responsive to the nature of the problem which the research systems address (30). Agricultural production is location specific, and agricultural technologies need to reflect this location specificity. However, diversity of agroecological environments is not the sole source of variability that must be considered; technology also has a social variable.

For research to be successful, its product must have not only an effective biophysical adaptive capacity, but also the ability to accurately reflect the diverse socioeconomic, political, and cultural constraints facing the farmers who make the adoption decisions (31). This characteristic of agricultural production calls for a physical infrastructure and for decision-making processes capable of reaching all relevant environments and accurately reflecting the needs of the different clientele in the research program development process. Both of

these attributes appear to be better achieved through a decentralized organizational structure. Nevertheless, it is important to recognize that this need for decentralization has a counterbalance in the need to achieve program coherence, and to relate research to the other components of the agricultural development strategy. Furthermore, decentralized systems are more management intensive than centralized structures (32).

As stressed in the previous section, the conditions of demand in each case were similar: poor agricultural performance, together with the recognition that agricultural research was essential to altering the situation. The state of the existing agricultural research systems were also similar: weak institutions with inappropriate human and financial resources. Under these conditions the prevailing trend was towards a centralized structure, but the capacity to mobilize research in terms of a given agricultural development was lacking, and human and managerial resources were scarce. Hence, high priority was given to minimizing duplication of effort and to reducing the number of decision-making levels. The different nature of the structural responses to these common problems can be explained in terms of the characteristics of the existing research infrastructures and the politico-administrative styles of the countries.

In Latin America the national institutes followed an already established centralization trend. At the outset, agricultural research was not a central government responsibility, although it became so in the 1930s and 1940s. This arose from the unified nature of the political organization in most of the countries and the financial weakness of the regions or provinces which prevented them from taking any substantial initiatives in this area. In the mid-1950s the existing research capacity was

centralized in the ministries of agriculture. The national institutes followed as a natural development, and the needs for operational decentralization were handled through their internal organization strategy, which emphasized program development and decision-making at the regional and local levels.

The influence of background and political system is further highlighted in the case of Brazil. As previously mentioned, very little happened in Brazil during the 1960s. The problems confronted were similar to those of the other countries in the region, and it was exposed to the same ideas that prompted the creation of the national institutes. However, Brazil has a stronger federal organization, which made it difficult to move in the same direction. A major political change had to take place before EMBRAPA could come into existence, and even then centralization was limited, as some of the existing state research systems remained outside the control of EMBRAPA (i.e., Sao Paolo) (34).

By contrast, in Asia (especially India), where the council model originated, there was a highly decentralized system in place. This had occurred when the Indian Department of Agriculture was placed under the aegis of provincial governments, and was furthered by the proliferation of research programs in the 1950s and early 1960s. The strengthening of the functions of ICAR was a response to the need to coordinate and to optimize the use of available research resources. It would have been unrealistic to have attempted to substitute the existing structure with a new institution of the type of the national institutes (33).

The dynamics of the Pakistan and Philippines experiences are similar, although the trends toward centralization have been greatly facilitated



by political changes towards a more centralized form of administration.

The size of the country and the diversity of the agricultural sector are also relevant factors in regard to the centralization issue. It is difficult to envisage a single organization able to manage the entire research effort in countries the size of Brazil or India.

## VII. CONCLUDING REMARKS

This paper has been developed out of the proposition that in organizational format matters, there is no one optimal way of organizing agricultural research systems, and not all formats are equally effective. Without attempting to put forward a formally testable hypothesis, it has been stressed that "optimality" results from political and technical fit within a given environment. An optimal format is one that gets the job done.

The previous sections reviewed the ways in which agricultural research systems in the developing world are organized and attempted to find commonalities and differences which could help to advance the understanding of relationships between organization and environment. In doing so, a great diversity in the way in which agricultural research is organized has been identified. At the same time it would not be difficult to associate success stories with each of the four main types of systems presented in Table 1. This can at least be considered as some proof, albeit inadequate, of the validity of the proposition that there is no one best way to organize. It was also found that each of the formats reviewed results from evolutionary adjustments to changing environments where the pre-existing structures were not seen as effective ways of mobilizing the needed resources and delivering the products expected from research. This observation may explain the proposition that not all the formats are equally effective.

When comparing the evolution of the organizational "models" in Asia and Latin America it has been found that the efforts which led to the

development and consolidation of the ARCs and the national institutes resulted from a confluence of forces and interests that created a favorable policy environment for research and institutional change. There were recognized needs, agreement about what the solutions might be, and the political decision to act. Research and technology diffusion were seen as solutions by the national leaderships, and the donor and technical assistance community was ready to help develop the institutional mechanisms needed to mobilize resources and implement research as an integral part of development policies. This presentation has hinted that conditions in Africa are not the same, or at least have not been so far. The contrast with the Asian and Latin American experiences may, however, be of value when discussing how to meet the challenge in Africa, particularly in relation to the time-scale involved, and the set of concomitant actions that should accompany the efforts in the agricultural research field.

Two aspects seem to be of some importance in this respect. First, there is the time scale involved in the institutional development process. The present state of development of research institutions in Asia and Latin America is the result of more than 20-25 years of continued support evolution. Most post-colonial African experiences are much more recent. Second, donor assistance in Asia and Latin America was channelled mostly into institution-building programs; in Africa the predominant trend has been to support individual projects, often directed at solving very specific problems rather than at creating new capacity.

The discussion of the evolution of the systems has concentrated mainly on how the different models originated, and how they were coherent responses to the conditions that existed at the time of their inception. The

analysis of their evolution, however, has been very superficial. Several areas should be considered further in future discussions, particularly in regard to how the "common" models have evolved and adapted to the different national environments. Comparison of the experiences of the different ARCs in what relates to the performance of the coordination functions vis-à-vis the expansion of their executive powers appears to be an area where more information could be extremely useful for new countries considering the council model. A further issue concerning the evolution of the systems is how they have coped with new developments. During the last 10-15 years conditions in the countries have changed substantially, and in many cases as the result of the very success of the new forms of organizing research. One of those changes, not discussed here, has been the increasing role and importance of private agricultural research activities. The analysis of the implications of this phenomenon in terms of the organizational structure, and the role of certain formats such as the ARCs or the national institutes, remains an important area for investigation and discussion.

Finally, some specific organizational dimensions were touched upon, particularly the degree of centralization-decentralization. Available evidence points to certain general patterns related to a country's stage of development, its political system and size, and the type of organizational format chosen. However, more detailed information is required before the nature of the parameters of the optimal environment for each different type of organization can be examined.

## NOTES

- (1) In describing the different formats, no effort is made to provide a fully comprehensive typology. Each organizational type is presented to emphasize what ISNAR considers to be its main differentiating feature in terms of its impact on the performance of the essential management processes and the effectiveness of the research activity.
- (2) Usually the ministry of agriculture and/or livestock. However, there are situations where other ministries are also involved: the most frequent cases are the ministries of education (or higher education) and science and technology.
- (3) An autonomous agricultural research organization meets the following criteria:
  1. it has legal personality and its own board of directors/trustees which oversees the execution of its mandate;
  2. it has independence in the management of its budget, and it does not have to go through the financial service of a ministry, even where it may formally report to the ministry;
  3. it controls its internal organization, as well as sets its own criteria for hiring, firing, and conditions of service (which may depart from civil service norms);
  4. it has formal reporting obligations to some public body (e.g., president, prime minister, ministry, research council, etc.) from which it is otherwise legally and operationally independent.

A semiautonomous agricultural research organization is an organization which has legal existence apart from that of a line division of a ministry, but does not meet all the criteria necessary for definition as autonomous.

- (4) Examples of this type of institutional model are the US Land-Grant universities, and the agricultural universities of India and The Netherlands.
- (5) Private-sector research activities are not included in the table due to lack of information.
- (6) See MOSEMAN, A., National Agricultural Research Systems in Asia. IADS, New York, 1971. Also, DRILON, J. D., Agricultural Research Systems in Asia. SEARCA, College, Laguna, Philippines, 1977.
- (7) See RUTTAN, V., Agricultural Research Policy. University of Minnesota Press, Minneapolis, 1982, Chapter 4.
- (8) The Agency for Agricultural Research and Development of Indonesia. ISNAR, The Netherlands, October 1981.
- (9) See HASIM M. Y., "The Agricultural Research System in Malasia" , in Resource Allocation to Agricultural Research. Eds. DANIELS D., and NESTEL, B. IDRC, Ottawa 1981.

## NOTES

- (10) See RUTTAN, V. op cit., chapter 4 and JAIN, H. K., "India's Coordinated Crop Improvement Project - Organization and Impact", Indian Farming, July 1984.
- (11) See DRILON, J. L. and LIBRERO, A. R., "Defining Research Priorities for Agricultural and Natural Resources in the Philippines", in DANIELS, D. and NESTEL, B. op cit.
- (12) See DRILON, J. L. Agricultural Research Systems in Asia. SEARCA, College, Laguna, Philippines, 1977.
- (13) See Agricultural Research Group and ISNAR, The Agricultural Research System in Sri Lanka. Report to the government of Sri Lanka, ISNAR, The Hague, Netherlands, June 1984 (out of print).
- (14) See TRIGO, E., PIÑEIRO, M., and ARDILA, J., Organización de la Investigación Agropecuaria en America Latina. IICA, San Jose, Costa Rica, 1982.
- (15) See ISNAR The Agricultural Research System of Guyana. March 1982. Report of the ISNAR review mission to Guyana. Also El Sistema de Investigación Agropecuaria en la República Dominicana. July 1983. Report to the government of the Dominican Republic, ISNAR, The Netherlands.
- (16) See for example ELGUETA, M., Evolución de la Investigación Agrícola en America Latina and MARZOCCA, A., Los Pioneros in Las Ciencias Agrícolas en America Latina. IICA, Editorial TREJOS, San Jose, Costa Rica, 1967.
- (17) See TRIGO, E., PIÑEIRO, M., and SABATO, J., "Technology as a Social Issue: Agricultural Research Organization" in Technical Change and Social Conflict in Agriculture: Latin American Perspectives. Eds. PIÑEIRO, M., and TRIGO, E. Westview Press, Boulder, Colorado, 1983.
- (18) See TRIGO, E., and PIÑEIRO, M., "Funding Agricultural Research" in Selected Issues in Agricultural Research in Latin America. Proceedings of a conference for Latin American Research Directors, sponsored by IFARD, IICA, and ISNAR in cooperation with the Spanish Government. August 1983. ISNAR, The Netherlands.
- (19) See EICHER, C., and BAKER, D., Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey. Michigan State University, East Lansing, Michigan, 1983. Also COOPER, St. G. C. Agricultural Research in Tropical Africa. East African Literature Bureau, Nairobi, Kenya, 1970.
- (20) See Agricultural Research Organization and Management in Africa. Report of a Seminar held in FAO, Rome, Italy, 1981. Advancing Agricultural Production in Africa. Proceedings of CAB First Scientific Conference, CAB 1984. Also, Strategies to meet Demands for Rural Social Scientists in Africa. ISNAR, The Netherlands, May 1982.

## NOTES

- (21) For example, the East African Agricultural and Forestry Research Organization (EAAFRO), which operated until the mid 1970s under the auspices of the East African Federation.
- (22) The Tanzanian Livestock Research Organization and the Tanzanian Agricultural Research Organization, respectively.
- (23) Le Centre Technique Forestier Tropical (CTFT); L'Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux (IEMVT); L'Institut Français de Recherches Fruitières Outre-Mer (IFAC); L'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (IRAT); L'Institut Français du Café et du Cacao et autres Plantes Stimulantes (IFCC); L'Institut de Recherches sur le Caoutchouc en Afrique (IRCA); L'Institut de Recherches du Coton et des Textiles Exotiques (IRCT); L'Institut de Recherches pour les Huiles et Oléagineux (IRHO).
- (24) Rapport d'une ISNAR/IITA auprès de l'Institut de Recherche Agronomique et Zootechnique de la Communauté Economique des Pays des Grands Lacs (Burundi, Rwanda, Zaïre). ISNAR, July 1981. Also Le Système National de Recherche Agricole au Rwanda. ISNAR, December 1982. Report of the Mission to the Government of Rwanda. Also Improvement of Agricultural Research Management in Cameroon. Report to the Ministry of Higher Education and Scientific Research of Cameroon, ISNAR, June 1984.
- (25) For a detailed discussion of these forces see RUTTAN, V., "Induced Institutional Change" in BINSWANGER, H., and RUTTAN, V. Induced Innovation: Technology, Institutions and Development. The Johns Hopkins University Press, Baltimore, 1978. Also ALVES, E., "Major Issues in Resource Allocation", in ELZ, D. ed., The Planning and Management of Agricultural Research. A World Bank and ISNAR Symposium, Washington, 1984.
- (26) See PIÑEIRO, M. and TRIGO, E. Towards an Interpretation of Technological Change op cit. PIÑEIRO, M. and TRIGO, E., eds.
- (27) See PRAY, Carl E., The Institutional Development of National Agricultural Research Systems in South and South-West Asia. Mimeo, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, March 1983.
- (28) For a presentation of this view see SCHULTZ, T.W., Transforming Traditional Agriculture. Yale University Press, New Haven, 1964.
- (29) For a summary of the arguments, see MELLOR, J. W., The Changing World Food Situation. IFPRI Food Policy Statement, IFPRI, Washington, January 1985.
- (30) See RUTTAN, V., op cit., Chapter 4. Also BONNEN, J. T., Technology, Human Capital and Institutions: Three Factors in Search of an Agricultural Research Strategy. Michigan State University, East Lansing, Michigan, March 1984.

## NOTES

- (31) See Considerations for the Development of Agricultural Research Capacities in Support of Agricultural Development. ISNAR, The Netherlands, 1984.
- (32) See PAUL, S., Strategic Management of Development Programs. ILO, Management Development Series No. 19, ILO, Geneva, 1983.
- (33) See RUTTAN, V., op cit., chapter 4. Also PRAY, C., op cit.
- (34) See PASTORE, J. and ALVES, E., "Reforming the Brazilian Agricultural Research System", in ARNDT, T., DALRYMPLE, D., and RUTTAN, V., Resource Allocation and Productivity in National and International Agricultural Research, University of Minnesota Press, Minneapolis, 1977.

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