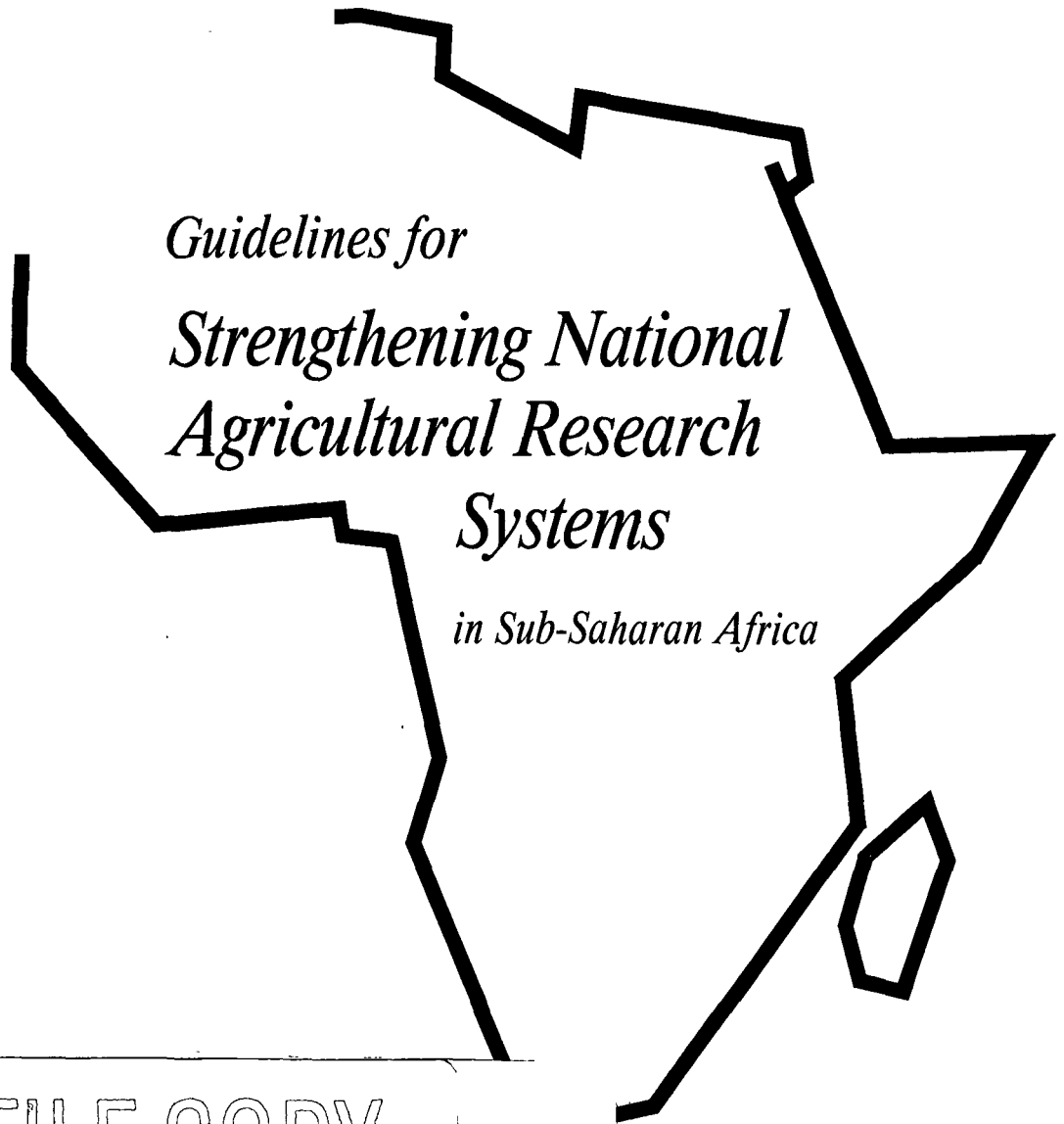
SPECIAL PROGRAM FOR AFRICAN AGRICULTURAL RESEARCH

SPAAR



Guidelines for Strengthening National Agricultural Research Systems

in Sub-Saharan Africa

Special Program for African Agricultural Research

SPAAR

Guidelines for Strengthening National Agricultural Research Systems in Sub-Saharan Africa

International Service for National
Agricultural Research
(ISNAR)

and

SPAAR Working Group for Preparation of Guidelines
for National Agricultural Research Strategies
in Sub-Saharan Africa

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The plenary meeting of the Special Program for African Agricultural Research (SPAAR), held in Washington in October 1985, identified a number of areas where donors could take a concerted initiative to help African states in their efforts to strengthen their national agricultural research systems. One of these areas of activity was the preparation of guidelines for national agricultural research strategies in sub-Saharan Africa. The World Bank agreed to convene a working group to carry out this task. The International Service for National Agricultural Research (ISNAR) was asked and agreed to be the principal author of these guidelines.

The judgments expressed herein are those of the author(s). They do not necessarily reflect the views of the World Bank, of affiliated organizations, including the SPAAR Secretariat, or of the members of the SPAAR, or of any individual acting on their behalf.

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PREFACE

The plenary meeting of the Special Program for African Agricultural Research (SPAAR), held in Washington in October 1985, identified a number of areas in which donors could take a concerted initiative to help African states in their efforts to strengthen their national agricultural research systems. One of these areas of activity was the preparation of guidelines for national agricultural research strategies in sub-Saharan Africa. The World Bank agreed to convene a working group to carry out this task. The International Service for National Agricultural Research (ISNAR) was asked and accepted to be the principal author of this guidelines paper.

The first draft, prepared by ISNAR, broadened the objectives of the paper to deal with research systems generally rather than limiting it to strategies, and the title was amended accordingly. This draft was reviewed by the working group, which at ISNAR's invitation met at its headquarters in The Hague, from June 9 to 13, 1986. The working group was chaired by the World Bank and was further composed of representatives of FAO, IFPRI, ISNAR, and UNDP, as well as two directors of African agricultural research institutes (from Cameroon and Malawi) serving in a personal capacity.

The text, amended at the June 1986 working group meeting, was then discussed by directors of national agricultural research institutions and senior planning officials of the member states of the Southern African Development Coordination Conference (SADCC), together with the working group and the Executive Secretary of SPAAR, at a seminar held in Lusaka on September 27, 1986. This seminar, held under the joint auspices of the Southern African Centre for Cooperation in Agricultural Research (SACCAR) and ISNAR, was financed in part by the Canadian International Development Agency (CIDA), which was also represented.

The document, modified at Lusaka, was then presented at the SPAAR plenary meeting held in Washington on November 7, 1986. At this meeting, the paper was approved with some suggested changes and additions. The same version was also presented at two World Bank-sponsored Regional Workshops, one on Agricultural Research in Eastern and Southern Africa (Nairobi, December 11-16, 1986), the other on West African Agricultural Research (Cotonou, December 10-17, 1986). Comments received at the last three meetings were taken into account by ISNAR and the working group in preparing the present text for publication. This document, published jointly by ISNAR and SPAAR, is intended for wide distribution to government planners, administrators and research leaders in Africa, as well as to donors, in the expectation that it will stimulate discussion and action on improvement of national agricultural research systems.

John K. Coulter

Chairman
SPAAR Working Group for Preparation of Guidelines for Agricultural Research Strategies in Sub-Saharan Africa

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The dramatic impact of recent droughts and the equally dramatic effect of good rains on agricultural production have once again focused attention on the dominant role of agriculture in Africa. This role involves not only feeding the burgeoning population but also providing more employment in the rural sector, and increasing exports for foreign exchange. Most countries in sub-Saharan Africa are still self-sufficient in staple foods whenever there is favorable weather. But with rapid population increase such years of self-sufficiency are becoming rarer, as the opportunities for expansion of cultivated areas disappear. With stagnating yields, an increasing number of countries can therefore expect shortfalls in basic food supplies even in years of good rainfall. In drought years, the downward trend of per capita agricultural production is emphasized, environmental degradation increases, and the vulnerability of many parts of the continent to this natural phenomenon dramatized.

Clearly then, increased productivity, in the good years and the bad, is absolutely essential for the future well-being of agriculture and all those who depend on it. However, it is not only a matter of increasing productivity per se. Irrigation, fertilizers and improved seeds can certainly improve productivity, but they must do so within a system that is environmentally sustainable and economically viable for the country and the farmers.

Agricultural research provides the technology to do this. Without it, sustained increases in productivity are impossible. Research plays a crucial role in:

* generating and adapting technologies which can increase agricultural productivity;

* developing sustainable production systems, particularly for the more fragile areas;

* providing efficient methods of processing, marketing and utilization of both food and non-food products;

* generating technologies which can provide productive employment in rural areas; and

* contributing to food security for the nation and the family.

This paper "Guidelines for Strengthening National Agricultural Research Systems in sub-Saharan Africa" is a discussion of the critical components of a research system, its funding, its management, the setting of research priorities from both the national and the farmers' point of view, the development of human capital, and the role of donors. It discusses some of the lessons that have been learned from the past, and uses these as a background to the guidelines for the development of national research systems. The paper is directed specifically at national policy makers in agriculture, planning, and finance, at research leaders in sub-Saharan Africa, and at donors. It emphasizes the crucial role that each of these play, and is intended to facilitate the necessary interaction between them. With the help of these guidelines, national planners and research leaders should be able to develop their own capacity to review their agricultural research systems, and to design improved systems with less reliance on external assistance.

The paper highlights areas requiring the combined attention of planners, research leaders, and donors. These include:

Funding of Research

Country comparisons suggest that allocations to agricultural research of less than 0.5% of agricultural gross domestic product (AGDP) are too low to serve a country's longer-term interests, and that at least 1.0 % of AGDP is desirable. However, year-to-year stability, timely disbursement, the inclusion of adequate provisions for operation and maintenance, and a minimum allocation of foreign exchange are as critical as the level of support itself. New investments in staff, infrastructure, and equipment must be accom-

panied by appropriate increases in operational budgets.

System-Building

More attention must be paid to the integrated development of research services, institutions of higher education in agriculture and related disciplines, and extension services. Regional and international linkages are also important, particularly for small countries. Twinning, research networks, and formal regional cooperation can contribute to the goal of increasing the productivity, morale, and professionalism of agricultural scientists in Africa.

There is no single model for an optimal structure of a national agricultural research system. However, any model chosen must facilitate:

* dialogue between research leaders and decision-makers in agriculture,planning, and finance;

* acquisition and disbursement of funds;

* flexible management of personnel;

* communication with the clients of research, notably farmers, extension services and rural development organizations; and

* collaboration with academic institutions.

Better integration of donor-assisted research projects into the national program is essential to ensure their continuation, and to promote institution-building. For donors to agree to such integration, host institutions must have well-defined research programs and demonstrate reliable resource management.

Determining Research Strategy and Priorities

The development of research priorities is a complicated process, which must be driven by national development objectives and agricultural sector goals. It involves national policy makers and planners, and research managers. This process should take into account rural institutions and services, investments in infrastructure, pricing policies and forecasts, marketing structures, and natural resource potentials. Analysis is likely to be handicapped by the absence of adequate data. Pending the development of analytical capacity in planning ministries and national research and academic institutions, the research system must define its priorities with the imperfect information and policy guidelines available; subsequently, it should inform the relevant ministries of the underlying assumptions used, and seek government reaction.

Research strategies should cover commodities, factors of the natural resource base, and geographic regions. When developing these strategies, there are at least five general considerations:

* the economic, social, and political importance of the commodities, factors and regions;

* current market demand for the commodities in question, and future projections;

* the chances of a successful outcome of the research, taking into account the results, positive or negative, of previous attempts to develop this technology;

* the influence of factors which may affect adoption of results; and

* the probable distribution of benefits.

Strengthening the Management of Research Systems

Once the major national research priorities have been determined and broad resource allocations made, managers of the research institutions can plan concrete research programs based on realistic projections of manpower, station facilities, and probable funding. The core management processes are long-term planning, short-term programming and

budgeting, monitoring and evaluation, human resource development and management, financial management and administration, management of physical resources, information management, and maintaining linkages with national and international institutions.

Long-Term Research Planning. After priorities have been set at the macro level and resources allocated, a long-term research plan for, say, 10-15 years, must be designed within each institution. This process includes making projections for manpower, infrastructure, and operating funds.

Research Programming and Budgeting. To select from among the wide choice of possible experiments, researchers must understand the conditions of farmers and rural support services. They must then take into account, through a program-budgeting (PB) exercise, the human, physical and financial resources required to conduct these experiments. All PB procedures are ineffective as long as national budget allocations fluctuate from year to year, are disbursed late, or are subject to sudden cuts during the year. Even a very simple PB system confers many benefits. It forces the research organizations to describe programs in specific terms, and with budgets which can be justified to policy makers. It permits analysis of resource allocations to commodities, factors, and regions. And it provides a basis for monitoring expenditures and the progress of research programs.

Monitoring and Evaluation. A monitoring process should provide managers with current information on money spent, people employed, materials used,and on progress in each of the research activities; but it should not become more time-consuming than the benefits justify. Monitoring also forms a basis for periodic evaluation of the research program's technical and scientific quality, and its relevance. This evaluation should examine progress against set targets; check the continuing relevance of targets and programs; and recommend the termination of old programs and the introduction of new ones. The product of a research system is new knowledge or new technology. Impact on national production involves additional factors and is therefore not the prime consideration in evaluating research.

Human resource development and manqgement. Human resource development strategies for African research must take into account the shortage and rapid turnover of well-trained staff in the continent. The long time span and the large investments needed to redress this should be fully recognized. Overseas training clearly is not the long-term answer. Attention must be given to strengthening the African faculties of agriculture and related academic departments, and planning should be coordinated among universities so that jointly they can provide the adequate mix of skills that agricultural research in Africa requires.

Research systems need a long-term training plan which is based on a detailed definition of projected agricultural research thrusts. It requires prior agreement from government on the evolution of staffing levels. The plan should include provision for management training, and for training and updating of skills of technicians and other support staff. Scientists also need opportunities for short in-service courses, attendance at workshops,and contacts with visiting senior scientists.

Selection and retention of the right personnel are critical to the effectiveness of a scientific organization, and a degree of autonomy from standard civil service procedures is usually required.

Promotion, salary increases, and various forms of scientific recognition should be the reward for professional performance and the main incentives for continued productivity. Productivity rather than length of service should be the dominant criterion for advancement, and promotion to the highest ranks should be possible without going to administrative and managerial positions, so that the most senior scientists remain available for research and scientific supervision. Staff at remote stations must have at least the same

access to promotion opportunities and other incentives as those at headquarters.

Financial Management. Good financial management includes timely acquisition and disbursement of funds, and sound accounting. It is a critical factor in maintaining confidence in the organization, not least among donors. Delegation of authority for disbursement to station heads and program coordinators is needed for flexibility in the use of funds. Attention should be given to possibilities of block-funding, carry-over of funds to the next year, and the release of funds to meet peak requirements. Many research institutions report to a variety of donors, each with its particular accounting and reporting requirements, which can overstretch the institution's capacity. Donors, ministries of finance and planning, and research managers should endeavor to harmonize these requirements.

Management of Physical Resources. National authorities must carefully consider: the number, location, and design of research stations and support facilities, including library and computer facilities; the selection of laboratory and farm equipment, and vehicles; the maintenance of all these, including procurement of supplies and spare parts; and provision for their replacement. Aid tied to the acquisition of equipment and vehicles from the donor country leads to many complications.

The efficient servicing, maintenance, and utilization of buildings, equipment, and vehicles require well-trained staff and efficient procedures. Systematic training of personnel in these management functions is needed. Sufficient local and foreign currency is also required for maintenance, but is usually the first to suffer in budget shortfalls. Whenever investments are made in physical infrastructure and equipment, there must be concomitant provision for operations and maintenance, which should be in the order of 20% of the capital outlay.

Information Management. Greater efforts are needed to provide:

* scientific and technical information for scientists to do their research;

* up-to-date information on the human, physical and financial resources and the programs of the institution, enabling it to manage these effectively;

* two-way information flow between research and its clients: policy makers, extension services, farmers and others.

It is particularly important to improve circulation of documentation, especially to staff at distant stations. Staff training in library science is required. Stable library budgets, with a foreign exchange component, are extremely important. The escalating costs of maintaining traditional libraries point to a need to consider systems based on advanced technology.

Databases and computerized information systems are becoming increasingly important in personnel management, program-budgeting, monitoring, and evaluation. The introduction, use, and maintenance of microcomputers require a commitment to keep them operational, and to use them to their fullest potential.

Some Issues for Donors

Improved national research systems and clearly defined agricultural research strategies will provide the framework within which donors will be able to improve the effectiveness of their contributions to research. Consequently, donors, in cooperation with national governments, should make every effort to improve such systems and support comprehensive strategies.

A critical area for donor attention is the need to move from project to longer-term program support. Such a shift requires joint commitment by national governments and

donors to institutional development. Assignment of expatriate staff for longer than the current average three-year period would greatly improve the quality of technical assistance. Harmonization of project accounting procedures with those of the recipient institutions would avoid much duplication and inefficient expenditure of time.

In the area of training, problems will continue as long as African agriculture and science faculties are unable to offer high-quality postgraduate programs. Some faculties have benefited from large investments in the past but now suffer from the same staffing and funding problems as the national research programs. Not only does this prevent them from participating in useful research, it also leads to poorly trained graduates. Donor-supported programs for selective strengthening of faculties, and of linkages between them, are therefore essential.

Donors could make a major contribution by sponsoring studies to define priority programs of strategic research needed to backstop African applied and adaptive research programs, and making arrangements for their long-term funding.

Lack of foreign exchange is likely to remain one of the major bottlenecks in improving national research systems. Generally, the amounts needed are not large. Donors might work together to develop a consortium approach to this problem.

Finally, donor-supported case studies on the economic returns to agricultural research investments in sub-Saharan Africa could further demonstrate the importance of research to attaining national development goals.

I. INTRODUCTION

In the early 1970s, parts of sub-Saharan Africa were overcome by drought and forced to import food on a large scale. Although far from being a passing phenomenon, the drought was only one of several elements of a long-term decline in Africa's capacity to feed itself. Other major contributing factors are:

1. population growth outpacing the rate of production increase, poverty, lack of productive employment, and environmental degradation;

2. policy weaknesses leading to misdirected development efforts; and

3. uncoordinated donor inputs.

The problems were debated at the 1985 OAU meeting of heads of state and government in Addis Ababa. The meeting recognized the low priority that most African states assign to the agricultural sector. While agriculture is the dominant sector in most African countries, only 5 to 15 percent of all public funds are allocated to it. An important element of the recovery program adopted at the meeting was agreement that African states would attempt to increase public expenditure on agriculture to between 20 and 25 percent by 1989. This was reconfirmed at the United Nations General Assembly meeting in New York in May 1986, where it was recognized that Africa's economic crisis is a manifestation of a number of long-term problems that require long-term solutions, first and foremost by African states themselves.

A number of important lessons about the nature of the development process have been learned over the past decades. These include the following:

1. Agricultural stagnation is at the core of the crisis. Since seventy percent of Africa's population live in rural areas, increasing the productivity of farming is a sine qua non for improving the standard of living of the average African.

2. Africa's food production-population race requires a redirection of both food and population policies.

3. Poverty is a central cause of hunger in both industrial nations and the Third World. Increasing total food production will not by itself end hunger. Hence, raising real per capita incomes of the urban and rural poor must be a central part of the attack on hunger, malnutrition and food insecurity.

4. The industrial and urban service sectors cannot be relied on to absorb the surplus population of the rural areas. Rural employment generation must therefore be a fundamental part of agricultural development strategies of African states.

There is an emerging understanding that comprehensive agriculture-led development policies are essential to turn African economies around. But although policy reform is currently stressed by donors, and is receiving increasing attention from African governments themselves, a favorable economic policy environment will not, by itself, bring about the changes needed to mobilize the energy of tens of millions of farmers and herders in Africa. Other important components of an agricultural development strategy are:

* human resource development, including the strengthening of agricultural education institutions;

* investment in rural infrastructure;

* developing agricultural support services: credit, agricultural chemicals, extension, marketing, etc.;

* improved accumulation and utilization of rural capital;

* improved management of the natural resource base; and

* the strengthening of research institutions for the generation of new technology.

This paper focuses on the agricultural research component of an agricultural development strategy. Faced with poverty, relentless population growth and a pressing need for income generation through rural job creation, productivity increases based on technical change will have to play a much greater role in Africa's future than it has in the past. This will require strong leadership, and sustained public and private investment in priority research by both African states and donors.

This paper offers guidelines for developing more effective national agricultural research systems in sub-Saharan Africa. It is directed specifically at national policy makers in agriculture, planning, and finance, at research leaders and at donors, and is intended to facilitate the necessary interaction between these.

By helping African governments to develop stronger national agricultural research institutions and well-conceived strategies, donors will be able to plan their assistance to agricultural research within a more comprehensive and coherent framework, and with greater confidence in the management of their contributions. This in turn should permit better cooperation and harmonization of their efforts.

This paper outlines the major principles for strengthening national agricultural research systems. Emphasis is on research system structure, national research strategies, long-term planning and management of the annual research program, human resource development, management of the physical and financial resources, and linkages of research with policy makers and farmers. The paper is a working document. It should be used and tested, and improved over time.

It is expected that a series of specific manuals will be produced by ISNAR and other organizations, as companion texts to this paper, setting out detailed procedures for implementation of major elements of the research management process, such as priority setting and resource allocation, program formulation and budgeting, monitoring and evaluation, and research-user linkages.

With these guidelines and future manuals national planners and research leaders should be able to develop their own capacity to review their agricultural research systems, and to design improved systems with less reliance on external assistance. Each country must decide for itself on an appropriate form of follow-up, coordinated within the country and, it is hoped, with other countries in the region. The SPAAR Secretariat will welcome requests from African governments for further information and assistance. It will channel such requests to appropriate organizations such as ISNAR and FAO, solicit the necessary support, and attempt to coordinate activites for the greatest multiplier effect.

II. MAJOR CHALLENGES FACING AFRICAN AGRICULTURE

African agricultural development is faced with numerous challenges, which include:

1. the food production-population race;

2. food security;

3. rural income and employment generation;

4. environmental protection and development of sustainable production systems;

5. generating and saving foreign exchange;

6. strengthening the institutional base of African agriculture.

The Food Production-Population Race

Food production in Africa grew at half the rate of population growth from 1970 to 1984. The rate of population growth -- not the current population density or the total size of a nation's population -- is at the heart of the food production-population race. Current population growth rates in African countries

-- 2.5 to over 4 percent, with an average of 3.2 percent -- are extremely high by world historical standards and imply a doubling of population within 15 to 25 years. This growth rate is roughly triple that of most industrial countries during a comparable stage in their economic history. The demand for food in many African countries is increasing at 3-5 percent per year, requiring corresponding increases in domestic production and/or imports. Rates of production increase of this magnitude have been achieved by only a few countries over the last three decades, none in Africa. Furthermore, this has been achieved and sustained only where there has been a plentiful supply of good quality idle land that could be brought under cultivation, or where irrigation and improved varieties have allowed double and triple cropping.

Population growth is also putting pressure on fuelwood supplies and the maintenance of natural resources such as grazing land, forest reserves, water catchments, and national parks. To reduce these pressures, sub-Saharan Africa will have to increasingly focus attention on both food and population policies.

Food Security

Until recently it was widely assumed that increasing food production was the key to solving the problems of malnutrition and food insecurity, but recent evidence has proven that the problem is much more complex. For example, India is self-sufficient in food production, but there are many millions of people who are hungry and malnourished. Food security should be defined, therefore, as the ability of a country to ensure that its total population has access to an adequate diet throughout the year.

Hunger can have different causes including a lack of income to purchase food, lack of access to land for family food production, low productivity of family labor, and instability of food production due to drought and environmental degradation.

Poverty is a major cause of family food insecurity because it prevents people from producing or purchasing an adequate diet. The majority of the poor in Africa are subsistence farmers and herders who are producing food for their families at very low levels of labor productivity. Furthermore, many family farms are managed by women, who apart from bearing children have major additional burdens, such as carrying water and gathering fuelwood from increasingly distant areas. One of the most effective ways of improving household food security in the rural areas is to increase the productivity of their main subsistence enterprise: staple crop or animal production. This may also produce surplus food for sale, and release labor which can be used to grow cash crops or for other income-producing activities. The generation of food crop and livestock technologies and the improvement of production systems are therefore major elements for increasing food security in food-deficit countries.

Rural Income and Employment Generation

Income and employment generation are important components of the strategy to combat poverty and household food insecurity. The inability of the industrial/urban sectors to provide enough jobs for the growing rural labor force is a major social, political, and economic problem throughout Africa. Simple arithmetic tells the story. It is estimated that between 1980 and the year 2000, Kenya's labor force will double from 7.2 to 14.1 million, and that around 85 percent of the increase will have to find jobs in farming and rural non-farm activities. Zimbabwe's 1986-91 Development Plan assigns high priority to rural employment generation because only a small fraction, fewer than 10 percent, of the newcomers to the labor force will be able to find employment in the industrial, urban and service sectors. Therefore, agricultural development policies must incorporate employment generation as an explicit objective because more labor will have to be absorbed in farming and rural non-farm jobs for a long time in the future. In this light, new technology is needed, not only for increased production, but also to

provide income and employment opportunities.

Environmental Protection and Development of Sustainable Production Systems

In view of increased pressure on natural resources -- land, water, and vegetation -- caused by higher populations of humans and animals, a major challenge is to develop agricultural systems which will accommodate increased population pressures while at the same time maintaining or improving the resource base. Improving productivity in the better areas can help limit the population pressure on the more fragile areas. Where possible, protection and rehabilitation of the more fragile areas through natural resource management should be organized. Solutions for improving these areas will have to be both social and biological. From the social point of view it will be necessary to work with local farmers to develop systems for better management of the resources, e.g., pasture management, controlled woodland exploitation, and improved water utilization. On the biological side, emphasis should be on multipurpose tree species, including species for fuel, fodder, and shelter-belts, and improvement of soil fertility; and on soil-plant-water relations, and conservation of water and soils. Special attention should be given to possibilities for small-scale irrigation. Research on utilization and conservation of natural resources should include the collection, maintenance, and use of local genetic materials. Future breeding may depend critically on diverse genetic material, the maintenance and use of which -- both nationally and internationally -- is of great strategic importance.

Generating and Saving Foreign Exchange

All of the African countries are deeply concerned about the generation of foreign exchange through the export of agricultural commodities, and with saving foreign exchange through import substitution. Export commodities provide the revenue base for taxation in most countries. The traditional export commodities of sub-Saharan Africa are under severe competition from synthetic products and from exports from Asia and Latin America. The decline of research on these crops is eroding their competitiveness, and in some cases quality deterioration has led to marketing problems. Investments in research, possibly supported by cesses on the commodities, need to be sustained and in many cases increased, to maintain competitiveness in quality and production cost.

Because of competition in traditional exports, and to develop cash income in certain regions, many countries are seeking to diversify their export commodities. However, many of these "new" commodities have small and volatile markets. Before embarking on costly research and development of such new potential exports -- including study of production potential and market opportunities -- governments and research institutions should carefully assess whether investments made on traditional export crops might not provide a better return. When considering diversification, governments should ask whether the country has any marked comparative advantage, and whether quality standards, which are usually the dominant constraint in developing a market, could be met.

Several countries are spending substantial amounts on importing food, particularly wheat and rice (but also sugar, barley, malt...), and wish to save foreign exchange by producing these locally. Most of these are consumed in the urban areas, so the demand is likely to increase rapidly with urbanization. At present, there is little comparative advantage in growing some of these crops domestically, but it is government policy in a number of countries to promote them for import substitution, hence the demand for research on these crops. In many cases the economic and ecological conditions make it highly unlikely that research can lead to local production that is cost-competitive with imports.

Where this is the case, research should be directed toward local products which could substitute for imported foodstuffs. More generally, perhaps the most promising possi-

bility of capturing additional economic benefits and foreign exchange from locally produced commodities lies in the development of local processing industries. Research must be accompanied by measures to develop industrial know-how and quality control.

Strengthening the Institutional Base of African Agriculture

In most countries of Africa there has been a rapid expansion of personnel in higher education, research and the extension services. In many cases this has occurred at the expense of quality, so that the effectiveness of the institutions has not risen correspondingly.

There is plenty of evidence to indicate that the pay-off to investment in any one of these components -- higher education, research, extension -- will be low unless it is linked with the other components in an interactive manner. Therefore, although this paper is mainly concerned with research, it is recognized that efforts directed solely at research institutions will not have the desired impact. In particular, an improved university system is a crucial factor in strengthening both the research and extension systems.

In addition, a general improvement of the agricultural sector will require the strengthening of institutions concerned with input supply, credit, transport, marketing, and agro-industries.

Conclusions Pertinent to Agricultural Research

- Agricultural research has a crucial role in: (a) generating and adapting technologies which can increase agricultural productivity, including intensive production of food and cash commodities in land-scarce areas; (b) providing efficient methods of processing, marketing and utilization of food commodities and non-food cash crops; (c) developing sustainable production systems, particularly for the more fragile areas; (d) generating technologies which can provide productive employment and greater returns to labor in rural areas; and (e) contributing to food security for the nation and the family. Research thus constitutes an essential component for both short- and long-term strategies for agricultural development and poverty alleviation. To fulfill this role, institutional and human capital development is of paramount importance.

- The development of agricultural technology is a long-term and uncertain process. Equally, the rate of adoption of technology by farmers is dependent upon many factors, including prices, input availability, and marketing structures. Consequently, policy makers and agricultural research planners, while dealing with the current problems, should also be looking ahead to problems and challenges that will exist ten to twenty years in the future.

- There is a need for both African governments and donors to give increasing attention to the simultaneous and integrated development of agricultural research institutions, institutions of higher education, and extension services.

III. AGRICULTURAL RESEARCH IN AFRICA: A HISTORICAL PERSPECTIVE

Guidelines for strengthening national agricultural research systems in African must be based on an understanding of the history of agricultural research on the continent, with its enormous diversity. Also, the history of agricultural development in Africa provides valuable clues, notably on how farmers have developed new cropping systems based on introduction of crops from other continents -- cassava, maize, groundnuts and bananas being a few examples.

Evolution in Relation to Changing Objectives

Before the food production-population race began, the objective of agriculture in

most of sub-Saharan Africa was to increase the revenue base. The accent was therefore on cash crops, and the research services responded to the challenge. Over time the developed technologies -- borrowed, adapted, and created -- gave rise to highly profitable production of a range of export crops: coffee, cocoa, cotton, groundnuts, oil palm, sisal, tea, etc. Advisory, input supply, and marketing services were developed to support commodity production, and research was closely allied to these services. The international scale of the commercial interests made communication among researchers on these crops world-wide. Only limited resources were devoted to food crops research, although sustained work on several major staples (maize in Zimbabwe and Kenya; cassava in Tanzania; rice, cassava and many other food crops in Zaire) dates back to the 1930s and 1940s.

Twenty years ago, food production problems were beginning to gain prominence, but the development strategies of the time were generally giving high priority to industrial and urban development, and the rapid expansion of education and social services. Political support for research was declining precisely when there was a rising need to address the more complex research problems of improving food productivity and incomes in diverse farming systems with weak institutional services.

During the past two decades these urban-biased national development strategies were accompanied by donor investments in short-term infrastructure and rural development projects rather than long-term institutional development and program support. Notable exceptions were the consistent support given by some foundations and donors to the development of international agricultural research centers and national universities.

In addition, research organizations themselves have been slow to make the transition from the traditional research programs geared mainly to single commodities to those needed to cope with the great variety of commodities in the complex farming systems of predominantly subsistence producers.

Agricultural Research a Profitable Investment

Accumulated evidence in Asia and Latin America shows that research is a highly profitable form of public and private investment that confers benefits to both producers and consumers. Of 50 rate-of-return studies completed, most have shown rates of return exceeding 20 percent, and several approach 50 percent. Although no empirical information is available on the economics of research in Africa, a strong case for agricultural research investments can be made on the basis of insights from Africa's history, which includes many examples of the successful application of new and imported technology.

Impact of Technology Generated in Africa

Many examples can be cited of the contribution of locally generated technology to agricultural production in Africa. These include crop improvement and agronomic research on a range of savanna crops in Northern Nigeria; coconut in Côte d'Ivoire; hybrid maize in Zimbabwe and Kenya; maize streak virus in Tanzania; oil palm and cassava in Zaire; sorghum in Uganda; groundnut in Senegal and the Sudan; cotton in Mali, the Sudan and Uganda; coffee in Kenya, Zaire and Côte d'Ivoire; cocoa in Ghana and Nigeria; pyrethrum and sisal in Kenya and Tanzania; animal breeding in Kenya and Zaire. Major advances have also been made in crop physiology, botany, soil physics, hydrology, forestry, marine fisheries, and other areas. In the early years, most research attention went to revenue-earning crops, mostly for export. Since the early 1970s, food crop research has received more prominence in response to population pressures.

Agricultural research in Africa has also made major contributions to agricultural development in tropical areas of other continents. Examples are the development of the oil

palm, coconut, coffee, and cocoa industries in the Far East, cowpea in Brazil and the Caribbean, grasses from East Africa in Australia, and millets in Northern Australia. Research in Sudan has contributed to the development of irrigation in several parts of the world.

Transfer and Adaptation of Technology

All countries in Africa, large and small, have benefited by importing technology and adapting it to local conditions. For instance, a small country such as the Gambia, with a limited scientific staff, tripled its maize acreage between 1982 and 1985 with a variety imported from Nigeria in 1974 and tested in local trials until 1981 in cooperation with SAFGRAD/IITA, FAO, CILSS, and USAID. This success was due to the introduction of a suitable variety combined with available fertilizers and an aggressive extension effort. This example also illustrates, however, that even transfer and local testing can take a substantial number of years to reach the stage of firm recommendations. Rwanda is another example of a country which has relied primarily on imported technology: the dominant varieties of many of its crops today are lines imported from other parts of Africa and other continents.

The Nile Valley Faba Bean Project is an example of successful collaboration between African countries (Egypt and the Sudan, later joined by Ethiopia), with support from an international research center, ICARDA. In this project, exchange of germplasm and technical information has led to the release of higher yielding and disease-resistant bean varieties. Relying on transferred technology is a more complex process than commonly assumed, and careful judgement is required for each particular case. Nor can results in one region be considered indicative of similar results in another. For example, following the Sahelian drought ICRISAT introduced sorghum and millet varieties directly from India to the Sahel, and found their performance to be disappointing. ICRISAT therefore decided to adopt a strategy of long-term applied research on sorghum and millet and established its Sahelian Center in Niger. By contrast, the new ICRISAT/ SADCC Center in Zimbabwe has found that varieties of these same crops imported from West Africa and India are performing well in initial adaptive trials.

While these examples are illustrative of varietal improvement of crops, they all have required research on cultural practices to allow these varieties to express their potential, e.g., fertilizers for maize, chemical weed control and pesticides for cotton, planting dates for all. There has also been successful adaptation of technology in other areas, e.g., the widespread adoption throughout the western Sahel of animal traction equipment developed in Senegal.

Need to Reassess Technology "On the Shelf"

The foregoing illustrates the impact of new and adapted technology produced by agricultural research in Africa. However, there is much research-derived information which has not had any impact on African agriculture. The reasons are many: the research was incomplete, or had not been tested on farmers' fields; or the technology did not fit the economic and social conditions of the time; or the necessary inputs were not available. Much of this information will therefore require assembly, reappraisal by agricultural scientists, and extensive on-farm testing for its usefulness under current climatic and economic conditions. In addition, a better understanding of the agricultural practices generated by farmers themselves could provide an important input into packages of extendable technology which are being developed.

The reappraisal should include attention to negative results, which may have been ignored in regular publications and reported only in a form which is difficult to trace, so that lessons from them are lost. The effort of retrieving and assessing these could be well worthwhile, as it would avoid unnecessary repetition.

The reappraisal of existing information, which should be accorded high priority by national research systems, could be of value not only in the national context but also across broad agro-ecological regions of sub-Saharan Africa, and beyond.

Recent History: Limited Output

Despite significant increases in agricultural research personnel, much support from international research, and considerable investments in extension since the mid-1960s, the output from national research and its impact on agricultural productivity in sub-Saharan Africa have been disappointing. Why? In addition to problems with prices, input supply marketing, and other policy issues discussed earlier, several factors have proven to be prevalent weaknesses in national agricultural research systems:

- the difficult agro-ecological conditions in much of sub-Saharan Africa, which have received comparatively little research attention in the past (in contrast to the large and heavily researched irrigated food production areas of Asia);
- shortage of experienced program leaders, and the high proportion (up to 50 percent or more) of research personnel with less than three years experience;
- inappropriate selection and training of many researchers;
- dispersion of research efforts and frequent changes in research personnel, leading to slow completion of research tasks and repetition of the same research;
- insufficient and inadequately trained technical support staff;
- insufficient funds for operation and maintenance;
- weak research management, notably in the utilization of research resources;
- poorly developed linkages with other research organizations and with clients of research.

Lessons Learned

A few important lessons flow from the past and current performance of agricultural research in Africa:

- Many countries in sub-Saharan Africa have been successful in generating and adapting agricultural technology. Such successes have arisen from a combination of several factors: concentration of human and financial resources on a limited number of commodities; a firm problem-solving orientation of research, linked to institutional and farmer capacity to implement solutions; teamwork; continuity of scientific leadership over a long period; and stability in funding.
- Importing, screening, and adapting technology has been widely practiced throughout Africa, but it is a complex process marked with many failures as well as many successes, and must be done judiciously. Emphasis on imported technology is especially attractive for small national research services. The time needed for adaptive research to yield results in the field can vary from a few years to ten or more.
- The development of an efficient national scientific capacity is a prerequisite even for the transfer and adaptation of technology.

- The need for stability and high motivation of staff, continuity funding, and concentration of effort, applies as much to adaptive research as it does to the generation of new technology.

- Large differences in environmental and economic factors between countries and regions in Africa make it necessary to adopt differing strategies for technology introduction and development for the same commodity in different countries. Success in one region is not a guarantee for success elsewhere.

- Notwithstanding the successful examples of technology application in African agriculture, recent experiences in agricultural development projects have shown that the lack of well-proven technical packages is a major factor in the failure of many of these investments.

- The results of past agricultural research should be carefully reappraised for their possible relevance under current social, economic and ecological circumstances.

- Serious problems affecting the current productivity of national agricultural research systems must be addressed in order to obtain the expected returns on investments in agricultural research and extension. These problems lie in many areas, including training, human resource management, program planning, financing of operations and maintenance, and communications. Programs for strengthening agricultural research systems in countries of sub-Saharan Africa must therefore deal with a highly complex situation.

IV. ROLE OF NATIONAL AGRICULTURAL RESEARCH SYSTEMS

To be able to respond to the challenges of agricultural development, each country in sub-Saharan Africa requires a national capacity for agricultural research to introduce, screen, test and adapt technologies to its various micro-environments, and where feasible to generate new technology. This chapter briefly addresses the following questions on the nature of this national capacity:

1. What constitutes a national agricultural research system?

2. What are the key objectives of national agricultural research?

3. What are the major activities of an agricultural research system?

What Constitutes a National Agricultural Research System

The elements of an integrated agricultural research system comprise:

- all organizations in the country, including the universities, having the capacity to conduct research relevant to agricultural development;

- their human, physical, and financial resources, documentation and information, specific policies, plans, and research programs;

- the linkages between the various organizations involved in research and teaching related to agriculture;

- their relationships with the clients of research: producers, extension services, policy makers and planners, development parastatals, and technical assistance organizations.

The system's structure consists of the organizational framework within which research is carried out. The system's component processes are: priority-setting and resource allocation, long-term planning, programming, budgeting, monitoring and evaluation, development and management of human physical and financial resources, information manage-

ment and documentation, and advice to producers, government and other clients on the output of the research system.

Objectives of National Agricultural Research

The key objectives of a national agricultural research system are:

* to make available to agricultural producers and support services:

  - appropriate, reliable, and detailed agronomic information for increased productivity, and for conservation of the resource base;

  - improved basic genetic material and equipment prototypes on which to base increased production of crops, farm animals, trees, and fish; and

  - technologies to deal effectively with various biological hazards.

* to make available to various government and private organizations and industrial decision-makers technical and socio-economic information for policy-making and planning purposes. For example:

  - information on new agricultural production opportunities (crops, animals, trees) for different agro-ecological zones, and assessment of technical, social and economic constraints;

  - technical information on storage, processing, transport and handling of produce to minimize post-harvest losses; and

  - estimates of land, labor, agronomic inputs, and capital needed to carry out national plans.

  - information on conservation and management of the country's natural resource base: land, water, and vegetation, including renewable energy sources and biological diversity.

Major Activities of an Agricultural Research System

To meet the above objectives, a national agricultural research system needs to develop a range of activities in line with the country's priorities and commensurate with its resources. These include:

* searching world sources for information and materials which could be useful for national agricultural development;

* importing technology and adapting it if necessary to the needs of agricultural producers;

* carrying out strategic and applied research to improve knowledge of the country's natural resource base and its management, and to generate new technology when imported options are not available;

* collecting, analyzing, and interpreting socio-economic and agricultural production data and research results with a view to providing producers, policymakers, and planners with insights on the feasibility of various development options;

* maintaining permanent collections of plant and animal germplasm;

* developing linkages with extension services to jointly define farmers' problems and transmit appropriate solutions;

* executing collaborative programs with other national research andacademic institutions, including those of other developing countries, and international agricultural research centers to take advantage of existing information, methodologies, and materials;

* developing and maintaining a cadre of well-trained, development-oriented scientists and technicians in appropriate disciplines.

V. STRUCTURE OF A NATIONAL RESEARCH SYSTEM

The structure of a national agricultural research system is determined by the governing structure of the country as a whole. This larger structure is influenced by traditions, political factors, resources, type and level of development, etc. Any change in the structure of the research system must be within this framework and consistent with established norms.

At present, in sub-Saharan Africa, national agricultural research services -- apart from research in institutions of higher education and development projects -- can be roughly characterized as follows.

a. Research service in the Ministry of Agriculture or Rural Development: The advantages of such a system are that the research programs can be directly linked to the needs of the country's agricultural development plan,which is prepared and implemented by the same ministry. Linkages with the extension service should be excellent. On the other hand, the efficiency of the research system can be impeded by the bureaucratic procedures and rules of the civil service. Linkages with higher education are generally non-existent.

b. Research service in the Ministry of Scientific Research and/or Higher Education: This structure has major disadvantages. Agricultural research is separated from the Ministry of Agriculture and from its agricultural development activities. It is also removed from the users of its results; linkages with extension are often poor. This lack of contact with users often leads to insufficient attention to the adaptive aspects of research. Consequently, there is a tendency for the Ministry of Agriculture or its parastatals to set up their own programs of adaptive research,without close linkages to the national research service. However, a major advantage of this structure is that linkages between research and higher education are usually good, and are facilitated by similar schemes of service.

c. Research services in two or more ministries: The research services are under the control of the relevant ministries, with, e.g., crops research in the Ministry of Agriculture, livestock and veterinary research in the Ministry of Livestock, forestry research in the Ministry of Natural Resources or Environment, etc. This model has some of the advantages of model 'a', in terms of linkages with the national plan and extension, but it shares all of the disadvantages. Major additional disadvantages are that it hampers an integrated approach to the farmer's problems and increases the risk of duplication in research and extension. Overall, the efficiency of the national research effort is impaired.

d. Parastatal research organization: The research system is set up as a semi-autonomous or autonomous organization, with a board of trustees, and a scientific advisory committee which supervises its overall activity. Because the organization is mainly financed by the government, it reports to a ministry. The board and the scientific advisory committee have representatives from the main interested parties (ministries of agriculture, planning and finance, university, farmers' organizations, etc.). This structure should ensure that the research programs are generally relevant to national development objectives and to producers' needs. Relations with the extension services are good at the top but often poor at the field level. The autonomy allows favorable schemes of service and relatively independent decision-making in financial and administrative affairs. Opportunities for inter-institutional coordination are good. The relative freedom from bureaucratic constraints provides the best opportunities to develop an efficient system, provided it is matched by good management.

e. Commodity-financed and controlled research groups: This approach has the advantage of focusing a critical mass of scientists on a specific commodity. It has independent financing and, consequently, control over its procedures and schemes of service. Such research groups are often associated with an extension and/or input supply service. They are highly responsive to users' needs and provide an excellent example of the integration of research and development in agricultural production. On the other hand, such organizations cater for only a specific part of the whole agricultural production system and are obviously no substitute for a national research system. They are highly dependent on revenue from exports and often do not respond well to the need for crop diversification.

Some systems combine two or more elements, and there are wide variations in the ways in which they operate and are controlled. In small countries geographical proximity permits a centralized system, composed of a central support unit and a number of field units, to operate effectively. In larger countries, most of the research must be decentralized to deal adequately with both overall national problems and location-specific needs. In both cases there is a need for appropriately delegated management authority to create a responsive research environment. Although a centralized style of management may have some administrative advantages, bureaucracy and distance from decision-making can reduce researcher motivation, especially in substations.

Potentially, a national research service that is linked to higher education,in which the combined system enjoys relative autonomy customary for universities, would seem to offer substantial advantages, provided there is some form of inter-ministerial governance which would ensure that the research program meets the needs of farmers and extension services.

However, to achieve this there would need to be coordination of funding and staffing within and among the different ministries involved. Given the great long-term significance of such cooperation, African governments should overcome institutional barriers and begin making some budgetary provision for cooperative activities (possibly helped by external funding) between the research institutions and the universities. This should be supplemented by the creation of effective inter-institutional mechanisms for the planning and programming of joint research activities and student apprenticeships at research stations. And it might culminate in a semi-autonomous combined agricultural research/education system under inter-ministerial control noted above.

Governments need a mechanism for advising them on scientific and technological policy. Some African countries have national scientific and/or agricultural research councils. The major role of such councils is to influence the allocation of funds to different research sectors: medical, industry, agriculture, etc. In order to do this, they must have a competent and adequately funded professional secretariat.

VI. BUILDING AN INTEGRATED SYSTEM

In sub-Saharan Africa, linkages between the elements of a national research system, vital to maximizing research scope and efficiency, are often insufficiently developed. Such associations include those among different research institutions, and between research institutions and universities. The system must communicate with, and be responsive to, policy makers, farmers, extension agents, parastatal development organizations, and private companies. An effective national system also fosters international cooperation. Regional linkages are particularly important to smallcountries. The need for stronger professional interchange and collaboration is imperative to alleviate human resource and funding constraints, and to reduce the intellectual isolation of scientists in many African countries.

Effective Use of National Scientists

National research talent is scattered over various institutions, organizations, and ministries, and cooperation is usually deficient. Development of linkages between researchers in dispersed institutions and locations involves a process of mutual confidence building, backed by improved information systems and explicitly supported by national authorities. Governments, donors, and the scientific community need to establish and finance appropriate linkage mechanisms. Steps include: (a) preparing a national inventory of researchers in agriculture and related disciplines, and their projects; (b) matching research priorities with existing institutional and manpower capacities in the country, eliminating duplication, and identifying critical gaps; (c) determining where additional resources would go to fill gaps, making the fullest use ofinter-institutional collaboration; (d) establishing an agricultural science ulletin or newsletter; (e) encouraging participation in national professional associations, both general and disciplinary; and (f) removing bureaucratic barriers to effective linkages between individuals across institutions.

The term "critical mass" is frequently used to indicate the minimum number and disciplines of scientists and technicians required to effectively conduct a research program or activity. The term can also be applied to entire stations, institutes, and the national system as a whole. The concept of critical mass is often violated by the dispersal of scientists among many stations and programs, even though this arises from the legitimate desire to serve each of the agro-ecological regions or administrative units. Continuing limitations in resources will impose hard choices between efficiency of the research system through concentration, thus inevitably ignoring many important needs, and attempting to provide uniform coverage leading to ineffective research. A few well-staffed and well-supported stations have a far better chance of producing useful technology than a widely dispersed system with all the attendant problems of difficult communication, intellectual and social isolation, and lack of support services and amenities. However, these few research stations must then provide their staff with sufficient mobility to conduct research off-station to cover regional needs.

Integrated Development of Research, Education and Extension

There is a need for both African governments and donors to give increasing attention to the simultaneous and integrated development of research, higher education, and extension services. Efforts directed solely at research institutions will not have the desired impact. The university system should make critical contributions to research and extension, by providing graduates adequately prepared for both these careers, and by collaborating in research. Similarly, effective research requires close relationships with farmers and extension agents.

Regional and International Research Linkages

Research efficiency can be enhanced by research linkages across borders in sub-Saharan Africa, and by making full use of opportunities arising from the regional activities of the international agricultural research centers. Linkages between African researchers and their counterparts in other countries can also be of great help in research and training, especially if institutionalized by twinning. African governments may also wish to consider more fully the possible advantages of creating new institutional frameworks for regional collaboration: for example, in research on certain commodities and factors of the natural resource base.

Inter-Governmental Institutions

After several successful precedents in Central, West and East Africa, most of which disintegrated as a result of political forces, the concept ofintergovernmental institutions is attracting attention again. Lessons learned from the East African Agriculture and Forestry Research Organization (EAAFRO) and

similar regional organizations in West Africa are relevant to promoting regional cooperation today. For instance, such organizations, with the better facilities and schemes of service which were necessary for their special roles, attracted the better staff and received more regional and international attention than the national research institutions; this aroused envy. There was also the perception that the host country benefited out of proportion to its financial inputs. While there is now little support for the concept of regional research institutes, there is growing attention to other forms of regional cooperation, which could avoid the problems inherent in the former. Regional cooperation will require strong political commitment from the participating governments. This commitment must find expression in the encouragement of staff and material exchange, and in reliable financial contributions. External support must be substantial and long-term (20 years). Centralized investments under regional auspices, if any, should be on a modest scale to avoid impairing each country's ability to ultimately take over the financial and management responsibilities. In planning programs of regional cooperation, each participating country must ensure that cooperative projects fit into and support national development plans and priorities, do not overload national scientific and administrative manpower, do not encourage brain-drain, and do not create serious imbalances in the utilization of scarce resources. Accepting cooperative projects without an overall plan all too easily leads to a situation where, after meeting the commitments to a few regional commodity-specific projects, there is no research capacity left for other areas of national or regional importance.

The establishment of the Southern African Center for Cooperation in Agricultural Research (SACCAR) in 1984 provides a positive example. Started at the initiative of the nine states of the Southern African Development Cooperation Conference (SADCC), SACCAR has a board of directors and a small secretariat at its headquarters. Its objectives are to assist in furthering mutual assistance and cooperation in research and training among scientists and institutions in the nine SADCC states through: seminars, workshops and meetings; publications; small research grants; travel grants for research workers to visit other scientists in the region; and the commissioning of studies on problems of regional importance. SACCAR is also responsible for monitoring three regional SADCC programs, on sorghum and millet improvement, grain legume improvement, and soil and water management. These three programs are examples of networking, a form of cooperation which is receiving increasing attention in Africa.

Networks

Networks may be limited to information exchange, or may encompass collaborative planning, implementation and monitoring of research activities. Networks are complements to, not substitutes for, national research systems. Without a strong national scientific capability, a country can neither contribute to a network nor effectively screen and import technology. The development and operation of networks will require a long-term planning and funding horizon on the part of participating governments.

In collaborative networking, each participant assumes the responsibility for specific research tasks for the benefit of the whole. The funding of networks should be an integral part of the financing of the national research systems concerned. Networks with a limited scope, clearly defined in technical terms and arising out of genuine local initiatives, have the best chance of success. Creation of regional research networks is especially relevant for countries with similar agro-ecological conditions and farming systems, possessing limited acreages of major commodities, and having common resource-base problems requiring factor research for which specialized knowledge is scarce.

A SPAAR Working Group on Agricultural Research Networks is making a comprehensive study of this topic.

Linkages with Senior Scientists Abroad

Senior staff of scientific institutions in industrialized countries can play a crucial role in helping African scientists -- particularly the younger ones -- and in backstopping and complementing national research. Such linkages also provide opportunities for better-focused short-term training. These advantages are similar to and complementary with those arising from linkages with international research centers. The full potential of such linkages with national institutions overseas are realized by formal twinning agreements and assured medium-term financial backing from a funding agency. The planning of such linkages should involve the researchers themselves to ensure their dynamic participation.

Management of Donor-Funded Projects

In many countries of sub-Saharan Africa much agricultural research is conducted by expatriates funded by donor agencies. These agencies often insist on considerable structural and managerial autonomy for their projects, their staff, and sometimes the local counterparts. They commonly cite the need to achieve project efficiency, and to comply with accounting regulations of their own governments. African research leaders are increasingly objecting to these demands, which complicate research structure, interfere with national programming and budgeting, and may distort program balance. Furthermore, donor-funded research programs often disintegrate when the project activities cease. Better integration of these projects into the national programs is much more likely to ensure their acceptance by the government, and their continued viability. Greater openness by donors about the recurrent costs of their projects will allow national authorities a better understanding of future financial requirements. Rational research programs, efficient resource management, and satisfactory financial control in the host institutions will be needed for donors to agree to closer integration.

Time Frame

Most governments and donors underestimate the time required for national agricultural research to generate and/or adapt technology. It usually takes at least three to five years to import and adapt technology, and ten years or more to generate technology. Also, the time needed for adoption of technology by producers is frequently underestimated, leading to wildly over-optimistic assumptions about the rates of productivity increase. Most important, the development of a stable research institution with asustained capacity to deal with difficult technical problems requires a far longer period of time than is generally planned for.

VII. FUNDING OF RESEARCH

How Much to Invest in Research

The share of national resources to be allocated to agricultural research can be rationally determined only when national political leaders have an appreciation of what research can do for the identification and implementation of national development priorities. This political allocation decision, therefore, will be more rational when influenced by technical information from the research system. There are no firm indicators for the desirable level of research investment, but rough guidelines may be drawn from country comparisons of financial allocations expressed as percentages of agricultural gross domestic product (AGDP). The national allocation to agricultural research in sub-Saharan Africa ranges from 0.1 percent to well over 2 percent of AGDP, with a decline in almost all countries since 1980. Although such figures must be used with caution, an allocation of less than 0.5 percent is almost certainly too low, and a target figure of at least 1.0 percent of AGDP would be desirable. Each country must interpret these guidelines, taking into account the projected national budget and AGDP, the tax revenue from marketed produce, the pressures on the agricultural sector, the diversity of agriculture, and the natural resource endowments.

Regardless of the target figure for budgetary support, year-to-year stability, timely disbursement, inclusion of adequate provisions for operations and maintenance, and a minimum allocation of foreign exchange for documentation, spare parts, and staff travel, are more important than the level of support itself.

Allocations of Funds for Operations, Infrastructure and Staff

One of the major problems in research financing is the low proportion of the research budget allocated to operations and maintenance (sometimes as little as 5 percent, compared with a desirable figure of at least 30 percent), making it difficult or impossible for research personnel to function efficiently. Moreover, allocating funds for the additional recurrent costs arising from investments in new infrastructure and equipment, particularly the foreign exchange element, is frequently neglected. The detrimental effects of inadequate operating funds are exacerbated by budget fluctuations. Since personnel costs are usually fixed obligations, most budget cuts affect operations and maintenance. In some countries political pressure for additional recruitment of young graduates, without a concomitant increase in funds for operations, further aggravates the problem. Incremental funding should therefore go to operations.

The cost to a nation of fluctuation in research funds is greater than in most other public functions. Although various proposals have been made to cushion the effect of these fluctuations and to allow for inflation (cesses on export commodities, stabilization funds...), there is no real substitute for government commitment to a stable budget. Only this can ensure that funds are available for both staff salaries and operational expenditures at a sufficient level to safeguard the high-priority programs. Governments need accurate projections of the cost of running the research services, on at least a three-year rolling basis.

Foreign currency allocations, a key component of the financial requirements, are often inadequate to maintain and operate laboratory and experiment station facilities and libraries. Donor support to specific projects usually fails to provide the financial flexibility to cover foreign currency requirements in other parts of the research system. A more flexible and coordinated donor approach could help African countries solve this very important problem.

Finally, the development of infrastructure for agricultural research must be analyzed on an individual country basis. The rising costs of maintaining physical plant, library and documentation services, and equipment pose serious problems to national research systems, especially as their budgets in real terms are generally declining. In some countries there has been over-investment in new buildings and equipment relative to the long-term development of human resources and institutions. Nevertheless, there are many experiment stations in Africa where relatively modest investments to modernize buildings and equipment would greatly increase their effectiveness.

VIII. DEVELOPMENT OF A NATIONAL RESEARCH STRATEGY

Research Response to Multiple National Development Goals

The national research program must be firmly in line with, and working at, the most critical constraints to achieving the national development goals. From 1970, all African countries have espoused multiple and often conflicting goals for the agricultural sector: higher output, food self-sufficiency, increased import substitution, higher agricultural exports, improved nutrition, improved employment and incomes, and upgrading of marginal areas. In principle, agricultural research can contribute to each of these goals, but in the face of limited resources, at least three major questions arise. First, is improved technology the most effective answer? Second, are anticipated constraints to adoption of the technology, once developed, likely to be resolved? Third, what is the priority ranking

ofthe specific commodities and research areas? Unfortunately, these questions are seldom adequately answered. It must also be recognized that research cannot resolve conflicts which may exist among multiple goals.

The problems of defining a national research strategy are exacerbated by the fact that the responsibilities for agricultural development and agricultural research are frequently scattered among several ministries. This makes it all the more imperative to have a framework for linking research and economic development planning: policy makers must be aware of the long-term nature of research, and researchers must understand their role in elucidating some of the complex technical and socio-economic problems of development.

Need for Balance between Various Kinds of Research

Research follows a continuum and the boundaries between different kinds of research are arbitrary. The categorization used here is as follows:

* strategic research: designed to generate new knowledge and new research methodologies needed for the solution of specific research problems;

* applied research: designed to create new technology, and to study market opportunities;

* adaptive research: designed to adapt technology to the specific needs of a particular set of conditions.

All countries of sub-Saharan Africa conduct a mix of adaptive and applied agricultural research. Strategic research is rare in Africa, even though it may be of critical importance to the solution of major problems. African governments must be realistic in their expectations: nearly half of all countries in sub-Saharan Africa have fewer than 50 national scientists in agricultural research. Clearly, this limited resource is best utilized by concentrating on adaptive and applied research. While such research requires lower investments in infrastructure and less reliance on some highly specialized disciplines, it provides at least as great a challenge to the imagination of the researcher, and often yields a quicker pay-off.

On the other hand, simple adaptive research, and even applied research, will not provide answers to the complex problems encountered in farming systems of smallholders, nor to more fundamental problems associated with the country's natural resource base. The development of suitable approaches to solve some of the major technical problems requires long-term strategic research. There is an urgent need to determine with precision the kinds of strategic research required, to identify the institutions able to provide this research, and to establish the mechanisms to link it with applied and adaptive research in Africa.

Institutions in industrial countries can and do provide some of the strategic knowledge and material needed for agricultural research in developing countries. But to focus more of their research on strategic issues especially relevant to African conditions they need appropriate professional links with African institutions, the latter receiving supportfor this type of activity. The international agricultural research centers will be expected to play a catalytic role in this, and to carry out some ofthe needed commodity-linked strategic research, notably in methodology development.

Adaptive agricultural research work is often conducted in isolation from scientists having more fundamental knowledge in the natural sciences and from specialists in socio-economic disciplines, who are generally associated with national academic institutions.

Closer collaboration between national agricultural research institutes and universities can make existing research programs much more effective.

In view of the complexity of research, national research policymakers must facilitate collaboration and sharing of research tasks between scientists in the national and international community. This collaboration will help national research scientists to articulate their strategic research needs and capitalize on the advances being made internationally in the basic sciences.

While strategic research is widely applicable across national boundaries, adaptive research must be location-specific, and must identify closely withthe wide variety of farmers' conditions and goals. Farming systems research (FSR) is widely regarded as an appropriate approach for defining farmers' constraints and thus for setting research priorities. However, in taking up FSR, national research leaders and donors must address the important question of balance between FSR and commodity research, and their interdependence. Many FSR projects across Africa have been over-funded relative to commodity research programs. Moreover, FSR practitioners have taken diverse approaches to FSR, which has overwhelmed African researchers. The challenge will be to retain the core concepts of FSR as an essential support for on-station research programs.

Socio-economic research falls outside the above three categories, but is needed in support of agricultural research programs. This research includes policy and sector analysis, study of resource management and environmental sustainability issues, setting of research priorities, analysis ofconstraints and potentials, and farm management. Choosing appropriate areas of technology development, and the right kinds of technology to develop, iscritically important to all countries, irrespective of size. More socio-economic research will help considerably to determine beforehand whether a particular technology is likely to be adopted.

Priority-Setting and Resource Allocation at the Macro Level

The research system must develop a research strategy which translates national development goals into research objectives and establishes research plans for the short, medium and long term. At the macro level, national decision-makers must set priorities and allocate resources through a five-step process involving:

1. the articulation of national development objectives and agricultural sector goals;

2. the design of development strategies to address these goals -- including farmer incentives, land tenure policies, rural institutions and services, and investments in infrastructure, irrigation, input distribution systems, extension, research, etc.;

3. the assessment of the potential contribution of research to removing agricultural constraints in the framework of the development strategies previously defined;

4. the preparation of an inventory of current research resources and anassessment of future needs, taking into account the stock of under- or unutilized knowledge and technology from national or international sources; and

5. the broad allocation of national research resources to specific priority areas, in relation to the inventory of needs, while ensuring that minimal resources (critical mass) are in place for effectively addressing the priority areas selected.

Steps 1 and 2 involve decisions made by national planners and the political process, ideally having received information concerning technical feasibility from the agricultural research system. In order to fully contribute to this process, the research system must strengthen its capacity for technical and socio-economic analysis. Steps 3 through 5 involve to a greater degree the agricultural research system itself. During the articulation

of national development objectives and agricultural sector goals (Step 1), governments face many difficult policy decisions, which they must often take without adequate data. These include the balance between:

- growth and equity,
- import substitution and export promotion,
- cash crops and subsistence commodities,
- increasing the productivity of existing farmland and the cultivation of new land,
- high-potential areas and the more difficult environments,
- dryland farming and development of irrigation,
- small-scale and large-scale farming,
- existing commodities and potential new commodities.

The necessary evaluation of alternative agricultural development strategies (Step 2) requires an assessment of the potential contribution of each option to the national and agricultural sector goals. This assessment relies on information and data on a number of parameters, as well as a national capacity to analyze them and present the conclusions in a form that can be used by policy makers. Many countries of sub-Saharan Africa lack such a reliable database. Nevertheless, a dialogue between policy-makers and research leaders would certainly lead to a more rational allocation of resources: a combination of the research manager's knowledge of the most important research problems and the planner's insights into government policy would markedly improve the quality of these decisions. Even so, the constitution of a reliable agricultural information system is important for evolving and refining development policy in the longer term.

Having answered the above broad questions (Steps 1 through 4), research priorities need to be developed for commodities,[1] regions, and factors of the natural resource base (Step 5). There are at least five general considerations which national planners and research leaders must take into account in priority setting and resource allocation, always taking account of limited staff and budgets, and the time necessary to produce results:

- The economic, social, and political importance of a commodity orregion. Relevant data are: area involved, potential production, numbers ofbeneficiaries and probable distribution of benefits, employment projections, and impact on foreign exchange earnings and savings. This involves a careful analysis of efficiency/equity, producer/consumer, and other interests.
- Current market demand for particular commodities, and future projections. Indicative data for food crops include: population growth rate, changes in land use, price trends, trade projections, and changes in consumption patterns. For industrial crops: changing demands for export and local transformation.
- The chances of a successful outcome of the research. This implies a subjective assessment of scientific probabilities, time scales, resources needed, and probable costs and benefits. Past experience and current knowledge would be guiding factors.

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1 Commodities relate to the production of crop, animal, and tree species. They should be clearly distinguished from the products derived from them. For example, cattle are a commodity; milk, meat, and leather are products. It is of utmost importance for research that government policy specify the products it wishes to promote, not just the commodities.

- The factors which may affect adoption of results. This involves assessments of the needs and perceptions (risk, cost, etc.) of clients, the effectiveness of support services, the level of political commitment, and the possibility of policy-imposed constraints, e.g., pricing, import policies, and market quotas.

- The opportunities for collaboration with other national andinternational research organizations, in order to optimize the use of scarce resources and make national research systems more cost-effective.

IX. STRENGTHENING THE MANAGEMENT OF RESEARCH SYSTEMS

For agricultural research to become more effective, research organizations must strengthen their ability to manage resources and programs. The following sections highlight the major aspects of agricultural research management. While seen as parts of a continuous process, these steps involve different sets of people and occur at different times. It must be stressed that in order to conduct effective and efficient research, all of these steps must occur, and with some degree of proficiency. Therefore, skilled managers are needed at various levels in the system.

Long-Term Research Planning

After priorities have been set and resources allocated at the macro level, a long-term research plan for, say, 10-15 years must be designed to address the major constraints and opportunities within each of these priorities. This is squarely the task of senior research staff within the institutions. This plan projects manpower requirements, including the numbers and disciplines needed, and the recruitment and training necessary to provide them. It also projects needed expansion and/or modification of infrastructure and equipment. The group, under the leadership of the institute director, should be interdisciplinary in nature. This planning process includes transmitting the long-term program directives to the research stations, team leaders and researchers, who are responsible for proposing specific experiments and studies which constitute the short-term research program.

In the absence of a comprehensive agricultural sector policy and strategy for research from policymakers (a condition that will continue to exist forsome time in many African countries), experienced research system leaders can develop a rational medium-term research plan based on general knowledge of technical and socio-economic conditions in the sector. While this is obviously not ideal, it is the best research managers can do to address priority concerns without having received clear guidance from policy makers. However, there are some areas for which research leaders must receive specific policy guidelines in order to orient research; e.g., government fertilizer policy will dictate the type of technology pursued in the research program.

When agricultural development policies and strategies are ill-defined, the research services should draw up their own research plan and then:

- inform government of the assumptions on which their priority choices werebased, thus giving national planners the opportunity -- and the challenge -- to verify, and confirm or modify, the rationale;

- explain why government policymakers must answer certain specific questions if research is to be more supportive of development priorities; such questions may help to provide a basis for better policy formulation.

Research Programming and Budgeting

Within the long-term research directives there is a wide choice of possible experiments and studies. To select the most relevant and urgent among these, team leaders and re-

searchers must have a good understanding of the capabilities and constraints of farmers and rural support services. An interdisciplinary group at the research station level, because of its proximity to both the farmer and the extension agent, is best suited to make this selection. It must take into account, through a program-budgeting exercise, the human, physical and financial resources required. The approved work plans from researchers, teams, stations, and institutions are aggregated to constitute the short-term or annual national researchprogram. This aggregated plan must be checked at the national level for consistency with the national long-term objectives, priorities, and broad resource allocations.

Each component in the annual work plan should be described in enough detail to be realistically costed in both staff time and operational costs. The least flexible and most critical resource is the time of research workers. It is particularly necessary to ensure that the time each researcher willspend on different research projects, as well as on other activities of the organization, is not unduly scattered and is correctly estimated. It is also necessary to budget adequate operational funds for researchers to work efficiently. A well-proven technique for realistic costing treats the researcher, with an associated pro rata share of support services and operational funds, as the budgetary unit. Clearly, reliable unit costs are needed for all operations.

When budget requests are only partially met, the institute often applies pro rata cuts across every program. In some cases the ministry of financeitself decides on program cuts. Research programs may further suffer fromadditional cuts made in the course of the year. In agricultural research, much of which is based on cropping seasons, expenditures are not evenly distributed throughout the year, but have periodic peaks. Disbursement of funds on a quarterly or half-yearly basis therefore causes cash flow problems. It is against this complicated background that programming and budgeting has to take place.

Sophisticated procedures for program-budgeting (PB) are of limited value in these circumstances, and they absorb an inordinate amount of the time of scarce manpower. Therefore the initial design of PB systems should be simple, keeping data collection and analysis to the minimum necessary. Microcomputers can help as tools to store and process the information. There are many benefits to research organizations of using a PB system. It forces them to describe programs in specific terms and with budgets thatcan be clearly justified to policymakers. It clarifies issues of resource allocation to particular commodities and geographic areas. And it provides a basis for monitoring both the financial and substantive progress of research programs.

Finally, it should be recognized that while the introduction of an effective PB system should have a fairly immediate impact in improving the management within the institution, it will take several years for its usefulness to be felt in the process of national budgetary allocations, as the financial authorities and the research institutions develop a mutual understanding and confidence.

Monitoring and Research Evaluation

Monitoring

The monitoring process is a management tool which provides managers with current information on money spent, people employed, materials used, and research results in each of the research activities. This information is reported at all levels, from the individual scientists to program leaders to the institute directors.

In setting up a monitoring system, managers must ensure that it does not become more time-consuming than the benefits justify, that no superfluous data are collected, that data analysis, interpretation, and feedback are timely, and that researchers perceive it as useful.

Monitoring provides the basic information for the programming and budgeting process, which uses this year's actual resource utilization to estimate next year's requirements, and

should also use evidence of success or failure in given areas as guidelines for budget increases or reductions. An efficient monitoring system, introduced at the start of a research project, also forms a valuable basis for any subsequent evaluation, i.e. an assessment of the research project's performance.

Research Evaluation

There are two aspects to the evaluation of research performance. The first concerns the quality of the experimental program at the technical level. This depends on the experience and integrity of the researcher. The second aspect is concerned with the relevance of the research to the overall objectives. Annual evaluation is needed in the context of the programming exercise; experience in some African countries has shown that this can be conducted very effectively through peer review. There should also be periodic evaluations of all research programs to: (a) examine their progress against set targets, and whether there is need for major adjustments; (b) check their continuing relevance to the overall objectives; and (c) decide on the termination of old or failed programs and the beginning of new ones. In addition, research institutions should undergo periodic management reviews. It is beneficial to have external members on such review teams.

In carrying out evaluations it must be borne in mind that the output of the research system is new knowledge and new technology, and not impact in terms of increased national production, where other factors intervene. Nevertheless, results of on-farm trials, important indicators of potential impact, must be taken into account. Much weight must be given to the critical assessment and timely publication of the results in annual reports and journals.

Human Resource Development and Personnel Policy

Sound personnel selection, training, and promotion are the three hallmarks of human resource development in a public or private research organization anywhere. A further element, closely related, is an appropriate scheme of service that will retain staff. All of these are necessary to encourage the most important, though least tangible, element in the research system: research entrepreneurship.

There are four important considerations in examining human resource development strategies for African research.

- The numbers of well-trained personnel in scientific fields in most countries of sub-Saharan Africa is grossly inadequate. This problem can only be resolved over a 20- to 25-year period, and will require substantial investments by African governments and donors.

- The shift to a science-based agriculture requires professional researchers who have formal training in research methodology, with a minimum of a Master's degree, an Ingenieur Agronome degree with some research specialization, or the equivalent. The most expeditious way of achieving this is by developing close cooperation with local universities, many of which need to be strengthened and linked in a regional framework to allow for a wider range of specializations.

- There is an international market for scientists, as well as a competetive local market. Agricultural researchers are highly mobile, and unless agricultural research managers in Africa pay special attention to changing local, national, regional and international market conditions, many productive scientists in the 40- to 50-year age bracket will move on to better opportunities, particularly in externally funded programs.

- Attrition rates in excess of 7 percent are the norm rather than the exception in Africa, as compared with 3 to 4

in Africa, as compared with 3 to 4 percent in research services in industrialized countries. These high rates imply that the entire pool of researchers and technicians in many national agricultural research systems has to be replaced every 14 to 16 years. These turnover rates obviously undermine the productivity of research programs, where continuity is required, and increase the need for training, particularly overseas, with the consequent heavy costs.

Research Entrepreneurship

The outcome of research is subject to risk and uncertainty, and research scientists, in addition to professional competence, organizational skills, and access to funds, need a special human ability: research entrepreneurship. The ability to articulate research hypotheses and to choose research priorities from among a multitude of possibilities, and then to put up with risk and uncertainty inherent in all research, is an innate and hard-to-define talent. This talent is rewarded haphazardly in public research worldwide, and is increasingly impaired by bureaucratization of research services. Research leaders in Africa must devise institutional structures and mechanisms to select, encourage and reward such research entrepreneurs.

Recruitment

Sound personnel selection is critical to the quality of a scientific organization. Candidates for the research service, whether they be scientists, technicians, or financial and administrative staff, must be selected carefully for their qualifications, aptitude and attitude by the research organization itself to satisfy its special requirements, rather than through centralized public service mechanisms, or under political pressure. University selection systems may provide a useful model. In addition, it is desirable that young scientists undergo a two-year probationary period.

Special criteria of aptitude and attitude need to be applied also in the selection for top management functions, and it is highly desirable that the research organization participate in this process also.

Because of pressures by some governments to secure jobs for the growing numbers of university graduates, their research institutions have be enforced to recruit staff in numbers well beyond their capacity to train and usefully employ them. This is especially true where operating funds have not kept pace with the expansion of personnel. This has serious consequences for research efficiency and output. To be realistic, recruitment must always be related to an agreed priority research program and the funds to carry it out.

Training

Only a few research services in Africa have a training plan, and even fewer have a comprehensive manpower development strategy. There is a shortage of postgraduate training opportunities in Africa. Some of the larger donors supporting agricultural research have concentrated on financing long-term training overseas and short-term training in international research centers. A challenge for both African governments and donors is to develop a coherent long-term strategy to shift the center of post-graduate training from industrial countries to selected universities in Africa, notably those which will be ready to assume responsibilities in a regional context. In addition, training at international agricultural research centers should be expanded and be responsive to the specific needs of African scientists and senior technicians, taking into account that they will be working under quite different conditions in their home countries.

At present, much of the selection for training is passive, with the institution merely responding to offers of scholarships or fellowships for overseas training. This is especially so where training is part of individual donor-financed projects, and is inevitable in the absence of a master training plan. Such a training plan should cover a ten-year period,

with a detailed definition of medium- and long-term agricultural research program thrusts, and agreement from government on the projected numbers of scientists. Plans for management training and support staff training are also imperative.

Overseas postgraduate training is very expensive for both donors and national governments, and the costs are increasing. Overseas training in an industrialized country now costs US$50,000 for a two-year M.Sc. and US$100,000 for a Ph.D. The development of more postgraduate schools in sub-Saharan Africa is urgently required to reduce the dependency on overseas training and to make thesis research more relevant to local problems. Improving the capacity of postgraduate schools is not only a matter of increasing enrollments and decreasing costs but, more important, a question of raising the quality of the national scientific system.

Formal training for a higher degree provides only the foundation for a research scientist's work. Throughout his career, he will need to develop his scientific capacity and broaden his understanding of agricultural problems. A desire to do so must be one of the innate qualities of those identified for a research career. However, this must be stimulated by opportunities for additional training, through short in-service courses, visiting senior scientists conducting seminars and coaching young scientists, and attendance at workshops.

Incentives, Promotion, and Retention

Promotion, salary increases and various forms of scientific recognition should be the rewards for professional performance, and the main incentives for continued creativity and service. Presently, in most national agricultural research services in sub-Saharan Africa the salary reward system is based on length of service rather than the productivity of the researchers. Many research officers gain their maximum rank within a short time span of five to seven years, and then salaries are increased only slowly according to the years of service. In most cases, promotion is tied to the assumption of positions entailing administrative and managerial responsibility, so that the most senior officers spend little time on research, often cutting short the natural development of their research productivity and scientific career. Promotion should not be tied to managerial posts only. A separate promotion stream based on the recognition of research performance should be created. Such a stream should have open career scales (in which numbers of posts at specific grades are not limited), and promotion within such a stream should not be based on seniority alone. Appropriate criteria for promotion should be developed, and these, as well as promotion opportunities, should be made widely known to staff. Such criteria should be balanced between the researcher's commitment to working toward national development objectives, publications in local and foreign journals, production of material for distribution to extension staff, and enhanced scientific capacity through training.

A desirable career structure, which would facilitate interchange of staff, is to adopt such a career system jointly with the universities. Higher salaries are not the only element of the total reward package, and in many systems where there is a limited opportunity to develop financial rewards, other incentives assume even greater importance: various forms of professional recognition at the national level (membership of boards, evaluation missions, and planning committees), merit research grants, editorial help and channels for publication, sabbaticals, as well as opportunities for participation in conferences and study tours.

Special consideration needs to be given to the working and living conditions in outlying stations, in order to attract and retain competent staff. Proximity to reasonable health and schooling facilities, and the availability of adequate housing, are essential. Where these cannot be assured, it is virtually impossible to maintain a station with resident scientific staff. In some cases, special financial incentives can help. Regardless of the quality of the

need to be assured that they have access to promotion opportunities and other incentives at least equal to those at headquarters.

Finally, special attention needs to be given to the total package of incentives for support staff. When well trained, such staff have many opportunities outside the research system, and their rapid turnover seriously interferes with the effectiveness of the research service.

Administration of Personnel Policy

Good personnel administration requires the collection of adequate personnel data, in the form of easily analyzable individual records. Every research organization needs to have up-to-date and accurate information on the number of people it has on the payroll, in what grades, with what special qualifications, experience and skills, and in what age brackets. Therefore, high priority for many agricultural research institutions in sub-Saharan Africa is to build a personnel database which can be used for recruitment, career planning, the planning of training, administration of training programs, and routine personnel and salary administration.

There are three ingredients in establishing and maintaining a personnel database: (a) a commitment by the research organization to make the database the central feature of its ongoing records and planning system; (b) a willingness to spend a modest amount of money and time over two to three years to get the database set up; and (c) a microcomputer for all except the smallest institutions.

Financial Management

Financial management involves the timely disbursement of funds for an efficient deployment of the research resources in relation to the annual research program. A sound accounting system is an obvious prerequisite. It is also a critical factor in maintaining confidence in the organization, not least among donors. But many African research managers admit that they have inadequate professional support for financial management, forcing them to spend much time on an activity for which they are not qualified and in which they are not deeply interested. As a result, operational responsibility for the day-to-day disbursement of funds and for the maintenance of records tends to pass to clerks. And they in turn are in no position to introduce flexibility to the government rules. Multi-station research organizations require delegation of authoritiy for disbursement of funds to station heads and national program coordinators, so that they have adequate discretion and flexibility in the use of these funds.

The structure of the research organization dictates the most appropriate form of financial management. Those with a degree of autonomy should be able to operate with considerably greater financial flexibility, including block-funding, carry-over of funds from one year to the next, and the release of funds to meet peak requirements.

The introduction of inexpensive microcomputers can strengthen financial management within African agricultural research institutions, and release valuable time of the professionals.

Accounting requirements imposed by donors for the administration of their grants and loans vary widely. Many research institutions have to report on a substantial number of projects funded by different donor agencies. This can stretch the institution's capacity beyond what is reasonable to expect. Donors, ministries of finance and planning, and research managers should come together to harmonize these requirements.

Management of Physical Resources

Sound management enhances the efficient servicing and utilization of buildings, equipment and vehicles. It is necessary to have

adequate workshops for service and repair, reliable power and water supplies, well trained mechanics and equipment operators, reasonable procurement procedures, a comprehensive inventory control system for supplies and spare parts, and sufficient local and foreign currency for the necessarypurchases. Systematic personnel training in these management functions is very important.

Funds for maintenance are usually the first to suffer in budget short-falls, as can be observed from the large number of non-functioning facilities at experiment stations across Africa. Considerable investment has been made in plant and equipment supply, not least by donors, without the concomitant provision for maintenance. As a matter of course, capital investment should be accompanied by an increase in the operational budget corresponding to some 20 percent of this investment. Maintenance requirements can and should be programmed into a multi-year plan, with financial provision as a high-priority budget line item.

Administrative rules and procedures in many African agricultural research institutions have not kept up with increasing complexity and new technological possibilities. Orders, reports, registers, and statistics are handled in a way which might once have been appropriate, but which is now cumbersome. Training in office management has much potential, especially if it can include the use of modern office equipment.

Information Management

Three broad categories of relevant information can be distinguished: (a) scientific and technical information needed by scientists to do their research; (b) information about the institution itself, enabling it to function; and (c) information flow between research and its clients: policymakers, extension services, farmers and others. More efforts should be made in all three areas.

Scientific and Technical Information: Library and Documentation

Improved management of a library and documentation system includes more efforts to obtain specialized literature such as commodity bulletins, more effective document circulation, and any other measures that can enhance staff appreciation of written professional information. Better training oflibrary and documentation staff will be a prerequisite for the performance of these functions. A special problem for most libraries is the lack of foreign exchange to continue subscriptions to scientific journals and up-to-date textbooks. The rapidly increasing cost of maintaining traditional documentation systems points to a need for consideration of systems based on advanced technology.

Internal Information

Databases and computerized information systems are becoming increasingly important in personnel management, program-budgeting, monitoring, and evaluation. The introduction, use, and maintenance of microcomputers require a commitment to keep them operational, and to use them to their fullest potential.

Information Flow between Research and its Clients

Research/Policy. Research/policy linkages permit the research system to provide government with information useful in policy formulation and the design of rural development programs. These linkages can be improved by the participation of senior researchers in development planning committees, and of agricultural planning staff in national committees on research priorities. While policy-making is not within the researchers' domain, development planning can be made more realistic if it benefits from information and data derived from research, and on the economic benefits stemming from it. Many research institutions need to strengthen their socio-economic capacity, to enable them to provide information for pol-

icy-making and at the same time to improve their institution's understanding of farmer conditions, market constraints and opportunities.

Research/Extension. Research/extension linkages are poor in most countries of sub-Saharan Africa. Mutually supportive mechanisms to promote effective two-way communication include:

- creation, at a suitable place in the national agricultural research system, of a central unit for production and dissemination of documentation for use in the extension services;
- collaboration in the preparation of regular radio broadcasts, newspaper and magazine articles, and field days;
- appointment of extension liaison officers in research institutions;
- posting of subject-matter specialists from the extension service to research stations to take part in pre-extension work;
- joint on-farm verification trials and demonstrations;
- joint conduct of farming systems research, and associated training courses, to improve the diagnosis of farmers' problems;
- encouragement of professional growth of extension agents, by providing career grades in the extension system and training to qualify for promotion to higher grades.

Research/Farmer. Direct research/farmer communication is critically important if research is to correctly characterize the socio-economic conditions of farmers and address the right problems. Despite the applied and adaptive nature of most research in sub-Saharan Africa, links with farmers are generally weak. Local and regional research station advisory committees, including farmer representatives, could improve the situation, as could intensified on-farm research.

X. SOME ISSUES FOR DONORS

Improved national research systems and clearly defined agricultural research strategies will provide the framework within which donors will be able to improve the effectiveness and efficiency of their contribu-tions to research. Consequently, donors, in cooperation with national governments, should make every effort to improve such systems and support comprehensive strategies.

Program Support

A critical area for donor attention is the need to move from project to longer-term program support. Such a shift requires joint commitment by national governments and donors to institutional development. Assignment of expatriate staff for longer than the current average three-year period would greatly improve the quality of technical assistance. Harmonization of project accounting procedures with those of the recipient institutions would avoid much duplication and inefficient expenditure of time.

Training

In the area of training, problems will continue as long as African agriculture and science faculties are unable to offer high-quality postgraduate programs. Some faculties have benefited from large investments in the past but now suffer from the same staffing and funding problems as the national research programs. Not only does this prevent them from participating in useful research, it also leads to poorly trained graduates. Donor-supported programs for the selective strengthening of faculties, and of linkages between them, are therefore essential.

Support for Strategic Research

Donors could make a major contribution by sponsoring studies to define priority programs of strategic research needed to backstop African applied and adaptive research programs, assembling the capacity to carry out this work in advanced-country institutions in liaison with developing-country research scientists, and making commitments to long-term funding.

Foreign Exchange

Lack of foreign exchange is likely to remain one of the major bottlenecks in improving national research systems. Generally, the amounts needed arenot particularly large, but most governments in sub-Saharan Africa are unable to give foreign exchange for research the priority it needs. Donors might work together to develop a consortium approach to this problem.

Case Studies

Finally, donor-supported case studies on the economic returns to agricultural research investments in sub-Saharan Africa could further demonstrate the importance of research to attaining national development goals.

XI. CONCLUSIONS

The strengthening of national agricultural research systems requires the full involvement of national policy makers, planners, research leaders, and the donor community. Of utmost importance is the development and support of a feasible research strategy which responds to national development objectives. Regional and international cooperation can greatly enhance research efficiency. For agricultural research to have an impact on growth of the agricultural sector, it will be essential to have concomitant strengthening of agricultural education, extension, and rural infrastructure and services.

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