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The Planning and Management of Agricultural Research

edited by
Dieter Elz

A World Bank
and ISNAR Symposium

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Foreword

Improved agricultural performance is of great importance, particularly among small farmers who make up the bulk of the population in many developing countries. Future growth in agricultural output will depend substantially on improved farming technologies, and sustained efforts will be required to make the improved technologies available on the widest possible basis.

The World Bank is the largest source of external financing for agricultural development and research in developing countries. Since 1974 the Bank has committed more than 25 billion dollars for agriculture. The research and extension portfolio alone is about 1 billion dollars. In addition, the Bank has contributed about 100 million dollars, or more than 10 percent of the total funding for the Consultative Group on International Agricultural Research (CGIAR), and has also provided its secretariat.

Although it is difficult to measure the precise effect of its agricultural lending, evaluations of the Bank's project experience thus far tend to indicate three common outcomes.

- The average economic rate of return for agricultural projects has been around 15 percent, which compares well with achievements in the industrial sector.
- Projects oriented toward meeting the needs of small farms have performed, on average, as well as the projects directed toward the commercially oriented large farms. This has demonstrated that small farms will take advantage of proven new technologies that can increase their economic productivity.
- These investments have had a substantial effect on world food supplies. On average, an annual increment in cereal production of 6 million tons stems directly from past Bank investments; this represents roughly one quarter of incremental consumption in developing countries, excluding China. The indirect effect of the investments for research and extension may be comparable in scale, but is much more difficult to measure.

At the same time, agriculture has encountered significant problems. In addition to the normal climatic and other natural risks that farmers face, in some countries the policy environment has been a strong disincentive to increased agricultural performance. This has been particularly true in sub-Saharan Africa, the only region in the world where per capita food production has fallen during the past decade. In Africa, as elsewhere, when government policies have discriminated against agriculture and small farmers, there have been lower growth rates and greater food insecurity.

Bank experience has shown that problems have arisen from a lack of productive new technologies to introduce. Important breakthroughs in improving plant varieties, such as rice and wheat, have been associated with a sure supply of water provided by irrigation. In areas where rainfall is low or erratic and where soils are marginal, technologies have not improved comparably. These are, unfortunately, the conditions under which most of the world's poorest farm families must live, and it underscores the reasons that the Bank believes greater attention to, and support for, research is essential for the future.

The Bank has also become increasingly concerned that strong links be forged between research and extension. In recent years it has widely supported the introduction of the Training and Visit (T&V) system of extension, particularly in Asia, where improved technologies are available already and where input supply, infrastructure, and marketing do not pose large constraints. The T&V system is essentially a unique approach to management and organization, and its simple principles can be adapted to different conditions. Its appeal rests on recognizing the need to develop more effective extension that reaches farmers through a disciplined program of regular visits, continuous training, and close linkages with research activities.

The Bank's priorities will continue to emphasize agriculture, but the financial resources available—particularly the concessional credits under the International Development Association, which go to the poorest countries—are limited. Human and material resources are even more limited in many of the developing countries themselves. Development progress, including higher agricultural production, will therefore depend on making better use of the existing resources, and this makes the emphasis of this seminar on improved planning and management especially timely.

The World Bank will benefit from the collective experience of the participants, most of whom manage national agricultural research programs. The cosponsor of this seminar, the International Service for National Agricultural Research (ISNAR), is involved in many of the countries where the Bank plans to expand its support of national research and extension services. Success will depend on the Bank's ability to work with the managers of these research systems in putting together sound investment programs, and ISNAR will most likely play an important role in this regard. This is the first seminar on research management given by the Economic Development Institute of the World Bank (EDI). The experience gained will enable the EDI to successfully continue to expand its high-level agricultural seminars in developing countries. The subject matter is most relevant to development, and the need for improved planning and management of research is of particular importance.

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November 1983

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Byron Mook of ISNAR and John Coulter and Price Gittinger of the World Bank assisted in organizing the seminar and developing the program topics. The greatest contribution was, of course, made by the participants. They took an active part in the seminar and some even sent written contributions after they had returned home. During the sessions they were ably led by senior Bank staff, who, in spite of other heavy commitments, gave freely and willingly of their limited time. Participants and seminar chairmen made the seminar the success that it was, and their contributions are gratefully appreciated.

Phyllis Prudent suffered cheerfully the tribulations in typing and arranging many of the manuscripts.

Acronyms

AID	U.S. Agency for International Development
ARC	Agricultural research council
CARDI	Caribbean Agricultural Research Development Institute
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
EDI	Economic Development Institute of the World Bank
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria (Brazilian Agricultural Research Corporation)
IARC	International agricultural research center
IBPGR	International Board for Plant Genetic Resources
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in Dry Areas
IDA	International Development Association of the World Bank
IICA	Interamerican Institute for Cooperation on Agriculture
IITA	International Institute of Tropical Agriculture
IRRI	International Rice Research Institute
ISNAR	International Service for National Agricultural Research
MARDI	Malaysian Agricultural Research and Development Institute
PARC	Pakistan Agricultural Research Council
PPB	Planning-programming-budgeting
T&V	Training and Visit system of extension
UNDP	United Nations Development Programme

PART I

Introduction and Overview

Session 1

Background

Food output in developing countries during the next two decades has to increase between 3.5 and 4.0 percent a year to improve the standard of living of people in the agricultural sector as well as the quality of the diet of the entire population in these countries. In the past few years, however, output has increased by only about 2.9 percent a year. This was enough to maintain the global per capita food supply, except in Africa, but is not enough to advance the economic situation and to improve the diet of the rural and urban population. In the past, agricultural production was increased largely by expanding the area under cultivation. Possibilities of continuing this trend have been nearly exhausted, and future increases in production will have to come almost entirely from increases in productivity. Thus, agriculture has become a science-based industry, and its growth depends on innovations in chemical, biological, and mechanical technologies. This demands a heavy emphasis on agricultural research and, connected with it, on communication between farmer and researcher to determine researchable problems and disseminate research results.

PLANNING AND MANAGING RESEARCH IN DEVELOPING COUNTRIES

Unfortunately, research facilities and programs in developing countries are not well established, and few are yet on a par with those in developed countries. The greatest deficiencies include excessive fragmentation of research activities among governmental agencies, the low priority assigned to research by governments, and inadequate institutional structures for research and extension (World Bank 1981, p. 6). Research staffs in developing countries are often small, do not have a balance of disciplines, and usually lack adequate budgets. In many cases there is no planning or management to direct the scarce resources available toward the most appropriate research priorities.

A first step in strengthening the national research system is for the political and administrative leadership to realize the importance of this system for the economic development of the country. But recognizing the need and granting the funds are not enough. Governments, together with scientists and other agencies, have to take an active role in planning and evaluating the research, although the research community will actually manage the research effort. There has been little analysis of the issues of strategy, planning, organization, and management of agricultural research in developing countries.

> Effective research management is the product of a unique combination of experience, insight, will and personality. I doubt that it could be taught. I would argue, however, that these qualities could be enhanced and refined by drawing on the

accumulated experience of research organization, management, and strategy that has accumulated since agricultural research became institutionalized (Ruttan 1982).

Planning is part of management. One of the first important books on management was written in 1916 by a French engineer, Henri Fayol, who listed five basic functions of management: planning, organization, command, coordination, and control (Fayol 1967). Although many books have since been written on management, and the field has undergone significant changes, these functions still form the basis of management.

A more general definition of management is given by Hulse: "... management comprises the planning, organization, and productive application of available human, financial, and physical resources towards a defined purpose" (Hulse 1977, vol. 2, p. 101). Hulse also points out that few natural scientists become senior managers, partly because of a belief that those who can do research can manage and partly because there is a lack of training in research management. This lack can be explained by the historical development of management studies and the philosophies underlying it. Most studies are based on analyses of industrial management and are oriented toward material gain since the goal of industrial management is greater profit. For research organizations that are not controlled by the profit motive, it is often more difficult to determine the nature, scope, and limits of the management function.

A similar statement applies to research planning. For public entities this process is much more influenced by political pressures, limited public resources, and manpower constraints than it is in industry. Agricultural research in developing countries depends to a large extent on public funding, whereas in developed countries such as the United States, only about one third of this research is funded by the public sector. This implies that the public sector and the forces influencing it exercise strong control over the direction of agricultural research in the Third World. Research planning not only has to fit the overall objectives of the national and sectoral plans but also has to fit available resources, such as manpower and facilities, into the national plan. This is no easy task and requires the research manager to be a politician, scientist, and manager simultaneously. Systematic organization of planning is necessary, and the supply of knowledge to it strengthens the manager's judgment, leadership, and vision.

Planning is a continuous process of making managerial decisions systematically, organizing systematically the efforts needed to carry out these decisions, and measuring the results of these decisions against the expectations through organized, systematic feedback. The first step in planning is to ask, "If we were not committed to this today, would we go into it?" If the answer is no, the question is: "How can we get out—fast?" (Drucker 1974).

Thus, the management and planning of agricultural research are closely linked at the operational level, but they also reinforce each other at the policy level. The planners of this seminar recognized that discussion of some of the important aspects of research planning and management would help to improve the process.

THE SEMINAR

In September 1982 the Economic Development Institute (EDI) of the World Bank and the International Service for National Agricultural Research (ISNAR) sponsored a colloquium in The Hague on training needs in national research planning and manage-

ment. It was determined that training should be specialized for each level of staff in the research hierarchy: new entrants; project leaders; directors of research institutes; and directors general of research, who are responsible for their countries' agricultural research. EDI was asked to hold at least one seminar for directors general. This first seminar was conducted from October 31 to November 10, 1983, to provide a forum for exchanging experiences and discussing approaches to, and policies on, selected issues in the planning and management of agricultural research.

The Program

Before the seminar, the participants spent three days learning about the work of the Consultative Group on International Agricultural Research (CGIAR), which was meeting during the first part of the seminar.

The first day of the seminar was devoted to a description and discussion of the Bank's and ISNAR's involvement in agricultural research. The seminar itself focused on four main subjects broken down into two subtopics each. The topics chosen were considered the most important which could be discussed within a ten-day time limit.

- Setting Priorities for Research
  - Research Allocation
  - Applied or Basic Research?
- Research Structure and Organization
  - The Links between Research and Extension
  - Agricultural Research Councils
- Finance and Evaluation
  - Financial Management of Research Programs
  - The Evaluation of Research Programs
- Managing Human Resources
  - Manpower and Financial Constraints
  - Staff Retention, Motivation, and Training

In this seminar, the major emphasis was on discussion. Main speakers and two respondents were selected to open each session. Although not specifically required, most of the main speakers prepared a paper on their presentation for this volume. High-level Bank and ISNAR staff helped to conduct the seminar by chairing the individual sessions.

The Participants

Twenty-two participants from twenty-one developing countries and four international institutions plus one observer attended the seminar. Except for three professors who are active in research management training, the participants are leaders in their countries' agricultural research. These senior-level managers are responsible for strategic decisions and target-setting and are usually concerned with the processes of setting goals and monitoring task performance rather than with the actual implementation of tasks in the field. For this reason the seminar concentrated on topics concerned with decisionmaking rather than with teaching the methodology of planning and management.

There was a wide variety in the research experience and problems of the participants. While this would have suggested regional groupings for seminars, the diversity of backgrounds proved a great stimulant for discussion and learning and outweighed the commonality of experience that would have been obtained in regionalized discussions.

Main Findings

Some of the main findings of the seminar have policy implications, and others suggest gaps in knowledge and indicate the need for future work and analysis.

For "Setting Priorities for Research" and "Resource Allocation," there does not seem to exist a methodology that would help research decisionmakers to set objectives and monitor the implementation of these objectives. This need was widely felt by participants, and a quick review of the literature did not reveal guidelines on how to solve that problem. Since the issues are very closely related to the specific circumstances in each country, it would probably not be possible to provide a methodology applicable to all environments. However, agricultural faculties, international research institutions, or even organizations such as the World Bank, which are involved in agricultural research, should use their experience to provide a methodological framework for establishing research objectives in developing countries. Although setting priorities or objectives is very much influenced by local conditions, including political influences and pressures, a useful training exercise would be to prepare a case study that would consider these issues and serve as a background for evaluating the problem.

A lively debate developed during the discussion of "Applied or Basic Research." Obviously there is a problem of definition, and again the literature is quite vague on this topic. But the problem goes beyond finding definitions. It very much requires an analysis outlining the prerequisites for doing applied or basic research and its implications for staff and financial requirements and training. There was a general, but by no means unanimous, agreement that developing countries should concentrate on applied research. Many suggested that basic research should be left to international research institutions. But what effect does such a choice have on the intellectual research capacity of a country? Some answers are provided, but the evidence is not conclusive.

Discussion on " The Links between Research and Extension" divided the examination of this field into two approaches: the dissemination of research findings and the discovery and transmittal of farmers' problems to the research institution for research. There was little argument that one of the primary tasks of the extension service is to disseminate research findings, with research personnel playing a secondary role, if any, in this process. Opinions clashed on the role of the extension service in communicating to the research establishment problems for study. Most of the participants had strong convictions that the detection or communication of researchable problems at the farm level should be the task of research personnel. Although there have been several conferences on the extension service and related topics, the issue of communication between farmer and researcher has not been fully covered—or, shall we say, publicized. The high-level research decisionmakers at this seminar, at least, were not aware of it. This may be a worthwhile and rewarding topic for future extension seminars.

Not many of the participants believed that extension personnel should concentrate only on technical subject matter, as, for example, the training and visit method. The participants concluded that administrative services, such as credit evaluation, were also the task of the extension service; extension personnel, its leaders, and organiza-

tions involved in research would probably not agree with this opinion. Thus, there is no consensus among researchers about the duties and objectives of extension services. Future seminars on extension should consider this in selecting topics and participants.

The discussion on "Agricultural Research Councils" moved along without great controversies, partly, no doubt, because many participants had limited or no experience with this form of research organization. There was a consensus that agricultural research councils have the potential to improve coordination and to act as a forum for discussion among the agencies and organizations involved in formulating and executing research. At the same time, it was pointed out that the coordination of research efforts was very much influenced by political and other pressure groups, which may invalidate the good offices of research councils. This topic is very country-specific, and it is doubtful that new councils will be established in countries that do not already have them. Future research seminars should probably consider this topic on an "information only" basis.

During discussions on "Financial Management of Research Programs" the lack of funds was, of course, a recurring theme. Related to this is the problem of tightness of funds, which allows little flexibility and freedom. The issue that caused most concern was the timing of funding, particularly the requirement in most countries to use funds within a specific time. This causes special problems in agricultural research, which is a long-term activity with many unforeseen risks cropping up along the way. One of the risks is the practice of governments of cutting funds even after they have been allocated. The shortage of funds also presents serious constraints on hiring staff and on the conditions under which they are employed. In the end, that affects the quality and volume of the research effort.

"The Evaluation of Research Programs" was another topic for which the lack of an appropriate methodology was strongly felt. Although everybody agreed on the importance of evaluating research, there are few experienced staff to do it. In the design of evaluation procedures and the selection of staff there are serious shortcomings. Obviously this is an area where institutions such as the World Bank would find a fertile field for training activities.

In the session "Manpower and Financial Constraints" the effects of the lack of funds and interruptions in allocation were the main topics. For some institutions 60 to 90 percent of the total budget is spent on salaries. This severely restricts the ability to maintain and improve research facilities, and has detrimental consequences for planning research, particularly long-term research. The shortage of funds also impedes the ability of research directors to pay remunerative salaries. As a result, well-qualified staff are unwilling to join the research service, particularly if higher salaries are offered in private industry. The low salary structure together with conditions of employment make it difficult to entice scientists studying or working abroad back into the research service of their home countries.

Difficulties in prefinancing project expenditures and sudden cuts in fund allocation severely interrupt operations in many research stations. The Bank recognizes this problem and is consequently financing recurrent costs during the development period and, in a special program, will provide a large proportion of financing in the initial phases of research projects, which tapers as the project nears completion.

The discussion on "Staff Retention, Motivation, and Training" concentrated on staff planning, qualifications, and difficulties in staff retention. The advantages of training abroad are well recognized, but this method of education is not without pitfalls.

Graduate study to the doctorate level, for example, should not become an end in itself, since many tasks in the home country can be carried out by masters-level students, whose experience outweighs the level of their degree. Many participants believed that the content of training at overseas universities does not meet the requirements students face in research institutions in their home countries. The lesson to be drawn is that overseas education requires careful assessment and evaluation to avoid misuse of resources. Most agreed, however, that there was comparatively little enthusiasm among prospective graduate students for study at local universities. It was not clear if this was because of the paucity of the training programs at home or the attraction of the shining lights abroad, but in the evaluation of each case this issue should be examined. It is no secret that study abroad reinforces the already existing desire of many research workers to find a more lucrative and, many feel, more satisfying job abroad. Appeal to patriotic duty sometimes helps to reverse that inclination.

ORGANIZATION OF THE VOLUME

This symposium volume is designed for the person who reads from cover to cover as well as for the one who reads bits and pieces. Each part stands on its own but is linked to the others. The volume is divided into five parts, following the organization of the seminar. Each part begins with an introduction to the subject and contains two sessions. Each session contains an introduction, the main paper presented by a participant, a detailed account of the individual comments, and a brief summary of the comments. It was considered worthwhile to include such detailed commentary since it allows the reader to relate the opinion of a particular country representative to a particular topic. The comments are not presented exactly as they were made during the seminar. The transcripts have been edited to eliminate redundant comments and to emphasize the important ideas and themes that emerged from the discussions.

Session 2

Opening Remarks

THE WORLD BANK AND AGRICULTURAL RESEARCH

John K. Coulter, The World Bank

The Bank's investment in, and support for, agricultural research is relatively new. There was a strongly held belief in the 1950s and 1960s among many agencies involved in agricultural development that the technology for improving agriculture was already available and that the most important need was to provide the investment that would bring these technologies into production. This was only partly true. For crops such as sugarcane, rubber, and oil palm, there had already been very large increases in yield from applying new technology. Some of these increases were quite spectacular. In rubber the yield of seedling stock was about 300 kilograms per hectare in the 1920s. As a result of the research started at that time, many estates using the improved clones and other management inputs were averaging 1,500 kilograms per hectare in the 1960s. There were also examples where research had saved an agricultural industry from disaster; the research on disease resistance in cotton in the Sudan is an example. Even in food crops there had been some improvements, but the advent of the short-strawed, nitrogen-responsive varieties of wheat and rice in the 1960s was the greatest innovation in food crop production. Given the right inputs of fertilizers and irrigation, these varieties began to have a great effect on yield.

A more recent happening that has increased the Bank's resolve to strengthen research is the evidence from a wide range of agricultural development projects which shows that the lack of improved technology can nullify the effect of agricultural investment. At the CGIAR conference, the director of the International Food Policy Research Institute has drawn attention to the significant role that improved technology can play in improving production. The experience of the World Bank supports this view. The Bank has been investing heavily in extension systems and, in the implementation of these systems, the lack of improved technology has often been pinpointed as a significant constraint to improving agricultural production.

Bank Investment

All of this is by way of saying that the World Bank is a latecomer to the scene of investing in agricultural research. Our first national research project was started in 1970 in Spain. Indeed, this is the only national research project for which there is a project completion report and consequently the only one for which there is an ex-post assessment of performance. A few others are almost or just completed: the MARDI (Malaysian Agricultural Research and Development Institute) project in Malaysia, the first research project in Brazil, and the first research project in Indonesia. Other projects are described in the Bank's policy paper on agricultural research (World Bank 1981).

In the three years up to June 1983, the Bank has been involved in agricultural research in four areas:

- National research projects
- Research components in agriculture and rural development projects
- Education projects with an agricultural element
- Grants to the international agricultural research centers (IARCs) through the CGIAR system.

National research projects. During 1981 to 1983 the Bank financed eight national research projects in Thailand, Brazil, Nepal (emphasizing extension), Pakistan, Senegal, Yemen Arab Republic, Peru, and Colombia. Several of the participants in this seminar worked on these projects and indeed did much of the work in getting them started. The total Bank loans and IDA credits for these comes to about 261 million dollars and the total project costs to about 730 million dollars. All the projects focus on goal-oriented, multidisciplinary commodity programs, and research-extension linkages, training and technical assistance, and institution building are important elements in all of them. At least one of the IARCs collaborates with each project.

Research components in agriculture and rural development projects. During 1981 to 1983 there were some ninety-four agriculture and rural development projects with research components—about 40 percent of all such projects. They are found throughout all the agricultural subsectors. The largest number are in rural development projects, but they are found in forestry, livestock, and even credit projects. The only subsector missing is fisheries. Research components are found in all regions and in forty-eight countries. Typically they are very small, with 40 percent amounting to less than 1 million dollars and 95 to less than 10 million dollars. Most research components finance both institution building and individual research programs. Some finance technical assistance, and a few finance training. Most focus on adaptive and applied research.

Agricultural components in education projects. One agricultural component of an education project—that in China—is very much larger than any of the others. It is an effort to set up a national rice research institution modeled to a large extent on the International Rice Research Institute (IRRI). The other five are in Niger, Egypt, Ethiopia, Syria, and Kenya, with the last aimed at upgrading graduate and postgraduate education in agriculture.

Grants to IARCs. In FY81 support to the IARCs amounted to 14.6 million dollars, in FY82 to 16.3 million dollars, and in FY83 to 19.0 million dollars. Since all of the participants have had contact with them and indeed several are on their boards, I will not discuss these any further.

What the Bank Has Learned

Since most of the Bank's investment in the agricultural research subsector is relatively new, there is still a lot to learn. There are, however, a few areas that need special thought and attention.

Financial resources. The problem that must be foremost in nearly every research manager's mind is that of financial resources. However, it is not only agricultural research in the developing world which has this problem. Very few research institutions, at least in the public sector, had to make budget cuts in the past, and they are finding it a very painful and very difficult exercise, especially as the easiest way—not filling vacancies--distorts the distribution of staff skills. For a variety of reasons, all of which are familiar, money is very scarce in nearly every research program. It can be shown that successful research has a very high payoff, but nevertheless it is always extremely difficult to persuade the political paymasters that it is a better investment than some highly visible and politically attractive alternative.

The problem that concerns the Bank, as an investment agency, is the ability, and also of course the political willingness, of a country to carry the operational costs once Bank project funds cease. It is relatively easy to invest in bricks and mortar for new experimental stations, in laboratory equipment and vehicles, and in training people, but these can add up to a formidable financial burden when the project training period is over and the government must take over full responsibility for funding. Adding to the difficulty is the fact that the payoff for research comes usually well after a project is completed and investment funds are disbursed--perhaps even ten or fifteen years after. There are no easy answers to these dilemmas, as they are a function of the nature of research. The sight of broken-down equipment or unused experimental stations is unlikely to persuade any politician to support investment in research. The situation also suggests that we should look beyond governments to the agricultural industry itself for help to carry the burden.

Relevance. The relevance of research to farmers' needs is a somewhat vague, all-embracing concern, which can have many different meanings. Researchers themselves seldom decide that research is irrelevant; after all it has relevance to something, if only to the promotion prospects of the researchers. Relevance is a concern often expressed by development agencies and sometimes by politicians and extension workers. It represents a new point that has led to many proposals for change—for the development of farming systems research, for greater emphasis on on-farm research, and for the use of economists and sociologists in agricultural research.

What it really amounts to is the problem of deciding on priorities, and this is where many of the difficulties arise, for research managers have many pressures and are pulled in many directions when deciding on priorities: their research workers want to do things that interest them and naturally wish to further their careers, politicians want them to solve the problems of their particular areas, urban dwellers want cheaper food, and the minister of finance wants more export crops or wants new crops to open up a new market or to substitute for imports such as bread wheat. The list of pressures is endless, including those from the World Bank and the International Monetary Fund. Thus, there is not a unique answer to the concern that research be relevant. Rather there are several interests and priorities, and research must focus on, and be relevant to, these and also must focus on those problems which can be solved through research.

Rainfed agriculture. There is increasing discussion about the problem of rainfed agriculture, particularly the improvement of rainfed annual crops. This is a very difficult problem, and, although it is being highlighted in Africa, let us not forget that

something like 75 percent of the agricultural area in India is rainfed and that by and large many of the poorest farmers in the world are in agricultural zones that depend on rain.

In irrigated agriculture the research problems are generally not so difficult, the probability of a successful solution is therefore higher, and, when the solution is applied in the farmer's field, the effect on production is likely to be higher. In rainfed agriculture, however, where agriculture is more susceptible to variations in climate, the problems are more difficult, so the probability of a successful solution is less—and even then the application of successful solutions is likely to have a smaller effect

In the developing world, much of the increase in production for rainfed agriculture has come from the cultivation of additional land. Likewise, in the United States, the vast exports of grain in the late nineteenth and early twentieth centuries came from land expansion. Land is becoming scarcer, however, and by the end of this century many countries will have largely exhausted the supply of new land for cultivation. The problems in rainfed agriculture are crucial, and they will require ingenuity and long hard work for research to devise useful solutions.

Trained staff. After money, shortage of trained staff is perhaps one of the most common problems in research systems. This is related to the relevance of research and priorities in that while there are obviously absolute shortages, there are also relative shortages—shortages brought about by asking research systems to tackle too many things at once. Everyone strongly supports the idea of more and better training, but there is nonetheless a great deal of room for thought on how best to utilize trained staff. One problem is that research managers often have little flexibility in how they employ staff. They may have a trained plant pathologist when in reality their first need is for a trained soil scientist—or vice versa. In addition, there are usually too few support staff. Development and utilization of staff are indeed very important topics. There may be a few widely applicable principles which over time can be explored.

Links between research and extension. From what one reads and sees, there appears to be a wide gap between research and extension, as well as a strong sibling rivalry. On the one hand, to listen to extension services, the research sister is the beautiful but spoiled member of the family—beautiful because so many gifts in the way of better salaries and better living conditions are heaped upon her and spoiled because she goes her own way without regard to family obligations. On the other hand, researchers regard extension agents as too obtuse or too perverse or even too idle to take advantage of their bright ideas. This is an exaggeration, of course, stated to make a point and to raise a question of why research and extension staff do not talk to each other more freely. If they cannot communicate informally, how will they do so when they are obliged to work together in more formal arrangements?

Concluding Remarks

This brief survey is neither comprehensive nor deep, but indicates some current issues of concern within the Bank. At the end of the day, however, it is quality above all else that counts in research. To illustrate through an analogy: one may travel along a poorly built road and yet reach one's destination, albeit at great cost in time and personal discomfort. In research, however, poor quality is worse than useless; it may be misleading and may cause the farmer to do things that lose money and, perhaps worse,

daily needs. Thus, despite all the problems outlined above, we must find the ways and means of performing high-quality research: research that is directed at priority problems, research that will have an effect when it is applied, and research that the country concerned can sustain financially.

ISNAR AND AGRICULTURAL RESEARCH

William K. Gamble
International Service for National Agricultural Research (ISNAR)

This meeting provides an opportunity for the leaders and representatives of national agricultural programs to discuss issues of general concern and to seek ways to work more effectively for a more productive and efficient agriculture. It also provides an opportunity for ISNAR to determine whether and how it should work—on an individual country basis or on a regional basis.

The Organization and Role of ISNAR

ISNAR began operating at its headquarters in The Hague, the Netherlands, on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of a recommendation from an international task force, to help governments of developing countries strengthen their agricultural research. It is a nonprofit, autonomous agency, international in character, and nonpolitical in management, staffing, and operations. Most of its funds are provided by an informal group of approximately thirty donors: countries, development banks, international organizations, and foundations that make up the CGIAR. ISNAR is the youngest of the thirteen centers in the CGIAR network.

ISNAR is the only center that focuses primarily on national agricultural research issues and works with governments upon request on organization, planning, manpower development, staff requirements, financial management, infrastructure requirements, and related matters, thus complementing the activities of other assistance agencies. ISNAR does not just diagnose the problem or constraints of a particular system. Its true role is to work closely with leaders of the national systems to diagnose the systems and then, together with the national leaders, to identify solutions that are feasible considering the resources of that particular country. Once recommendations are made and accepted by the leaders and decisionmakers of the country, ISNAR helps to implement them. Diagnosis is only the first phase of what is expected to be a continuing relation.

ISNAR's activities can be grouped in separate, but complementary, areas. Members of the interdisciplinary staff work as a team, and all senior officers participate to some extent in all the areas. Programs in each area help sharpen and extend the growing base of knowledge about national agricultural research, and all activities feed back to that base, thereby improving the total capability of ISNAR to help strengthen national agricultural research systems.

There are four main areas of activity at ISNAR:

- Review, diagnosis, planning, and continuous cooperation with national agricultural research systems in developing countries
- Research on organization and management and on the performance of agricultural research systems
- Training and conferences
- Communication and information.

Work with national agricultural research systems. ISNAR's work with national programs often concerns the development of research programs, research organization, management, and staff development, all of which require several years to develop and reach measurable results. Thus, it is too early for any visible effect attributable to ISNAR programs. Steps in the longer chain of events require close and continuous working relations with national systems. To date ISNAR has established working relations with approximately twenty national programs in Africa, Asia, the Pacific, and Latin America.

Research. Research within ISNAR has two primary functions: to obtain a solid information base for its own use in advising national agricultural research programs and to develop an information base that national research programs can use as a guide for themselves based upon the experience of others. To carry out these functions, the research section is guided by five generalized objectives:

- To test methodologies that measure the output and effect of the research system and determine its productivity
- To describe forms of organization or structure that are well adapted to differing circumstances for national programs
- To describe resource management practices and procedures used in successful systems
- To describe productive linkages among elements within national programs and among national and international institutions
- To conduct periodic inventories and assessments of financial and human resources used in selected national systems.

Training and conferences. The training and conference activities within ISNAR are carried out in three main areas: management training to assist national agricultural research systems developing the management skills of their personnel; manpower planning to help determine manpower needs for efficient program operation; and conferences. Its strategy and program are complementary to, and dependent on, the other three principal ISNAR program areas—review, communications, and research.

Management training includes analysis of management training needs for national research systems and support for courses that address those needs. Six subjects have been selected for special attention: program planning, budgeting and finance, personnel administration, information systems, program evaluation, and station management. These subjects are reflected in this program. ISNAR collaborates with institutions in organizing and presenting courses on research management training and gives con-

siderable emphasis to preparing materials and developing curriculum. It also carries out this work independently.

In manpower planning ISNAR works with national leaders on recruitment and career planning within agricultural research systems and on analyses of conditions of service for agricultural research staff.

ISNAR organizes and supports conferences either on its own or jointly with other organizations, both to bring together research leaders to discuss common problems and to encourage these leaders to develop common responses to shared challenges.

Communication and information. The staff engaged in communication and information at ISNAR work with other ISNAR staff to develop communications materials for ISNAR and to work with national agricultural research systems on information management.

ISNAR is a relatively small organization by most international standards and is expected to remain relatively small for the next several years. In the face of virtually limitless needs for strengthening national agricultural research systems, ISNAR recognizes that it cannot work with all countries nor respond immediately to all requests. Systems building is a complex and often delicate process, which must take into account factors such as economic, social, cultural, and ecological issues as well as human and financial resources. To best serve national programs, ISNAR's professional staff of about twenty to twenty-five people, plus some consultants, is first trying to build up its understanding of the problems and its institutional memory before expanding the size of its staff and the scale of its activities.

The Role of Agricultural Research in Development

Agricultural research is an integral part of the process of agricultural development and should not be looked upon as a separate entity to be carried out at isolated research stations. It must be an active part of the development process. It must be concerned both with the problems and the constraints that are vital to the livelihood of the farmers who produce agricultural products and with the use of the agricultural product and the inputs used to produce it.

Agricultural research is not confined to planning and executing research and communicating research results alone. It links back into the national planning and forward to serve the farmers.

It has been well demonstrated in many places that where the role of agricultural research is duly appreciated, and where the programs of research are organized and managed with a focus on national objectives and farmers' requirements for improved technologies, agricultural research can contribute very effectively to the development process.

Before looking in greater depth at agricultural research, one must determine whether a nation really wants to develop its agriculture. In a great many developing countries agriculture is the most important sector, and it is essential to make it productive. Agriculture does not stand alone, however, but must be viewed as one sector within the total economy, and the overall agricultural policy must be determined within national policy goals.

A clearly defined agricultural policy with a firm commitment to science-based growth is an essential prerequisite for defining a national agricultural research program. Such a policy will assign clearcut responsibilities to research and will help to determine research priorities. Unfortunately the policy framework for agriculture in many coun-

tries is neither stated nor developed to the point required as a reference for agricultural research. At an even more basic level, the commitment to overall agricultural development is crucial. It is not sufficient, as is now the case in many countries, for political leaders to state that "agriculture is the priority of priorities." What is required is a policy that incorporates tangible support for the agricultural sector.

The goals that many nations find desirable for their national agricultural research system can be described as three broad objectives:

- To make available to governments, in an appropriately interpreted form, the information needed to form reliable agricultural development policies and plans
- To make available to farmers, in appropriately interpreted form and through appropriate channels, the detailed agricultural production information (including economic and social implications), based soundly on adaptive research at the farmer's level, needed to plan and implement the production of crops and livestock
- To develop and maintain a group of well-trained, competent scientists in appropriate disciplines in research, in problem resolution, and in interpretation of national and international scientific advances for the benefit of national development.

A close examination of these can help to clarify the role of research.

Responsibility to the government. Governments are interested in development and in visible results. It is essential for a government to assure its constitutency that its money is being well spent. Agricultural researchers must develop the information base for agricultural development plans and not come onto the scene late in the process and be asked to implement research after projects have been formulated and committed—then discover that expensive plans are unrealistic and that the set goals cannot be achieved. There are many examples in which considerable losses on projects or project failures could have been avoided if appropriate research had been conducted before the project had been finalized.

Related to this issue is the question of who benefits from agricultural research. A great deal has been written about the benefits of research to the farmers, and in recent years several studies in various countries have estimated returns on investment for certain types of research from 20 to 90 percent a year. But not only farmers benefit from productive research; the consumers benefit as well through lower food costs, better nutrition, a more reliable food supply, and satisfaction in national accomplishment.

Government planners are under pressure from various sources to set targets to achieve certain national goals. However, they also are under pressure to produce plans and targets that are realistic and well documented. It is essential that agricultural research provide government with appropriate, reliable, interpreted, and well-documented information on the present agricultural situation, its potential, the time frame needed to achieve the potential, and the human and financial resources required (and available within the country) to achieve the potential. The government must have the best information possible on opportunities for successful development and on the potential dangers and limitations in technical details of any proposed plans. This information may be based on direct experimental work, on the implica-

tions of survey data on the natural resources of the country or market potentials, or, more frequently, on the sound professional interpretation of world knowledge of agricultural science in relation to the needs of national development. The agricultural research service should be the best source of such information and should be linked with developing planning and the agricultural policymaking, with a significant voice in the process. By the same token, it should be held answerable for its advice.

Responsibility to the farmers. The second goal of agricultural research concerns its responsibility to the farmers. The adoption of improved technology by farmers is one of the most important products of agricultural research. For this to occur, the farmers and the conditions under which they operate must be the key variables for any research effort. Translated into operational practice, this means that more time and effort need to be spent in understanding, interpreting, and documenting farmers' circumstances and in actually conducting research in farmers' fields than has been the case in most countries. This requires the active involvement in research programs by all three parties concerned: the researcher, the farmer, and the extension worker.

I have first emphasized research that solves problems and produces improved technology for immediate use by farmers. This role is important in all countries but is of greatest importance in developing countries with scarce resources of both expertise and finances. An enormous amount of research has been carried out or is being carried out throughout the world. The developing countries need access to this research and its interpretation, and they need the ability to test and adapt it to local conditions. Often for failure to spend a few dollars on international journals or on travel funds for scientists to participate in international meetings, a nation loses access to relevant research findings that could accelerate its development and agricultural growth and save both time and money. Whenever the number of research scientists in a country is small compared with its needs or where finances are a serious constraint, it is a very unwise saving to reduce access to the international scientific community.

Agricultural research in a country with limited resources—and this applies to almost every country—must make difficult choices. Even if a research organization concentrates to a large extent on applied research and on solving actual problems at the farm level, it cannot cover every crop and every problem. There must be a system to determine which are the critical problems for immediate attention and which ones can wait and then to allocate staff resources accordingly. This process is further complicated (or perhaps the decision is made easier) by the availability of staff trained in particular disciplines. When there is a shortage of staff or gaps of certain disciplines, one must look to short-run solutions. The first place to look is within the country in other government departments, in educational institutions, or in the private sector for the particular expertise needed to carry out a specific research project. If the required skills cannot be found within the country, then the research organization must seek support from an international agency.

There needs to be a balance between short-term and long-term research in developing countries, but the balance should be in favor of the short-term research. Even so, it is essential that some long-range research be carried out to meet future needs. Such research requires the same careful planning as does short-term research, but it is often difficult to gain the administrative and financial support for long-range work. The issue

is further complicated when staff are in short supply. In these situations they are under constant pressure to do short-term research and often do not have the time to obtain the information needed to plan ahead and determine future problems and needs. To define long-range agricultural research needs, a qualified research unit (and not a single scientist) must conduct a detailed study of potential economic and technological development in the national and international fields for at least a few years ahead. When a nation does not have the necessary expertise to do this kind of a study, it should seek outside assistance. However, it is not something to be left completely to consultants or advisers. Their expertise must be sought, but the national research organization must be a full partner in the study and fully understand the problem and the implications of undertaking the research.

The second goal of agricultural research includes identification of research problems, the importance of applied research in adapting technology introduced from the international community to local conditions, and short- and long-term research. The goal—or the role of agricultural research—goes much further. Although the stated goal is very short, it is full of meaning. It demands that agricultural (crop and livestock) research take into account the economic implications to the farmers and their families. In many cases the social implications need to be considered as well. This means that the market for the product must also be considered, so market research must be a part of the research package.

It further demands that the adaptive research be carried out at the farmers' level. Research does not stop at the gate of the research station. The research station represents only one situation, and recommendations to farmers can only be made on the basis of research conducted or verified under local conditions. This is still a part of the role of research, for it is at the farm level that the real interface between the farmer, the extension worker, and the research team occurs. The correct balance between on-site research (on a research station) and off-site research (mainly in farmers' fields) will vary from situation to situation but probably should average between 25:75 and 50:50. If research is verified in this manner and there is a real interaction between research and extension, then the research is easily interpreted, and the extension workers can concentrate on a wider adaptation of the improved technology. Some research staff and some extension workers feel that research should only pass its results to extension. The implication of a one-way process, however, should be dropped. The development and transfer of technology must be an interactive and continuous process with continual dialogue between the research team, the extension team, and the farmers.

Responsibility to the organization. The third goal of agricultural research concerns its responsibility to the research organization itself. It not only refers to assuring a continuing supply of well-trained staff to develop and maintain an effective research organization, but it also implies how research is organized and conducted.

The research organization in any country must develop a staff of appropriate size and ensure that training and positions match changing needs. All too often in developing countries there is inadequate planning for, and insufficient training of, staff to meet the needs.

These three main goals of an agricultural research system define the role of a national agricultural research system. Regardless of structure or organization, successful systems are able to respond to needs and to identify, resolve, and interpret findings

in terms of problems of the client groups. They also have the institutional flexibility to adapt to changing conditions. In the successful systems, the researchers have usually been involved in identifying the farmers' problems and in delivering and introducing the research product, either directly or in close liaison with the agency responsible for this delivery.

PART II

Setting Priorities for Research

The issue of setting priorities in agricultural research cannot be analyzed without looking at the development of science. The organizational framework of research, its goals, scientists' conceptions of their work, and even the funding process are closely related to this historical development.

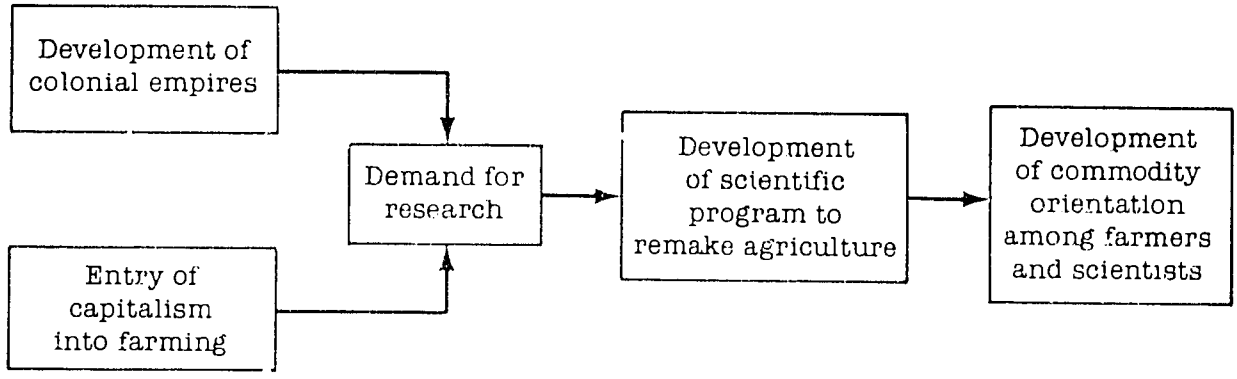
Agricultural science developed worldwide as a part of the development of colonial empires and of the shift in perspective and lifestyle from subsistence to capitalist farming, in which the purpose of the crop—cash rather than subsistence—determined orientation of the research (Bush and Lacy 1983, p. 34). For example, much research was done on smallholder cash crops, such as cotton and coffee. Figure 1 illustrates this process. The movement depended fundamentally on the concern of the farm or plantation owners to control pests and diseases and to increase productivity. Local farmers, particularly smallholders, had little, if any, influence on this process.

Since then, the goals of agricultural research have broadened. Productivity improvement still plays the most important role, but other considerations, such as social science issues and management problems as expressed in farming systems research, have widened the field of research. The specific needs of developing countries have also gained more prominence and have influenced the setting of goals that emphasize research on crops for food rather than for export. Although the need to establish research objectives is recognized, little systematic work has been done to explore this process.

In the first place, it is not clear who should formulate the research objectives. Should it be the administrators of public institutions, including the government and elected legislative bodies, or the scientists conducting the research, or the clients of agricultural research through their agents, the extension service? No matter who the final decisionmaker is, the process will not be perfect. Since agricultural research must be carried out within the framework of a country's economic, social, and technical priorities, the public administrator may better understand these and be able to decide on agricultural priorities accordingly. Administrators are susceptible to pressure from interest groups, however, which may distort the judgment of the institutional decisionmaker. If scientists have a significant role in deciding on research priorities, their choices are also not likely to be entirely unbiased. They are motivated by their training, supervisors, and, to a certain extent, the prestige that is determined by journal articles. The way in which farmers or the extension services can influence the determination of research priorities is controversial and by no means resolved. It appears, however, that

Note: W. David Hopper chaired the two sessions in Part II.

Figure 1. The Worldwide Development of the Agricultural Sciences



usually these two groups play a lesser role in determining priorities than do the scientists.

Agricultural research priorities are closely determined by a country's social, economic, and political circumstances. These not only depend on agriculture, but also involve the development of the economy in general. For example, in many countries the dynamics of rural and urban development put great stress on improving the supply of food to feed the growing urban population and to generate higher income for the agricultural sector to increase agricultural output even further. Obviously, in such a case, food production and distribution would play a significant role in setting research goals, a development that is recognized and treated by the international research services, particularly the Consultative Group for International Agricultural Research (CGIAR), which is almost entirely involved in research on food production.

If the rural sector, especially the rural poor, is the main focus of the research, nutritional aspects and social returns would be the most important considerations in setting priorities. More economic topics are involved if problems of farm productivity are concerned, which puts emphasis on farm systems research. Having set these overall objectives, the policies to achieve these goals, such as introducing high-yielding varieties and encouraging better use of fertilizer, have to be established to achieve the broader aims.

Political factors come into play if research is directed toward specific groups of the population or if priorities set by individual states have to be considered. The latter is particularly relevant if, for example, the importance of commodities in the agricultural production pattern varies from state to state. Generally speaking, in developing countries regional research priorities are often closely related to land settlement and land tenure.

Although it may be comparatively easy to set research objectives in theory, practical impediments, such as funding, costs in relation to benefits, and readiness or timing, often pose severe problems. For example, in India organized agricultural research existed before independence, but few resources were devoted to developing high-yielding varieties to help ease the ever-growing food shortages because scientists did not consider the time ripe for such research. High-yielding varieties require fertilizer, pesticide, and other inputs, but these were not available, and without fertilizer and control of water the benefits of research could not have been realized.

Of course, the best objectives are of no use if the funding is not available. This is a question of resource allocation, which will be treated in the following session. Since funding for agricultural research is provided in increasing amounts from bilateral or multilateral sources, these donors can influence the setting of research priorities. But their perceptions may not always coincide with what a country really needs for agricultural development. To avoid conflicting goals, bi- and multilateral contributors would have to analyze and allocate their contributions within the framework of a country's development plan.

National governments face directly the difficult choice of determining who will benefit from the results of research. Ideally, of course, everyone does, but there are several, sometimes conflicting, demands. Farmers want higher net incomes and greater security. Cash farmers particularly want to receive higher prices for their products and to pay lower prices for their inputs. Subsistence and tenant farmers also want higher incomes, but at no greater risk, while maintaining food security and the continued tenancy on the land they work, or the chance to own land may be paramount. Urban consumers want reliable and inexpensive supplies of food. National leaders want crops for import substitution and to export to help the balance of trade. They also want to reduce rural and urban poverty and their accompanying unrest. They may place a high priority on national food self-sufficiency or on diversifying their export crops to the national economy from markets where changes in demand can profoundly affect prices. Still, they acknowledge the need to produce products for which they have a comparative advantage. Only some of these issues directly affect agricultural research priorities, but most of them at least indirectly affect the amount and timing of resources available and the decisions of which crops or livestock activities are to be emphasized.

Session 3

Resource Allocation

The allocation of resources and the justification for starting and continuing programs is very much the domain of those who manage the research. Rarely, however, does a research institution have access to all the resources it needs, particularly in developing countries. Decisions must be guided by what the institutions can and must do themselves and what they can borrow or adapt from elsewhere. A research policy that seeks to do everything is unlikely to succeed in doing anything. But how can research be planned, and who should have the authority to do so? Research policy, planning, and resource allocation are not simple technical exercises that can be left in the hands of research scientists and managers. Judgments about the priority of public sector support for agricultural research in relation to other demands for public resources must evolve out of an intricate bargaining process between national legislative bodies, executive agencies, and the research community. The political dialogue leading to resource allocation should consider the costs and benefits of the decisions. Although these processes have been relatively well developed in some industrial countries, this is not the case in most developing countries, mainly because of limitations of data. In these countries only rarely is there a methodology to evaluate decisions on resource allocations that are based on limited data. The framework for negotiating and facilitating the allocation process is also usually not established, and many of the decisions have to be made on an ad hoc basis, influenced by political pressure groups, funding agencies, and researchers.

In planning research there are three main questions that have to be answered before resources can be allocated:

- What are the possibilities of success if resources are allocated?
- How long will it take?
- What will society get in return for providing resources?

The first two questions are mainly addressed to the research community, which is in a better position than government administrators to judge this issue, since the solution depends largely on the available resources of existing knowledge, manpower, technology, and facilities. It is also an important question affecting the decision of the researchers to commit themselves to a particular project, since very few would be inclined to do so if the prospect for success was small or the time required very long.

Note: This introduction drew heavily on Ruttan 1982.

A research program that has no definite timetable is likely to prove wasteful. Timing is important for planning budgets, for coordinating with other research activities, and for maintaining a sense of urgency so that the benefits are delivered in the allotted time. Research projects have a habit of going on forever; it is much easier to decide when to start than when to stop. Timing and monitoring are required to discipline the research process.

The third question of the value of research to society is difficult to answer, not only because of the lack of a suitable evaluation methodology, but also because it involves value judgments, which are often subjective and change over time. For example, benefits of agricultural research are no longer judged only on productivity returns or other technical input-output relations, but increasingly on their effect on distribution and the environment.

Resources for agricultural research can be allocated four ways: among commodities, such as rice, wheat, and beef; among resource categories, such as soil, water, and labor; among stages or levels, such as industrial inputs, farm production, and processing; and among disciplines, such as genetics, social issues, and nutrition. As explained above, the decision about the distributive shares has to involve the public authorities as well as researchers. Both are subject to specific influences and inclinations. Public authorities, including research administrators, tend to be demand oriented and to favor social and economic objectives. In contrast, research scientists are more supply oriented and give more importance to the scientific or technical aspects of research; if left to themselves, they would allocate a greater share of the funds to these fields. This technical slant probably partly explains why this group does not deal effectively with budget officers, legislative committees, and special interest groups.

The political power constellation also influences the allocation process. Strong farmer organizations favor research benefiting farmers, such as research to develop techniques to increase productivity, while predominant consumer power groups shift the emphasis toward social or distributive types of research.

Increasingly, research funds for developing countries are now being supplied from external sources, such as the multilateral finance agencies or bilateral programs. Since, in most cases, this kind of financial assistance requires the concurrent allocation of national resources—monetary, technical, manpower, and so forth—this development not only tends to move the allocation process in the direction favored by outside interests, but it also ties up considerable national resources.

The actual allocation should, of course, be made on the basis of relevant and accurate data to support cost-benefit and input-output analyses. The weakness of the data base in most developing countries has already been indicated. Even if data are available, however, this process should avoid being overly specific. Apart from the fact that this makes allocative authorities suspicious, particularly when the research is a long-term activity where input and output can never be accurately assessed, it may also force research authorities to a level of commitment that may reduce the flexibility that is essential in the research process. In practice, many decisions are made by research directors on the basis of years of experience and a gut feeling of how best to match resources with what is scientifically feasible. To be overly precise would not be consistent with this process and might even impede the research. However, gut feeling is not enough. Priorities should be determined and resources allocated with the use of a methodology that takes account of economic, social, and political considerations and, most of all, the capacity and capabilities of the available research staff and facilities.

MAJOR ISSUES IN RESOURCE ALLOCATION

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There are two ways to solve the problem of allocating resources for agricultural research. First, the problem can be seen from society's point of view. Mainly, why consider investment in agricultural research as a priority for the public sector? In other words, one major issue is how to increase the total funds allocated to agricultural research. This issue has been treated inadequately in the literature. The second way to treat the problem is to establish priorities for allocating available research funds. This aspect has received considerable coverage in the economic literature. The following discussion covers both aspects, emphasizing the ways to increase overall agricultural research funding.

Identifying the Demand for Agricultural Research

Agricultural research activities increase when the private and public sectors perceive the need for new knowledge and demand the necessary new technology. As a result, both sectors create research institutions to supply the needed research services.

Two relevant questions can be raised:

- How does demand for agricultural research emerge and grow?
- How can government be made to properly interpret this demand?

The demand for agricultural research is different from, say, the demand for food since there is no organized market for agricultural research activities where a price and relevant quantity can be established. Still, the demand for agricultural research is derived from the product and production factor markets.

Let us trace this process. Initially, in a given country, there is equilibrium between its population and its natural resources. The population is stable or grows in proportion to the increase in cultivated area. The technology is based on land and labor, and technical change, if any, is not significant. In other words, as the demand for food grows, the supply is increased by expanding the so-called agricultural frontier. As long as this is possible without increasing the production cost, there is no demand for agricultural research and the resulting new technology. There may be pressure for research from a selected group, encouraged perhaps by the developed countries, but there is very little chance of developing agricultural research institutions. The existing tradeoff between expansion, through bringing into production new lands, and increasing productivity of cultivated areas favors expansion.

As the country grows, it changes. Industrialization develops, and some social services, such as health, improve. Population increases, wealth grows, and poverty decreases. More exports are needed. Increased urbanization, resulting from the rural exodus, creates a fast-growing demand for food, which the traditional food supply cannot satisfy.

The following chain of events eventually creates a demand for agricultural research services.

First, food prices rise in urban areas. Low-income groups, many of which have come from rural areas, are hurt the most. Social disturbances become a real danger. The

stability of government and other established institutions is endangered. These social conditions create an urgent need for agricultural development.

Second, the expanding demand for food puts pressure on the cost of traditional production factors, such as land and labor. The agricultural sector must struggle to obtain higher prices and, often, subsidies. There is a conflict of interest between agricultural producers and urban consumers; between cities and rural areas; between new industry and traditional agriculture.

Third, exports of agricultural surpluses are diminished, which causes a balance of payments problem.

Finally, the country must increase the productivity of land and labor. This means using modern agricultural inputs to replace the need for additional land and labor. It also means integrating biochemical technology (to replace mainly land) with mechanized technology (to substitute for labor).

The increased cost of production, which results from the growing prices of agricultural inputs, causes producers to demand higher commodity prices. This leads the consumers to react, sometimes violently, to the increased food prices.

Even though consumers, producers, and even exporters have not consciously spoken about agricultural research, the demand for an accelerated research system has been created. But it is not easily recognized by the government.

In Brazil, the search for a solution to the crisis that was provoked by increased agricultural prices went through the following stages.

First, an attempt was made to expand employment in new agricultural frontier lands by building railroads and, later, through large highway construction schemes.

Second, storage infrastructure had to be built or upgraded to even the flow of goods to the market and to cut losses through spoilage. It has been estimated that 15 percent of the commodities produced were lost. Decreasing this loss could supply a part of the growing food demand.

Third, since the food shortages continued, the productivity of the land had to be increased. It was assumed that a sufficient amount of knowledge existed to do this, either accumulated by progressive farmers or stored in the archives of the agricultural research workers. Based on this assumption, a massive technical assistance and extension program was begun, including large investments in subsidized credit for modern inputs and guaranteed minimum prices. At the same time, research funding was decreased, since it was assumed that agricultural productivity would increase on its own by activating this hidden reserve without a large investment in agricultural research.

Finally, starting in the 1970s, it was realized that the third approach would not work and that only a systematic effort to organize and expand agricultural research would produce self-sustained growth of agricultural productivity. In other words, several failures to increase food and other agricultural production through extension and supervised credit were necessary before the real needs of agricultural research activities were fully realized.

As in Brazil, there are usually serious obstacles to establishing viable agricultural research programs in developing countries that keep the appropriate authorities from recognizing the signals of growing demand for agricultural research. Four examples of such obstacles follow.

- Because of the low level of savings and a shortage of capital, investment priorities have been oriented toward short-term projects that give immediate returns. In

other words, it has been felt that investing and obtaining the return should be done in the shortest possible period. Such opportunities occur in the consumption goods industry and in the expansion of the agricultural frontier. This policy cannot include the investment needed to create advanced agricultural technology; the full cycle for that is rather long because research workers must be trained and new technology must be developed and then adopted. A research institution is just like a hydroelectric plant that initially requires time and investment to build. Once constructed, however, the plant provides a continuous supply of electric power. Similarly, an agricultural research system, after the initial period of training and institution building, can be expected to produce a continuous flow of research results. Some long-term research projects of great importance may, however, still take a long time to produce results.

- Another parallel situation occurs in countries that have given high priority to forced industrialization and, as a result, have invested all their savings in industries and services in the urban sector. Agriculture has been left to grow by incorporating new land and additional labor: that is, the country has chosen an extensive, rather than an intensive, way to increase agricultural production. Agricultural research is perceived as a way to create demand for modern inputs, and as requiring additional capital for agricultural production and the allocation of part of the savings to rural areas instead of to the urban-industrial complexes. This is not considered a priority within the above-mentioned policy of accelerated urban and industrial development.

- Agricultural research needs human capital in the form of highly trained research workers, laboratory personnel, and others. These types of professionals are in short supply because graduate training has not been institutionalized or is just being established.

Proper institutional development of research systems requires paying salaries well above the existing scales for most public service personnel. In addition, the cost of hiring foreign technicians may have to be included. The political structure may not tolerate a large salary difference within public service, however. Once the difference is institutionalized, political pressures may force the criteria for filling any high-paying position to be allegiance rather than professional merit.

In addition, inflation may wipe out any established salary difference because of the common practice of adjusting salaries at a rate below the actual level of inflation. Thus, the community of research scientists could easily be lost to the urban-industrial complexes of developing countries or even to the developed countries before they make any significant contribution to their own country and its agriculture.

- Even when the government is mature enough to accept increased salaries for its research personnel, it may not be able to allocate additional resources for complementary expenses, such as foreign specialists, outside training, and modern research equipment. In this case, international financing institutions become very important. During the past ten years, various bilateral and multilateral assistance agencies have learned how, and have accepted the need, to finance research. Still, there is a long way to go before the needed flexibility can be worked into foreign grants and loans given to agricultural research.

Motivating Investment in Agricultural Research

How can the public authorities be persuaded to invest in agricultural research when it becomes clear that the vertical (productivity) frontier represents a better alternative for increased production than the traditional horizontal frontier (the occupation of new agricultural areas)? The latter alternative may be based on opening new production areas in far away and sometimes nonfertile lands with no infrastructure. Occasionally, as in the Amazon basin in Brazil, rational exploitation of new frontiers in a different ecological system depends on the results of new research. Quite often a country has run out of new unexploited land and has no alternative except to increase the productivity of already cultivated land.

It is important to make society and decisionmakers realize that increasing agricultural productivity will satisfy both consumers and producers, will stop rising food prices without diminishing the supply of food and related items, and also will increase their country's competitive position in foreign markets. Finally, it is essential for the success of the overall development policy.

To change the traditional attitude of indifference, or even opposition, to research to one of full-hearted support requires time, particularly when little has been invested in education. Still, the only way is to start a program to educate the people and their leaders about the potential value of research and about the great need for building a strong national agricultural research system. Mobilizing the overall support of society, including the support of special interest groups, is the best way to assure that resources are continually allocated to a given activity like agricultural research.

Building this support requires various activities, such as organizing debates at universities and other educational institutions, which generate continual coverage by the popular press. Special seminars and other cultural activities may have to be organized, with consideration given to the special situation of each country or region. Some of the topics could be:

- Research as a means to improve nutrition and stabilize food prices
- Research as a means to improve the quality of food and reduce environmental pollution
- Research as an instrument of self-reliance to decrease dependence on imports
- Research as a way to increase export earnings; the agricultural surpluses resulting from increasing productivity could pay for imports needed for development programs
- Research as an agent to redistribute income; changes in food prices affect mostly the low-income population, so a decreased food budget will provide the largest percentage of additional income for this group
- Research as a factor for social stability; food shortages contribute to inflation and may result in public disturbances, which may affect the stability of government and other institutions
- Research as a means to stabilize and increase rural income; better yields and control of the environment will decrease the risk and stabilize production
- Research as an instrument to solve the major problems affecting the country; the

linkage between the results of a research program and the great social and economic problems faced by the country is very important

Too often, this task of educating society falls upon traditional research workers and administrators, who are not used to dealing with people outside the research institutions. Poor communication between researchers and the general public may constitute a significant bottleneck. Thus, these educational efforts should be undertaken by professionals acquainted with social sciences, communications, public relations, and politics.

Influencing the general public is a slow process, but work on special interest or target groups may have a faster payoff. These groups include people who hold political and economic power and who influence the process of allocating public and private resources. Since the research must be based on long-term financial stability, a support base cannot be limited only to those in the existing power structure. Due attention should be given to people who may eventually replace the current power structure. Some special target groups are elected and appointed executives, including the congress; the established press; economists and other social scientists; military establishments; church organizations; and producers' organizations and labor unions.

These groups can be influenced in various ways, such as:

- Preparing short and easily readable material showing the potential and actual benefits of research
- Organizing special events with wide participation, such as inaugurating new research units, releasing new cultivars, and other public activities
- Scheduling lectures by researchers and research administrators during various public events
- Organizing visits and guided tours of research units with special emphasis on research results
- Providing special advisory services to selected farms or whole regions
- Undertaking joint research projects with the private sector
- Developing special children's or student programs, including specially selected schools from various neighborhoods; parents can often be easily influenced by the favorable responses of their sons and daughters
- Organizing media programs on television and radio, through popular newspapers and magazine articles, and so forth
- Making a special effort to establish good relations with those involved in resource allocation and decisionmaking, such as state and federal officials, legislators, and others
- Participating in academic activities, when possible, with university systems, particularly graduate training programs
- Organizing joint activities with international institutions that offer technical and financial assistance so as to keep research in the spotlight for obtaining financial and technical assistance when needed.

Agricultural research often is carried out in many public institutions without any coordinating structure. In this case, it is advisable to establish a committee to coordinate these activities. Individual efforts by each institution to get recognition may hurt the whole system or may result in duplicated efforts and wasted scarce resources, such as the researcher's time and money needed for experimental work.

The agricultural research system must include two special groups in addition to young and established research professionals. First, it must include professional journalists with established reputations and access to communication media, who will help to create a good, direct contact with the media and will advise the research community on how best to deal with the general public. The system must also include economists trained and experienced in macroeconomics, who will relate agricultural research to aggregate, sectoral, and regional planning and to the relevant resource allocation activities of various governmental and private organizations.

Finally, it is of paramount importance to have research workers trained and experienced in relating not only to professionals, but also to the general public. They should be able to give talks and make public appearances whenever possible and to present their individual results without exaggeration, excess humility, or shyness. They should know how to appear on television and radio, to give interviews, and to prepare news releases for the popular press. There must be a continuous effort to promote and recognize good research workers and to obtain society's respect and admiration for these professionals.

Establishing Research Priorities

Once enough resources have been mobilized, every effort must be made to allocate them in the most efficient way. There are various problems involved in establishing priorities to allocate resources within a research institution. In mature and established research institutions with a tradition and a mission this process is rather self-perpetuating and has a self-correcting feedback system. The problems come in new organizations, which are in the process of institution building and are searching for the best alternative among various possibilities, as well as identifying the target groups. Here, the situation will vary from country to country and from one region to another.

Countries with a large urban-industrial complex are preoccupied mainly with maintaining the food supply for the urban population. Other countries that are trying to keep their population in rural areas are concerned with improving per capita income, nutrition, and the food supply at the farm level. In other words, the location of major social problems and the current trends in population movement and migration rates must be carefully identified. There are several implications of these situations for allocating resources in research.

Portfolio of research projects. Research projects must be selected that will help the institution to get established and to grow. For this reason most of the projects selected should be able to produce results that will potentially affect relatively large areas in a relatively short time. Crops that have been studied for a long time in both the developed and developing countries are better to work with since it is possible, by adaptive research, to obtain results quickly. If these crops are cultivated in large landholdings for export, conflicts of interest with the small farmers and consumers are likely to occur. In addition, these crops may not be considered a priority by the donor community that supports the interests of the small farmers. If the interests of con-

sumers and small farmers in research are strong, the research projects will tend to concentrate on the crops mostly cultivated by the small farmers for the internal market. But in most cases these crops will not have been studied before, and consequently the results will probably not come in the short run, which may cause the research institution to be discredited. In selecting the research priorities, it is therefore important to balance the interests of the pressure groups such as small farmers and consumers, with the need to obtain results in the shortest period possible.

Welfare of the urban and rural populations. When the welfare of the rural population is made the major criterion for setting priorities in agricultural research, the emphasis on technology for the small farmer becomes obvious, given the larger number of small producers. However, these farmers produce little, if any, surplus for the urban sector. If the larger part of the total population, including most of the low-income groups, is located in urban areas, the supply of technology to the low-income farmers may further reduce the food supply and increase the poverty in the cities.

At the same time, there may be so much migration from rural to urban areas that by the time technology for the small farmers has been developed, they may have already migrated to the city, and there may be no more small farmers in a particular area to use the new technology developed especially for them. Or these small farmers may have formed a cooperative to use modern large-scale technology, and some may have grown into larger farmers and may no longer be interested in small-scale technology. In this case, the resources allocated to create technology for the small farmer may not be of any use and may be considered to have been wasted. Thus, the existing trends of population movement and the time needed to generate special kinds of technology must be projected to obtain the proper mix of technology that will best serve all the social groups involved at some future time.

Research must follow the historical trend of social progress and related technological development and not go against the grain. The conflict of interest, if any, between large and small farmers can be analyzed only in terms of the level of urbanization of the country and the real objectives of economic development policy. In addition, research institutions cannot neglect economically strong interest groups within commercial agriculture who could influence the overall mobilization.

With the increase of urbanization, a new concern—marketing losses between producer and consumer—becomes a priority. These losses can grow so large that, for the consumer, they may cancel out most of the increase in productivity of the farmers.

Development of new arable land. Some countries still have large potentially arable areas but very little knowledge about their agricultural potential and limitations.

The benefits of research on the best way to cultivate these areas are not obtainable in a short time because agricultural activities have to be implemented first before one can see the actual fruits of research. There are always strong political pressures to develop these areas. Thus, in spite of their need to generate quick results, agricultural research institutions have to get involved in long-term undertakings, which do not produce immediate results to show to the public. There is a temptation to start the research in new areas by first producing a detailed inventory of existing natural resources, including photogrametric mapping, soil surveys, and a climatic data bank. This type of research work, however, does not appear to the general public to increase agricultural production. Even though this work is essential, an immediate action program should be

undertaken to solve the problems of the already established agricultural producers in the area. This may include introduction of new crops and livestock production.

Production for local consumption. Production for local consumption is a problem in newly industrializing countries with a high percentage of urban population and conflicts of interest between the urban and rural areas. In general, most of the crops consumed locally are produced by small farmers. At the same time, crops for export, and more recently for energy in some countries such as Brazil, are dominated by large commercial farmers, who are usually well represented in the existing power structure. It is difficult for a research system to be established and to have continuous financial support without producing concrete results for these crops.

At the same time, the society undergoes a transition that affects food habits, with mostly higher income groups increasing their consumption of meat, fruits, and vegetables. The low-income population, however, still consumes the traditional subsistence diet based on starch and vegetable protein. Since these commodities have a low income and price elasticity of demand, the large commercial producers try to avoid such crops. As a result, the prices of these products either increase greatly, adversely affecting the urban poor, or drop drastically at the farm level, adversely affecting the producers. Since there are no corresponding substantial price decreases for urban consumers, most of the benefits are absorbed by the intermediate sector.

The political implications of these increases and decreases in price are dramatic for the research establishment. Sometimes the research is made the scapegoat and is blamed for neglecting basic food crops. Thus, these crops must undergo research that produces quick results. At the same time, changing preferences and habits have to be considered in medium- to long-term programs to avoid future criticisms.

Intermediate technology. There is strong pressure for research to generate simple technologies that require relatively low-energy inputs, that can be easily adapted to existing production systems, and that can be assimilated by large numbers of producers. As long as the spread of this kind of technology does not substitute for a more productive alternative technology and limit the potential productivity of land and labor, it should be encouraged. However, if this technology has an opportunity cost—sacrificing potential increases in productivity and total production, hurting the welfare of consumers, and decreasing potential export earnings—it has to be reevaluated. In other words, in newly industrializing countries with large urban populations, overemphasis on intermediate technology that does not make full use of available scientific knowledge and does not result in high productivity of agriculture may limit the overall growth and development of the country. In this case, on a national level, more people will lose than will benefit if the full capacity of science-based agriculture is not used.

Various agricultural technologies consume varying amounts of energy. When energy, and not land, is the limiting factor, the technology assessment should be based on the production obtained from the use of a unit of energy and not on the traditional concept of energy consumed per hectare. At the same time, measurements of energy efficiency should not be limited to what is consumed on the farm, but should be expanded to include all the energy used until the product reaches the consumer.

Sometimes the strong urban-industrial and marketing interests press for decreased use of energy or for more expensive energy for the farmers. This pressure may decrease consumption on farms, but may increase it in transport, storage, and distribution channels, where these groups have a vested interest. For example, a large farm using

few modern energy-intensive inputs, located far from large urban consumption centers, and requiring high transport costs, may be less energy efficient than the use of energy-intensive inputs in areas close to the urban consumption centers, which require a low transport cost.

Social sciences. There is a strong tendency and tradition among agricultural research institutions in developing countries not to invest in economic and rural sociological research. This type of research, however, generates most of the information on the actual and potential problems of the population that is needed to establish research priorities. For example, economic evaluation of the potential for adopting new technologies provides a feedback for scheduling various research programs and projects. Relating technical recommendations to market conditions will indicate the most economically sound new technologies for immediate diffusion and adoption. In addition, as mentioned before, a well-trained group of social scientists acts as a liaison with the political and economic power structure, which controls public and private resources.

Exclusion principle. The rationale for any resource allocation system is based on the exclusion principle: we assume that most of the technology developed for large farmers automatically excludes small ones; that the technology developed for commercial farmers excludes subsistence groups; or, that the technology of interest to consumers will exclude any benefit to, or will hurt, producers.

This may be due to the fact that we are not properly using organizational technology and a new management systems approach to solve many of the potential conflicts. These so-called small producers can be as sophisticated as the larger ones when given proper technical assistance or when organized into cooperatives to take advantage of the economies of scale inherent in many modern technologies. An alternative to buying large-scale machinery is having firms that will rent machinery or cooperatives that will provide mechanization at cost for any farmer and will provide artificial insemination and other services not usually available to small farmers in developing countries. Examples of this can be seen in Puerto Rico, Japan, and some European countries. The exclusion principle, which lies at the heart of most potential allocation conflicts, loses its importance when modern management or organizational technology, including the data processing capacity of new computer technology, is fully exploited.

Final Remarks

This discussion has concentrated on the practical problems encountered by a young and growing agricultural research institution when it receives a substantial flow of resources. In allocating these resources among alternative programs and projects, the institution needs to consider many issues—how to increase the overall allocation of resources to agricultural research, stimulate discussion, and establish priorities based on each country's stage of development and projected growth.

Only some of these issues have been covered above, but there is a rather extensive literature dealing with quantitative methodology, based on subjective and objective data. A bibliography of these studies is included as an appendix.

Appendix: Bibliography on Resource Allocation in Research

This bibliography is reproduced from Elisio Contini and others, Prioridades e Alocação de Recursos na Pesquisa Agropecuária [Priorities and Resources Allocation in Agricultural Research] (Brasilia: EMBRAPA-DDM, 1983), pp. 40–46.

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COMMENTS BY PARTICIPANTS

Mohamed Bakheit Said (Sudan)

Research scientists are in short supply in the Sudan. Inadequate research facilities and declining real incomes encourage many of them to find employment in other countries, and thereby reduce the supply even further.

It is essential to make society and decisionmakers realize the importance of research and to persuade them to increase funding. In applying for funds, unrealistic and exaggerated claims should be avoided. Three sources of funds include the central government, grants from local institutions, and projects financed by international organizations.

Funding from international organizations is increasing. However, this creates two problems: external agencies demand control over projects, which makes continuing postproject funding difficult; and donors tend to use expatriate scientists, which is very expensive. It would be better to use the funds to supply research materials and to hire national scientists where possible.

There are several measures that could help to make the best use of the available resources.

- Research organizations should be permitted to sell their produce and publications and to keep the proceeds.
- If an interdisciplinary approach is used, the research plots could be used for more than one experiment, in order to save on the costs of labor and materials.
- The smallest statistically acceptable research plots should be used.
- Research headquarters should be placed as near as possible to policy headquarters.
- There should be a coherent national research policy to help establish modest and attainable research goals.

Jacques-Paul Eckebil (Cameroon)

When deciding how to raise more funds for research and how to allocate these funds, one must consider the conditions of the individual country, such as the fact that a population is mostly rural—80 percent in our case. Several important points were raised about the allocation of resources at a meeting in Singapore about two years ago.

- Some of the difficult issues in setting priorities have to do with the differences in the needs of small and large farmers and in the goals of long- and short-term research.
- The national plan, which includes cropping objectives and other target figures, must be considered, but authorities usually will be concerned with short-term (five-year) objectives, although it is necessary not to overlook the long run.
- Three models can be used to try to determine research priorities. First, assume that the national goals for agriculture include attaining self-reliance and exploiting comparative advantage and use these as criteria to measure research priorities. Second, base research priorities on the market value of the produce, which involves projecting the future prices for the commodities in question. Third, use a

weighting system based on several criteria (such as value per hectare, number of jobs created, savings earned by import substitution, and so forth) and rank animal production and crops on the basis of these weights.

In the Francophone countries of Africa research has concentrated on export crops in the past. Now that self-reliance in food has become a major objective, there must be a significant effort to aid the small farmers who produce food and represent such a large part of the population. Also, the emphasis on coffee and cocoa is doubtful, as the strategy study by the World Bank has projected that the prices of these commodities are expected to fall in the long run.

W. David Hopper (World Bank)

Setting research priorities is one of the most complex issues faced by researchers and research administrators. Most good researchers are convinced that their projects deserve the whole research budget. Yet choices must be made and each brilliant promise must be assessed for its effect on the whole.

We can ease the problem of allocating priorities by increasing the resources available. In most circumstances this means an appeal to the power structure controlling budgets. In countries with a free press, direct lobbying through the communications media is often effective. For example, newspapers can be used to convince farmers or consumers or politicians that added allocations are needed for research to ensure a balanced program with a variety of projects.

Research findings often have a great effect on more than just a production unit or even a sector. Important discoveries or innovations often have profound implications for national policy, most often national economic affairs. Most research organizations should have economists on their research staffs, both farm (or, more generally, agricultural microeconomists) and macroeconomists, who can view the whole sector and even indicate which aspects of public policy might be involved should new research findings become widely used. Because of generally tight budgets, however, very few research institutions can afford to staff their economic units satisfactorily. The cost of understaffing can be large either because national economic managers fear that productive opportunities opened by research results will be too expensive, or because the public purse will not be repaid for the cost of successfully spreading the new findings. The main constraint to agricultural advance in most of the world's developing countries today is the macroeconomic policies of national governments, that is, the allocations of public revenues, the development incentives to farmers, the import of productive factors such as fertilizer, and so on—all of the matters embraced in the "how" of managing the national economy. An economic research team of both micro- and macroeconomists is a necessary part of a comprehensive research program. Public policymakers will know that the relative costs and benefits to producer and consumer of newly uncovered technical research results that are widely adopted and practiced have been analyzed for the farm-level impact, the sector implications, and the effects on the overall balances of the national economic structure.

The involvement of the micro-level agricultural economist too early in the research process, however, may be counterproductive—even destructive—to the whole research enterprise. Too many agricultural economists approach technical innovation and change with a strongly negative bias. Most truly innovative research is done by hard work, careful observation, and "gut" feeling. None of these reactions is easily embraced in theory or rigor of the economic analysis of scientific study. I have yet to find

a realistic case in which the probability tools of the econometrician helped to guide the development of a research agenda or the work of a technical research team. Let the technical research staff start their work, and, if results are forthcoming, then ask the economists to assess the economic worth of the new finding. Above all, do not let the economist smother inventiveness or innovation.

Eliseu R. de Andrade Alves (Brazil)

Agricultural economists have been very useful in EMBRAPA. Their critical manner and minds have helped biologists to understand the role of research. They have rationalized why agricultural research was so important in Brazil.

Amir Muhammed (Pakistan)

Agricultural economists should play a crucial role in devising solutions to the socioeconomic problems of the agriculture sector. They must have a thorough knowledge of the different aspects of agriculture and the policymaking apparatus in the country to be able to suggest ways to improve agriculture. I believe that for an agricultural economist to be effective, the person must be very bright. An average agricultural economist is good only for preparing status papers, analyzing data, and so forth. Unless agricultural economists have vision, they cannot make a meaningful contribution to research. Average biological or physical scientists can contribute meaningfully by undertaking routine experiments to select new varieties or by determining the best agronomic practices, tasks that do not require much vision but a sound knowledge of certain techniques. But an average agricultural economist has to have vision and imagination to be effective.

In assigning priorities for research, gut feeling is not enough; there must be a proper methodology for weighting the various aspects to determine overall priorities for agricultural research in a country. I believe the system being followed by EMBRAPA can be suitably modified to determine the relative importance of various commodities or disciplines for setting priorities for research. This system needs to be elaborated to develop guidelines for various national programs to determine priorities in a systematic manner.

Carl Pray (Observer)

Resource allocation has to be a joint process. The economist can put some values on the criteria, but he must work with the agricultural scientist to find out what is technically possible. The economist's job is to say something about the values and to project the results twenty to thirty years down the line.

Edgardo C. Quisumbing (Philippines)

We assign the job of ranking priorities to a team of agricultural economists. The priorities recommended by the scientists then are referred to the policymakers, and any adjustments are made in consultation with the policymakers.

Fernando Gomez Moncayo (Colombia)

Instituto Colombiano Agropecuario decided to test the differences between the results reached by economists using a weighting system to assign research priorities and by

researchers simply giving advice, and the differences were minimal. Since that time, both economists and agricultural researchers have worked together on these issues.

Samsundar Parasram (CARDI)

Research priorities are related to our strategy for Caribbean food and nutrition. The priority areas include:

- Increased production of food
- Security (storage and so forth) of food
- Special attention to "at risk" groups, such as subsistence farmers.

The livestock research directors of the various regional and national institutes meet once a year and review ongoing livestock programs in the light of the above priorities. Crop research directors will soon be doing the same thing.

There is also the issue that long-term planning and organizing, while quite necessary, are very difficult in situations of uncertain markets, especially when much of the national income comes from export crops. A fall in market quotas or unit prices means reduced incomes, often with little notice. In such cases, research funding is the first item to be cut. Yet, if research funding is cut, then the vital area of agricultural research, which can help to develop new crops and strengthen production technologies for existing crops, will be weakened or destroyed.

Also, in allocating resources for research, there is tremendous pressure from consumers and businessmen to import food, either to keep food prices down or to satisfy certain market interests. Yet if imported foods replace those produced locally, the livelihood of farmers is destroyed, and they then become parasites on the cities, with no place else to go. As a group, the Caribbean countries have agreed not to import large quantities of food—we cannot afford it, and we should produce more of our own. Therefore, self-sufficiency remains a major goal of food research. Measures to ensure food security, which is especially critical in times of climatic and other crises, should also receive significant attention.

Balint Szaloczy (Hungary)

Three percent of our national budget goes to research, of which 8 to 9 percent goes to agricultural research. Land is the limiting factor in Hungary, and we find it necessary to set priorities among crops on the basis of several factors:

- Geographic or ecological characteristics
- National economic demand
- Size of the area that is required to grow the crop in question
- Human concerns, such as the available knowledge, tradition of growing the crop, and so forth.

For example, cereal crops have a very high priority because ecological conditions are favorable, twenty years ago Hungary decided to become self-sufficient in cereal production, cereals cover more than 50 percent of the arable land, and cereal crops respond to

research as shown by the fact that cereal yields have doubled in the past ten to twenty years. In addition, they can be exported when the market is good and can be fed to livestock if the prices are low. We have the tradition of growing them and the knowledge to do so.

M. V. Rao (India)

The character of the country ultimately decides the priority issues. In India, we use five-year plans, and it takes about two years of debate to establish the plan. Out of a hypothetical 10 rupees spent on research, we will spend at least 2 on education and infrastructure development. It is essential not to take a short-term view and to base one's plans on a market that may crash.

Our priorities now include:

- Rainfed agriculture, because 110 million hectares out of 140 million rely on rainfall in our country
- Oil seeds and pulses
- The basic crops of wheat and rice.

Looking toward the future, I would suggest we put our money on biotechnology, tissue culture and biomass, and so forth.

Philip R. N. Chigaru (Zimbabwe)

In our three-year-old country, the setting of agricultural research priorities is crucial. Before 1980, our priorities were different than they are now. Our agricultural system is a dualistic one, in which the large-scale sector produces up to 90 percent of all market produce, while the small-farm subsistence sector, containing 70 to 80 percent of the population, produces only 10 percent of the market produce. The society is not in a position to industrialize rapidly, and so people's livelihoods will improve only by increasing agricultural production. We have considerable agro-ecological diversity, but most of the people are in areas of marginal rainfall. All these factors must influence our decisions.

Papa I. Thiongane (Senegal)

Our number-one goal now is food security. In our institute, we integrate the disciplines of agronomy, forestry, livestock, and so forth and develop a system of priorities, which goes into our six-year plan for rural social and economic development. The national budget is revised yearly. International funding is a help, but we are not comfortable with it, because it will stop at some point, and we must be prepared for that time.

We use a regionalization process in planning, starting with small regions and synthesizing to a national plan. The ministers of the plan, of rural development, of scientific research, and of finance must evaluate this plan.

Throughout the Sahel there is not enough water. Therefore, our first priority is to combat drought by building dams and developing more drought-resistant crops.

Ibrahim Manwan (Indonesia)

We have a five-year plan, and agriculture is a part of it. It takes about two years to develop the agricultural plan. We hold consultations with regional economic development authorities, within the Ministry of Agriculture, with other ministries, such as trade, finance, and international relations, and also with the national training agency. In the past, we tried a ten-year plan, but it was too long a period to project accurately.

The various sectors must submit yearly budgets. Research funds are then allocated on the basis of the importance of the commodity involved and the availability of scientists to do the work. We now have more than 100 people with masters or doctorate degrees.

Summary

The discussion of resource allocation emphasized three issues:

- The process and factors for setting research objectives and monitoring their implementation
- The actual selection of research priorities
- The ways to influence the selection process.

Setting of objectives. There is no appropriate methodology for setting objectives and monitoring their implementation. The World Bank and other organizations engaged in research funding and advisory work could play a role here. Research objectives must be realistic in the light of available resources and should have a reasonable prospect of success. Of particular importance is the availability of sufficient, appropriately trained staff.

Selecting priorities. The special conditions of each country obviously have to be considered when setting priorities. These involve physical and geographic factors as well as the social structure; for example, if a large proportion of the population lives in rural areas, increasing food production would be an important goal. Other aspects to be considered in setting priorities and allocating resources are the farming structure, traditional cropping patterns, the importance of the crop in a country's agricultural system in terms of the amount and value of the area required and the export income, and the variation in the income produced. Objectives have to be set and priorities have to be selected within the framework of existing and proposed development plans. In many cases this involves emphasizing research to achieve self-sufficiency in food production, a goal that may not always coincide with the most efficient allocation of resources.

Priorities are determined mainly by the research community, which makes the first selection. Various committees at different government levels and in various agencies can appeal or suggest changes to the priority list put forward by the research community. In this respect the role of agricultural economists comes under fire. Although most participants felt that agricultural economists play a useful role in both determining priorities and implementing programs, one or two participants indicated that their role is doubtful, mainly because of their usual negative attitude and the "on the other hand" arguments.

Research priorities, however, are not always established on the basis of the criteria listed above. Political influences and donor demands also influence the allocation and

direction of priorities. This tends to have a detrimental effect on the allocation of resources, including the distribution of scarce research staff

Influencing the setting of research priorities. Scientists and professionally skilled government officials in advisory bodies play the most important role in setting research objectives, and their decisions are generally determined by technical arguments. However, politicians also play an important role in the decisionmaking process, and the research community should influence these people to make decisions in line with what has previously been determined as the most appropriate order for research priorities. Research directors, both in their institutional role and in their public relations capability can influence this process. EMBRAPA employs several journalists and allocates special funds to influence this highly important process of setting research objectives and determining priorities.

Session 4

Applied or Basic Research?

The two functional components of research activity are science and technology, which are analogous with basic and applied research, respectively. Basic research is essentially the generation of knowledge with varying degrees of applicability to immediate problems. Applied research is the generation of technology based on scientific knowledge, which leads to mechanical, biological, management, or institutional innovation. Basic and applied research are at either end of the spectrum of research activities, and in practice the resolution of a particular problem may require both types of research.

Basic research is necessary to explain and understand observed phenomena or to provide additional fundamental information needed before practical solutions can be developed for current problems. Basic research in agriculture has four main functions (National Science Board 1978, p. 4):

- Creating new knowledge that will help to advance all future agricultural research
- Creating new knowledge that will help to solve a specific problem
- Providing a sufficient base of scientific expertise to communicate with the scientific community at large, so that applicable scientific advances may be interpreted and used to advance agricultural research
- Contributing to the range and diversity of scientific expertise needed in research program planning, evaluation, and development.

Some examples of basic research are the development of vaccines for the control of animal diseases, the control of soil structure, the understanding of nutrient cycling in farm and forest ecosystems, and research on human requirements for nutrients.

Applied research is generally focused on solving a specific problem after the basic knowledge underlying the issue has been established. Examples of applied research are numerous and include, for example, the development of high-yielding plant varieties, determination of the fertilizer requirements of particular cropping systems on specific soil types, and research on farming systems. Occasionally, the pursuit of an applied problem generates a new field of basic research. R. W. Holley's experiment to understand how nutrient elements are moved from the soil into food and feeds, an applied research problem, eventually led to his explanation of the structure of ribonucleic acid (RNA) molecules, for which he was awarded the Nobel prize (National Science Foundation 1978, p. 4).

The development of basic and applied research is closely linked to the whole educational system in general and to agriculture in particular. The chronological steps in the evolution of knowledge are education, basic research, applied research, and development. This essential linkage was well recognized as early as the eighteenth century, when Liebig, the German founder of agricultural science and research, strongly supported the unity of teaching and research. In time it was found that agricultural faculties of universities could not fill the need for applied agricultural research. This led to the establishment of public and private sector agricultural experimental stations, which are now spread all over the world.

The selection of the subjects of research for basic or applied study depends on several factors, of which the most important are the availability of basic research as a foundation for applied research; the urgency of current practical problems; the priorities assigned in the allocation of manpower and funds, which are almost invariably in limited supply; and the backing for agricultural research provided by the national educational systems in preparing qualified scientists and scientific support. These factors should not be seen only from a national perspective, but should also be considered in their international context. For example, until World War II, Europe was the main source of basic research results for the United States, but through using this supply the United States developed the most sophisticated and efficient applied research system in the world. Today, however, the situation has changed, and the United States is now placing much greater emphasis on basic research while maintaining active programs of applied research.

The practical and often political pressure for immediate results may cause applied research to be started before the essential basic research has been completed. Emphasis on applied research, rather than basic research, may be expedient in the short run but may lead to greatly diminished returns in the long run. However, developing countries may not have the resources for basic research, such as staff and equipment, and may have to rely on other sources, such as international research agencies or other developing or developed countries.

The availability of resources affects the whole range of considerations, from training researchers to the partition of funds between basic and applied research. As research equipment has become more specialized and sophisticated, it has also become more expensive. This and the fact that the primary need in many developing countries is to solve urgent problems of food production have combined to produce the widely held opinion that developing countries should concentrate on applied research and leave the basic research to the most developed countries, which already have the facilities, the trained scientists, and the tradition of doing such research. This is a realistic approach, and yet it is not a perfect solution. It implies an extreme degree of reliance on the developed world for all essential basic results. Although most of these results are available, most of the agricultural research in the developed world has been geared toward the crops and livestock systems of the temperate zone. Some of the work is transferable, and some is not. The most basic work on the physiology of plants and animals may be universally applicable, and yet some basic work, such as the research to understand the physiology of drought and salinity tolerance of plants, has not been undertaken in the developed countries until very recently.

A second, related issue is that many scientists give basic research the highest priority. The most capable students are usually attracted to basic research and frequently are directed into it by their professors. A scientist's standing among peers is

often, and quite properly, a function of results, which are usually measured in terms of publications. These results are more often concerned with basic than applied research. The danger is that, by insisting upon applied work only, a research system may lose or discourage some of the country's most capable people. Since the distinction between applied and basic research is a function of the use to which the results are put, the research planners must find the balance of research programs that will be most useful in the long run to the country as a whole.

Generally speaking, it is not possible, nor is it advisable, to make a clear-cut distinction in allocating resources to basic or applied research. The two are interrelated and nourish each other. In many developing countries, however, the need for immediate practical research results puts more emphasis on applied research. This is not an entirely satisfactory situation, since there is a danger that applied research will drive out basic research. This could have detrimental effects on the intellectual resource base; in other words, the short-run tendency may have serious long-run repercussions, since basic research is the foundation of all agricultural research efforts. The direction research should take must depend on the individual needs of each country.

APPLIED OR BASIC RESEARCH: THE ISSUES INVOLVED

Samsundar Parasram
Caribbean Agricultural Research and Development Institute (CARDI)

The choice between basic and applied research is not a simple question to approach, and there are several points that I would like to make. First, every country, even every little island, would like to have all good things on its own soil and be self-sufficient. To illustrate how this is applicable to this subject, imagine a circle. It represents a closed system, or a person, or a country, which has everything that it wants. This condition could be described as complete independence or freedom or self-sufficiency.

Once this system (let us say country, since that is what we are discussing) requires something from the outside, it makes an opening in the circle to allow inflows. I will call this the grant phase. At this point, the country opens up a window to get the grants that it wants, but it also has to let in some investigators or conditions with the grants, which it may not want.

The next phase is a period of grants and loans, where the national economy grows larger and stronger. More goods and resources flow into and out of the window. The resources going out are actually a little greater than those coming in because of service charges on loans obtained in the previous phase.

In the next phase, the country is doing still better, and it no longer qualifies for grants, so now it has only loans. In the final phase, the country is again self-sufficient and can close the window up again. In reality, however, once the grants and loans start coming the dependence seems nonending.

Within agriculture, we in the Caribbean have found that countries that are the most dependent on agriculture often allocate only a small percentage of funds to the agricultural sector, and within that allocation the part that goes to research is even smaller. The first issue then is allocation of available resources to research.

Every nation would like to have its own research capabilities and to be totally self-sufficient in research. But it is not practical for all to do so, especially the very small ones. We can tabulate the general idea of how the different countries will deal with

satisfying their needs for agricultural research as shown below. Here the scale of from 1 to 5 indicates a country's reliance on a certain type of institution to fill its research needs, with 1 being the least and 5 the greatest reliance. The developed countries, larger developing countries, and smaller developing countries all have, of necessity, different strategies.

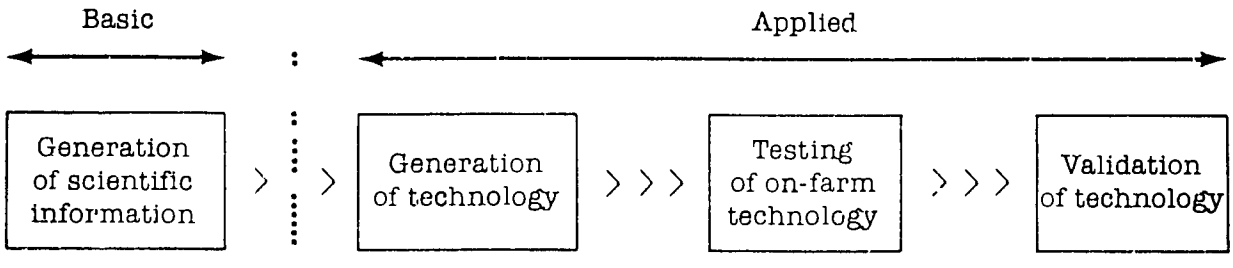
Institution	Developed countries	Large developing countries	Small developing countries
CGIAR institutions	0.5	1	2–2.5
Other international institutions	0.5	1	1
Regional institutions			1
		(aspire to)	
National institutions	4	3	0.5–1.0

The next issue is what kind of dependence should be created to get the most benefits from research available. In a general way, the table above shows that the developed countries rely on their own national systems for research, the larger developing countries rely on the various international institutions, but aspire to have their own national research centers as fully developed as possible, but the small developing countries must rely upon the CGIAR centers most heavily and upon other international or regional centers as well.

The third issue is how much of the national research should be basic and how much should be applied. A very small country, say a small island, will have a very small ministry of agriculture. The ministry's job will be to see that whatever the farmers produce can be sold and to liaise with the international and regional bodies about technology. Larger countries have fairly well-established laboratories and research efforts. In between, at an intermediate stage, the countries can test on farmers' fields and validate technology, but they do not have the resources necessary to generate new technology. The range of research possibilities is shown in Figure 2.

The first activity, generation of scientific information, is basic research, and the other three are applied research. Many nations do not have the capability to do all four

Figure 2. Progression of Research Activities



activities, but even the smallest country doing any research should be able to do some testing and validation for itself. It would be very costly for the international centers to do this.

In general, the developed countries and some of the larger developing countries have the capability to do basic research. If a developing country does not have this capability, it may not be worth establishing it. The technology for doing this kind of research changes so fast that it may not be worth the expense. By the time the facility is set up, it may already be outdated. As there is only a limited amount of money available, it must be used in the most efficient way. The external funding community has a role to play in making these decisions. There are also ways around this for the small countries that are willing to cooperate with their neighbors and establish regional research centers. CARDI, for example, has concentrated on operating technology and on working with national governments on testing and validation. Its mandate also includes some long-term research.

COMMENTS BY PARTICIPANTS

Ibrahim Manwan (Indonesia)

We have three major objectives in our agricultural research:

- To increase individual farm income as well as gross national agricultural product
- To improve the support services to agriculture
- To provide information for developing national agricultural policy.

We have scientists involved in both basic and applied research, and they can move freely between the two. However, a higher priority is given to applied research to utilize our resources more effectively. The real issue is how to allocate resources among applied research projects. When we have a need for basic research, we hope that it can be provided by the international research system, and we regard links between the national and international centers as crucial. For example, through the germ plasm utilization program, we have produced twenty new varieties within our country.

Carl Pray (Observer)

In the United States the allocation of resources between applied and basic research is changing. Increasing emphasis is now being placed on basic research. This is a function of changes within biological and other sciences, of the policies of the current administration, and of the importance of the commercial sector, specifically the fact that the private sector is now able to carry on much of the applied and some of the basic research, which was formerly done in the public sphere. In the United States today approximately one third of agricultural research is financed by the public sector through the U.S. Department of Agriculture's state and other experimental stations, and two thirds is financed by the private sector. These changes will likely affect the developing countries in several ways.

- More technology will be available to transfer to developing countries, and it will be more applicable to various locations.

- Costs of basic research in developing countries will increase, partly owing to higher laboratory and staff expenditures, but it will be less costly to transfer new technology from developed countries since computers have generally made such transfers less expensive.
- The transfer of technology may be speeded up because private corporations have incentives to diffuse technologies rapidly.
- There may be less free exchange of ideas in an early stage because of the proprietary nature of information, but the finished products may be easier to get.
- Agricultural research institutions will have to strengthen ties with science departments in universities where more basic biological research is done.
- There will be a greater return to investments in the acquisition of research results (such as investments in education, journals, meetings, and so forth) and the transfer of technology from the developed to the developing countries. The success of Japan has made it clear that, especially in early stages, a country does not have to be a leader in basic research to develop very rapidly. However, the acquisition of basic research results requires substantial investment in communications.

These changes imply three possible changes in the role of the international research centers. First, they could shift toward doing more basic research applicable to the needs of developing countries, which would require an increase in staff with training in basic biology. Second, communication with national and regional research centers to conduct tests and decide what is transferable will have to increase. Third, the international research centers may be able to help provide an alternative to the influence of multinational corporations.

Henry Kanjobe Mwandemere (Malawi)

The most important question is not so much that of basic versus applied research, but the question of what is relevant and effective. We must both meet our needs for food and generate foreign exchange. We need to inspire in our scientists a commitment to the national goals, so that they will generate research that is relevent to national priorities. Also, the productivity of research efforts can be greatly increased if we try to identify which countries are best able to do certain types of research to avoid duplicating work.

Yookti Sarikaphuti (Thailand)

The question of basic versus applied research has mostly to do with the stage of development of the country. In our commodity-oriented programs, we first try to look at what has been done and what are the gaps, and we then often transfer research results from other countries and from the international centers with which we have memoranda of understanding. In our case, the private sector does not seem to have much interest in investing in basic research.

Jonah N. R. Kasembe (Tanzania)

The role of the international centers must be to make a significant contribution to basic research, because, unfortunately, the national institutions do not have the capa-

city, the skills, or the financial resources to do so. The developing countries should put more emphasis on linkages between the universities and the national research organizations and on profit from the research being carried on in the universities.

Regional organizations that were formed, not by CGIAR but by the developing countries themselves, such as the West African Rice Development Association and the East African Agricultural and Forestry Research Organization, should play a greater role in basic and applied research. Unfortunately, they have been somewhat unstable organizations.

Fernando Gomez Moncayo (Colombia)

It is the planners and politicians who back research, and they have tended to think that "basic" is synonymous with sophisticated, costly, and impractical, at least in the short run. Some opportunities for agricultural research have been reduced because of this erroneous conception. A better classification might be:

- Speculative research, for which no practical use is foreseen
- Explorative research, which might have practical application, but which requires further investigation
- Mission-oriented research, which uses either basic or applied methods to solve a specific problem.

Most projects are mission oriented, not speculative. They seek solutions to practical problems, but they may involve some basic research, and resources should be available as necessary to carry them through.

Eduardo Vasconcellos (Brazil)

After the director of research decides which type of research—basic or applied—is to be pursued, then personnel management becomes critical. You particularly need to have an evaluation system that will reward the type of research you want to get. This may mean promotions for publication if basic research is wanted, and for contacts with farmers if applied research is wanted. A different recruiting system will also be needed to get the type of scientists you want.

W. David Hopper (World Bank)

There is a continuum in scientific research that is obscured by the binary classifications of "basic" and "applied." At one end of the continuum is the most fundamental kind of investigation: the pursuit of curiosity or the investigation of phenomena solely to increase knowledge and to better understand nature. At the other end of the continuum is research that has a specific purpose: investigations to find practical solutions for perceived problems. This kind of research blends into, and is virtually indistinguishable from, developmental investigations that will lead to new techniques that, when bundled with other techniques, will make a productive package called a technology. The testing and validation of a new technology is often called "applied research," although it can be equally regarded as part of the developmental activity. Good scientists should be able to work with equal ease across the full range of the continuum, although their talents and training may equip them to contribute most to particular parts of that range.

Farming systems research in its modern guise was pioneered by Richard Bradfield, a world-renowned soil scientist as well as a practical farmer, who, on retirement from Cornell University, moved to the International Rice Research Institute (IRRI) in the Philippines. There he investigated agronomic practices to increase the total annual output of rice land through carefully patterned intercropping techniques and crop sequences. His system maintained the soil structure and enabled rice to be inter-tilled with upland crops or to be followed quickly by dry season crops that would germinate on residual moisture. With a carefully planned farming system, yields from rice land were increased from the excellent level of around eight metric tonnes of paddy per hectare per year to more than twenty-two metric tonnes of paddy equivalent grain in the full growing period. Bradfield contended and proved in the field, that the potential of the year-around tropical sunlight and warm climate to produce food could (and should) be better exploited.

Subsequent work throughout Asia has demonstrated that despite these excellent beginnings, the work on farming systems has not yet been able to be generalized much beyond a specific region. In other words, there is not yet a science of farming systems that can recommend new farming system practices that could have a broad application. In contrast, the dwarf wheat varieties developed in Mexico by the Nobel laureate, Norman Borlaug, were able to jump international boundaries with little required to adjust the necessary complementary agronomic practices to ensure the capture of their productive potential. A great deal more work on the underlying elements of successful farming systems is needed to unlock their scientific promise.

It is imperative that research goals be set in concrete and monitorable terms. When IRRI opened its laboratories in 1962, its goal was to double the yields of tropical rice in Asia in the next ten years. They succeeded in reaching this goal with many rice varieties but did not succeed in doubling the average rice yield. The effort, however, did two things: it concentrated the work of the scientific staff on the factors affecting and contributing to rice yields, and it led to a careful and searching analysis of how best to transfer new rice technology to the many millions of farmers throughout tropical Asia. Each of these outcomes has characterized the work of IRRI during the past two decades. Work on the productivity of the rice plant has focused not just on contributing to knowledge, but to the knowledge of how to push the genetic material of the plant to its maximum output. Because maximum output is but one component in attaining the research goal, IRRI has built an extensive outreach and training program to better bring the results of its findings to the farmers in Asia.

Had the governing trustees of IRRI set their goals differently, say, to conduct research into the gene structure of the rice plant or to study its adaptation to differing ecological conditions, the resulting research would have doubtless been as fine as the attainments now credited to the institute's scientific staff, but the results would have had little influence on Asian agriculture. The original goals kept the focus on research, and the unfinished business of low rice yields throughout tropical Asia continues to guide the applied orientation of the institute's scientific and teaching staff.

The case of IRRI illustrates the importance of establishing an easily understood purpose for the research through a goal or set of goals that can be monitored for progress through objective measures. Without such goal setting, scientific work will reflect either the individual interests of the scientists involved or rapidly become an ad hoc pursuit of just about anything that seems connected (or possibly connected) with the general area of the research.

Eliseu R. de Andrade Alves (Brazil)

The danger in emphasizing applied research is that to a certain extent "basic research" means "basic intelligence." I am worried that countries that do not do any basic research will not have scientific wisdom and that they will not have qualified scientists. The great danger in classifying research this way is that you end up classifying your scientists, and the fundamental (basic) issues and the less practical scientist will lose out. A well-known Brazilian mathematician said that basic research is that which has not been applied yet. Mission-oriented research is a good idea, but we may put off or eliminate all the brilliant basic scientists we might have. All the classification systems of what is basic and what is applied finally break down. What is important is to protect the most competent people.

Thirty years ago, we in Brazil were told that as a developing country, we did not need the most competent, highly trained scientists. I say, the tougher the problem, the better the scientists must be. Unfortunately, the international centers really do not know how to work with a country which does not have a good scientific community.

Hugh T. Murphy (IRRI)

Because the final goal of our research is to produce more food, there is a great emphasis on applied research. The role of the international agricultural research centers (IARCs) is to provide a basis for national research as well as a network of research. The IARCs can farm out much basic research. They can sometimes play a helpful political role, for instance, in getting access to the president of a country for visiting groups. The IARCs can also help in training, with both informal short courses and more formal long-term training. Part of the advantage of training scientists at centers such as IRRI is not only the professional contacts the scientists make but also the fact that the collaboration continues through IRRI's mailing lists. The goal is to work with a country in a way that the country feels will be helpful for it. There is the possibility, for instance, that the IARCs may be able to help in the issue of patent rights.

Amir Muhammed (Pakistan)

Developing countries have to undertake research on different aspects of agriculture to solve problems hindering agricultural development. This may require both basic research on the problems specific to a country and applied research involving verification, adaptation, and improvement in the agricultural production technologies. However, it is desirable that the basic research should be meaningful and should not be confused with aimless or irrelevant research. In developing countries, scientists returning from developed countries tend to continue working on the topics similar to their dissertations, whether or not this research is relevant to the problems in their country. Such research often leads to frustration and wasted resources because scientists in developing countries cannot compete with scientists in the developed countries in research areas that require sophisticated laboratories and other facilities.

In most developing countries most agricultural problems, particularly those concerned with providing improved production technologies to the farmers, can be overcome through applied research. Therefore, besides doctorate-level training, the specialized training to develop advanced skills for applied research in selected areas should be

emphasized. However, there will always be a need for imaginative group leaders thoroughly trained in research methodology. The best alternative would be to have a proper mix of the scientists with different backgrounds.

M. V. Rao (India)

Our priorities differ according to our situations, but in the long run what is basic today is applied tomorrow. It is also true, however, that to be successfully applied, basic research needs infrastructure. When Borlaug's varieties were grown, for the first two years they were inferior to the local varieties. We had to do more studies before we could use them.

It is true that we can take for granted the basic scientists who publish for thirty years, but there are also some less-educated ones who deliver the goods. To get the most use out of some of our best minds, we have taken our retired professors, have called them "national professors," and have built institutions around them.

Summary

Developing countries should concentrate their greatest research efforts on applied research. However, the definition of applied research may not be fully understood. Many feel that the technical application of research findings, such as executing research trials and tending demonstration plots, constitutes the largest part of applied research. This narrow interpretation of applied research may result from the lack of a clear definition and the absence of a methodology on how to select and apply it. As with the process of determining research priorities, a methodology for using applied research is needed and should be developed.

The discussion on basic research focused on three main issues:

- The definition of basic research and the problems of deciding what is suitable basic research for developing countries
- Technical, human, and physical factors influencing the decision to select basic research
- The role of international and national agricultural research centers in supporting basic research in developing countries.

It is difficult to undertake basic research. It is expensive and requires a pool of research staff, which many countries cannot afford. Most consider generating basic research as acquiring such research from sources outside their countries. The main concern is to determine where the type of basic research their country needs is being done and then to acquire it from these sources. Thus, communication among research institutions and scientists is very important. This seminar provided a useful channel for such communication.

Concerning the first issue above, there is a danger in classifying basic research as "basic intelligence." This gives it a connotation of excellence, which might be transferred to the scientists doing the research, thus giving them a higher status than that of scientists doing applied research, who would be classified as technicians. This would be an unfortunate situation and does not correspond to the truth. It is true, however, that basic research involves more theoretical science and that a country that fails to

conduct this type of research runs the danger of having a vacuum of knowledge in this field. Similarly the emphasis on basic or applied research very much influences the recruitment of researchers and the composition of the research community.

Given the limited intellectual resources in developing countries it is difficult to select the type of basic research that is uniquely suitable for a particular country and that would have a chance of success in competition with other, particularly developed, countries. It is also difficult to choose basic research topics in the light of fast changes in research development.

The technical, physical, and human factors influencing the selection of basic or applied research are related to the availability of resources. The size of a country and its economic strength and stage of development influence the decisions about hiring scientists, providing facilities, and so forth for basic research.

Basic research should be one of the most important activities of international research organizations, such as those grouped under CGIAR, and they should provide a network for disseminating research findings and programs. Experience shows that international research organizations seem to have difficulties working with countries with small research communities. These topics should be considered in improving communications between national and international research bodies.

In the United States increasing emphasis is being placed on basic research, and about two thirds of the research there is done by the private sector. The implications of this situation are illustrated in Part III.

PART III

Research Structure and Organization

How should an agricultural enterprise be structured? This question, while crucial for agricultural policy, is not widely viewed as interesting—at least not to scientists, who typically distrust administration, or to economists, who are naturally suspicious of organizational solutions to policy problems. This may be why agricultural research organization has been sadly neglected as a topic of scholarly inquiry.

THE PROBLEM

From a development perspective, greater attention to the effectiveness of the international and national agricultural research administrations is needed for the following reasons:

- Although technical innovation has been instrumental in averting large-scale famine during the past decade, the arithmetic of population growth, inelastic food demand, ineffective stocking policies, and uncertain weather leave no room for complacency; the global food system remains vulnerable.
- The capacity to develop, adapt, and disseminate the right kind of technologies is the most important factor explaining differences in agricultural productivity among nations.
- There is evidence of a growing disequilibrium in agricultural productivity between crops and regions. In particular, the challenge of development in sub-Saharan Africa will not be met without significant technological breakthroughs in rainfed agriculture and livestock husbandry.

RESEARCH EFFECTIVENESS

More and more questions are being raised about the effectiveness of existing agricultural research systems, both at the national and international levels. Although there is little dispute that the overall returns to investments in agricultural research have been and remain very attractive, not all the components of the far-flung international

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Note: Robert Picciotto chaired the two sessions in Part III. His opening remarks have been combined here with a written introduction by Dieter Elz.

research enterprise constructed during the past two decades have produced results commensurate with the resources invested. Therefore, agricultural research cannot be spared close scrutiny when a worldwide financial crisis is causing severe budget cutbacks. More will have to be done with less. This is the organizational mandate for agricultural research in the 1980s.

The search for increased organizational efficiency in agricultural research involves three distinct sets of issues: the linkages of agricultural research with overall scientific research; the appropriate role of public and private sectors in agricultural research; and the choice among models of agricultural research organization.

A Separate Science?

First, in the words of Andre and Jean Mayer, "Intellectually and institutionally, agriculture has been and remains an island—a vast, wealthy, powerful island, an island empire if you will, but an island nevertheless."(Mayer and Mayer 1971).

Is this institutional isolation efficient? The Mayers do not think so: "Although the independence of agriculture has ensured the power and prosperity of its large-scale practitioners and clients, it has been tremendously costly. For lack of effective outside criticism, a great deal of agriculture research has proceeded on assumptions which are very much open to question."

If so, one important question is whether and how the organization of agricultural research can combine the vigor of autonomy with the intellectual cross-fertilization arising from regular commerce with the other sciences. Such linkages have become critical given the rapid evolution of biotechnology, the changes in chemical input prices following the oil price shocks of 1973 and 1980, and the information revolution spawned by the microchip.

Public or Private?

The second fundamental set of issues has to do with whether the overwhelmingly public sector character of agricultural research is appropriate. The need for significant public funding of agricultural research is not an issue for two basic reasons. First, the producer of agricultural innovation can rarely capture more than a small fraction of its benefits to society. Second, modern agricultural research enjoys economies of scale because of its need for specialized services and large-scale trials. Therefore, it is essential for the public (and the private nonprofit) sector to continue to play a role in funding agricultural research. For if they did not, inadequate resources would be channeled to an activity that has long been and remains an area of investment with one of the highest returns in the developing world. It is clear, however, that profit is a powerful engine of invention, as is evident from the surge of private investment in bioengineering in the United States and other developed countries.

In addition, there are severe institutional problems to be overcome in organizing public agricultural research administrations. They are often hamstrung by inadequate civil service regulations, poor working conditions, and weak leadership. Others, especially in large countries with a federal structure, may have grown beyond a manageable optimum.

Therefore, a more active search for more effective organizational approaches to agriculture research, tapping the initiative and using the methods of the private sector,

is needed. Greater competition is necessary. This can be achieved by introducing one or more of the following measures:

- Shift of budget controls to users (as proposed by the Rothschild Commission in the UK)
- Greater reliance on contract research (the highly successful "National Institute of Health" approach)
- Direct support to private-sector research institutions, for example, in mechanization, post harvest technology, and agriculture processing
- Specific projects of collaboration between public and private research.

The scope for all four initiatives may well have been underestimated in the developing world.

STRUCTURAL ISSUES

The third category of issues is structural. In the developed countries agricultural research has progressed through three stages (Ruttan 1982). The first stage consisted of innovative activities by individual farmers, such as Justus von Liebig's treatise on the chemical basis for plant nutrition in Germany and Thomas Jefferson's experiments with soil fertility in the United States. In the second stage research workers established agricultural experiment stations, such as the Rothamsted experiment station in the United Kingdom founded by Sir John Bennet Lawes in 1843. Finally, integrated national agricultural research systems evolved, with the planning capacity to relate research priorities to the allocation of professional and financial resources.

This development led to four basic research models, which are operative today and which characterize the research structure in particular countries (Ruttan 1982, p. 107):

- The integrated research, extension, and educational model, which is exemplified by the U.S. land grant university
- The autonomous or semiautonomous publicly or privately supported research system, originally developed in the United Kingdom, which remains a model for research support for export or large-scale types of production
- The ministry of agriculture model, which is mainly concerned with domestic food crops in the smaller countries
- The agricultural research council, whose greatest emphasis is on coordinating a system in which two or more of the above models develop alongside each other.

There is no simple way to determine which of these models is "the best" since they respond to a wide variety of institutional traditions. Numerous examples of failure (and of success) can be adduced for each one of them. In some countries, a mix of these models can be observed, often the result of strings attached by different donors at different times. On the one hand, a shift from one model to the other occasionally has helped to shake institutional inertia or facilitate managerial changes. On the other hand, there are numerous examples of misguided, partial, or poorly planned interventions, which have hurt rather than helped the cause of agricultural research.

Whether a pragmatic, gradualist approach to institutional reform is to be preferred to a major shake-up depends on the resources available, the commitment to reform, and the quality of local leadership. Scientific entrepreneurship is often the missing ingredient of productive institutional change.

During the historical development and modernization of agricultural research systems, increased emphasis was placed on planning and management. In this process several important issues and stresses developed, such as what were the linkages among research, education, and extension; whether to centralize or decentralize agricultural research; whether to emphasize basic or applied research; and how to distribute costs between the public and private sectors.

PRINCIPLES OF A RESEARCH ORGANIZATION

No single organizational model can be recommended as the most effective way to organize a national research effort. A model will need to be developed or modified to meet the special needs of each country. Nevertheless, a review of country experiences suggests that several basic principles are widely applicable in the design of effective research programs (World Bank 1981):

- Research goals must be clearly stated.
- There must be continuity in research goals, management policies, and supervision of the research program.
- The research agency must have an acceptable degree of autonomy from bureaucratic constraints.
- The national research effort must be provided with financial support consistent with the importance of agriculture in the economy.
- The level and quantity of research expertise must be consistent with the severity of the problems that limit agricultural production.
- The research staff must receive continuous information about the production problems confronted by farmers.
- Mechanisms must be provided to permit the flow of results to farmers, with emphasis on on-farm testing.
- The government should encourage arrangements that facilitate coordination and cooperation of a country's total research establishment (public or private) in pursuit of common objectives.

Research organizations in a growing number of countries embody these principles. In these improved systems, the national research organization is frequently structured on the basis of major commodities (crop and animal) and production factors or of special problem research (soil, water, engineering, national resources, or processing). A socioeconomic research division is an integral part of the national research system.

BASIC CONCEPTS OF ORGANIZATIONAL STRUCTURE

The organizational structure of agricultural research can be analyzed by looking both at the total system and at the individual research institutes. The total system includes policy instruments such as control of agricultural policy and research planning; institutional issues determining the role of universities, the extension service, and farmers in the research framework; and aspects of financing, such as the role of funding agencies. At this level several important questions need to be asked:

- Should extension be separated from research?
- What are the roles of the university and research institutes?
- How should research policy organizations be structured to ensure adequate participation? Are research councils feasible alternatives?
- How much decision power should each component of the system have?
- Should policymaking and funding activities be performed by the same organization, or should they be decentralized?

Organizational structure of the individual institutes is the framework in which activities, authority, and communications are established to achieve the organization's objectives. Three basic questions have to be considered in designing the structure at this level:

- Who is going to do what job?
- Who will have the decisionmaking authority for each position in the organization?
- What will be the communication system within the organization?

DETERMINANTS OF AN ORGANIZATION

Each organization has specific needs depending on its particular characteristics—called determinants in organizational parlance. The main determinants are objectives and strategy, task characteristics, environment, human aspects, and organizational conditions.

Objectives and Strategy

The goals (objectives) of a research institute determine its strategy of how to solve problems. For example, an institute whose most important goal is basic research has a different strategy for policy orientation, staffing, communication, and so forth than an institute whose objective is applied research. Many research institutes have problems because objectives and strategies change, but the structure is not adapted accordingly.

Task Characteristics

Within the framework of goals and strategies, the specific task characteristics influence organizational structures. This can best be illustrated by indicating the type of questions that determine task characteristics. For example:

- How much research is basic, and how much is applied?
- How many projects are large (in terms of budget, duration, number of researchers), and how many are small?
- How much of the research institute's efforts are devoted to routine services and technical assistance?
- How much effort is put into extension activities?
- What percentage of the total budget comes from research contracts?
- What percentage of projects is interdisciplinary?

The answers to these questions will determine a certain profile of activities. The structure will have to be consistent with these activities, and it will have to change when the tasks change.

Environment

The environment and changes in it are also determinants of the organizational structure. This involves aspects such as government research policy, scientific and technological innovations, changes in the agricultural commodity production, and changes in priorities of international funding agencies.

Human Aspects

Trained and experienced researchers are difficult to find, especially in developing countries. This makes the human factor a very relevant determinant of the organizational structure. Studies in research management have shown that researchers are sometimes more difficult to manage than other staff, because of the individual and creative nature of their work. The structure for a research organization should consider very carefully the human characteristics of the people involved. Many organizations have failed because advanced structural forms were copied from developed countries without being adapted to the cultural characteristics of the people in the particular developing country. For example, a decentralized structure cannot be implemented without considering the technical and managerial capability of researchers to handle these new responsibilities. Other types of structures, such as matrix and project (discussed below), will not operate effectively if researchers are not trained in certain managerial and interpersonal skills, even if these organizational forms are the best in terms of the other determinants.

Organizational Conditions

Although the above determinants refer to specific factors, organizational conditions are a conglomerate of factors, including the determinants listed above, influencing the structure of the organization. Among them are the stage of a country's development,

cultural and sociological aspects, and the history of research in that country. These factors often cannot be quantitatively managed but exercise a great influence on research structure.

In designing the structure for a research organization three aspects are of great importance: organization pattern, also referred to as departmentalization; role definition; and level of structure. Since the head of the organization can supervise only a limited number of people, units must be formed, each with a supervisor, who reports to the director of the institute. As the organization grows, subunits are created to form another hierarchic level.

Departmentalization. Many criteria can be used to form these units. Departmentalization is the process of selecting the best set of criteria for a given organization. The most common criteria for organizing research activities are:

- Functional—researchers are selected for a given unit (division, department, or section) according to their technical background, and they report to the unit manager.
- Project—researchers are grouped according to the projects to which they are assigned, and they report to the project managers.
- Product—researchers are grouped according to the commodity they are researching.
- Geographic—researchers are grouped according to geographic factors, as often occurs when the research institute has experimental research stations in different regions. In this case the researchers report to the station manager.
- Matrix—researchers are grouped simultaneously in two organizational units and report to the supervisors of both units. For example, a researcher can report to the head of the genetic section as well as to a project manager of another section about aspects related to that particular project.

Usually, an organization has several types of departmentalization at the same time.

Two important aspects should be considered in the departmentalization process: span of control and decentralization. Each supervisor should have an adequate number of subordinates. There is no precise number for this, since it depends on factors such as the nature of the task, the ability of subordinates, and the leadership capability of the supervisor. In addition, support activities, such as computer facilities, labor, and equipment should be decentralized so that each division or section will have its own facilities. Care must be taken, however, to avoid idle capacity and duplication of resources.

Role definition. Having an organizational chart is not enough. Researchers should know what is expected of them. They must know which activities they should perform to contribute to the organization's goals, the limits of their decision power, and the procedures for communication so that they can obtain the necessary information to accomplish their tasks.

Some important aspects of role definition are:

- How much authority should be concentrated at the top of the hierarchy, and how much should be decentralized to lower levels?

- Which activities should be performed by each organizational position?
- What are the communication procedures required to give all researchers and unit supervisors the necessary information to do their jobs?

The success of a creative, problem-oriented environment depends a great deal upon a flexible and frequent flow of information. This is particularly important in a research organization where a large proportion of the staff does independent work, the results of which will be used in a larger comprehensive research effort.

Degree of formalized structure. Another factor to be considered is the degree of formalized structure. Studies have shown that creative organizations need less formal structures than the routine type of organization. One of the managerial problems that developing countries face today is the lack of research management techniques adapted to the needs of the country. Because of that, research institutes tend to be structured like the routine type of organization, and this structure is often not suited to the specific intellectual research environment.

In considering organizational research structure at whatever level, one should be aware that there are no magic structures guaranteeing success. The structure of the total system as well as that of each research institute will have to be developed within its own political, intellectual, economic, social, and cultural environment and constraints. In most developing countries, research managers operate with scarce resources, uncertain and changing political support, and increasing pressure for instant results. To make research operate effectively under such conditions is a significant challenge.

THE CASE AGAINST A READY-MADE MODEL

But perhaps these and other important questions about research organization cannot be answered decisively for fundamental reasons. Research is a leap into the unknown. One should certainly look before leaping. But in what direction and how far should one leap? Should organizational structure attempt to reduce the uncertainties involved? Can agricultural research managers be the arbiters of all the vast issues that alternative technological changes can create for the farming enterprise? Or can they assume that sensible policy goals will emerge from the political establishment?

It would seem that an appropriate research structure should, within itself, provide the arena in which policy choices involving all relevant decisionmakers are made. Just as important, policy choices should be made in full awareness of the scientific work done by others as well as of the views of those most likely to benefit (or be hurt) by the research—one of the reasons why a strong linkage between research and extension is needed.

In the last analysis, it may be that strong leadership (together with appropriate funding), rather than any particular form of administration, is what best characterizes an effective agricultural research system. But organization is important too, and it is hoped that the greater emphasis currently being put on the strengthening of national research systems in developing countries will spur systematic analysis of the issues mentioned here.

Session 5

The Links between Research and Extension

Just as design engineers and marketing managers tend to blame each other for any failure of their bright new package, agricultural researchers and extension workers find in each other a convenient alibi if the farmers ignore their message. Farmers are portrayed either as conservative or as very smart, depending on how they react. Just as the marketing manager needs the design engineer to produce a gadget that the public needs (or can be persuaded to think it needs), so the extension agent needs the researcher to design the package that the farmer needs. Indeed, the researcher may, on occasion, design a package that sells itself and needs no advertising or face-to-face encounters with farmers. This is probably the exception, however, and in most cases the two systems—research and extension—must interact closely to have a discernible effect on production.

To be effective the research system must generate technical recommendations, and the two systems must develop linkages at both the institutional and personal levels: institutional so that they are mutually supportive, and personal so that they understand each other's problems. Such understanding is particularly necessary in the poorer countries and for the poorer farmers, where circumstances often demand simple, low-cost solutions to problems, but where such solutions are by no means either easy or quick to obtain. Indeed, high-quality research is usually essential to solve problems that are often complicated and difficult. Where solutions are simple, farmers often find them themselves.

There are obviously several essential components needed for a successful extension system. One of these is a technique that the farmer can use and benefit from. Such technical packages emanate from the experience of the more progressive and imaginative farmers and from research either in the area concerned or elsewhere.

In turn, a research system produces new knowledge and new technology. But it is the application of that new knowledge and new technology that improves production, because there is no improvement unless the technology is applied by farmers. To apply it, they need to know about it and how to use it. Although new technology can spread without the intervention of extension services, a formalized two-way system of knowledge transfer is needed and is, for example, at the heart of the training and visit (T&V) system.

Linkages between research and extension exist at both the formal and informal levels. Formal links are often weak because of institutional divisions, since research

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Note: This introduction has been taken from John K. Coulter, "The Interdependence of Research and Extension: A Comment," in Cernea, Coulter, and Russell 1983.

and extension may be in different ministries or in widely separated departments of the same ministry. Little attention may be given to organizing formal contacts, such as field days at experimental stations or joint meetings of research and extension workers. It is not clear, however, how the lack of formal linkages influences the formation of informal links. For example, do extension staff lack contact with research staff because many of the research staff live and work in large cities and, thus, there are very few opportunities to confer? In such cases even the best-developed formal linkage will be of little use in encouraging interaction. Sometimes it is suggested that there is a "cultural" gap between research and extension staff, because the former are more highly educated and better paid and thus more respected. Certainly there is plenty of evidence to suggest that extension staff are poorly paid and have poor career prospects compared with research staff.

NEW DIRECTIONS IN RESEARCH-EXTENSION LINKAGES

Edgardo C. Quisumbing, Ministry of Agriculture, Philippines

Through the years, developing countries have waged a relentless struggle to keep their food supply a safe distance ahead of the demands of ever-increasing populations and to assist in the general effort to improve the quality of life of their rural poor. Individually, these countries have been successful and have attained considerable progress in agricultural development. Despite these accomplishments, however, they are finding it more and more difficult to cope with the increasingly severe conditions that now prevail in agriculture in the developing world. Keeping food production ahead of the population explosion will continue to be a significant problem in the coming years.

Developing countries have responded to the challenges posed by accelerating changes and emerging situations in agriculture by resorting to new strategies and measures to further improve their capacity to tackle difficult conditions.

Among the problems that need immediate attention is the improvement of farming technology in the agricultural areas. It is ironic that research in agriculture during the decades has led to the development of new technologies, but that farmers have been slow to adopt or use them. Apparently, the traditional mechanisms for transferring technology in many of the developing countries can no longer keep up with the needs of current times and, worse, have even become anachronisms.

In many ministries of agriculture the linkage between research and extension has come to be regarded as one of the most important parts, but possibly the weakest of the entire system. A wide gap between the generators and the users of technology continues to exist.

Barriers to Interaction

Researchers and extensionists in developing countries are very different individuals, who are influenced by their varied orientations. Several characteristics of research and extension systems are common to many developing countries.

Professional attitude. Extension workers have generally been considered to be inferior to researchers. They have less training and equipment for the requirements of their work. Many researchers, however, have higher status and qualifications because researchers are encouraged to pursue their academic training. Extensionists feel that

their own contribution is undervalued by the researchers, a feeling that is compounded by the aloof stance of many researchers.

Incompatible organizational setups. The systems for extension and for research in many countries do not permit viable collaborative mechanisms to be established. They have scarcely enough points in common to facilitate the communication of ideas from one discipline to the other.

Uncoordinated programming and prioritizing of efforts. Plans of activities are generally drawn up separately for research and extension, so timing and prioritization of efforts often do not coincide.

Financial constraints. Financial resources and budgeting of both research and extension activities restrict the opportunities for joint activities. Because of fund limitations research institutions, in particular, do not have the flexibility to adjust their work program quickly to deal with farmers' problems—when these manage to reach them.

Systems to Promote Linkages

The recent upheavals in global economics have forced the developing countries whose economies are based on agriculture to strive for high efficiency and maximum effectiveness at the least possible cost in their individual efforts in national development. All of them have adapted to the needs in various ways.

Adaptations to agricultural realities. In agriculture the link between research and extension is seen as very necessary in the light of current conditions and has been forged through two general means. The first is through existing setups. The second, and more drastic, is by establishing new integrated systems among the existing organizations, such as merging research and extension into a single department; by having regional research-extension coordination bodies headed by directors with jurisdiction over both services; and by establishing field research centers in which both services formally work together. Most developing countries have adopted a modification of either strategy, with a general tendency toward the latter. For some countries it was enough simply to adopt a policy that would force a change in attitude and to resolve to improve cooperation and coordination between research and extension, as in India, but most were compelled to address the general situation in a more forceful manner, as in the Philippines and the Republic of Korea.

The T&V strategy. One of the most important developments that occurred with the worldwide effort to improve delivery systems was the training and visit (T&V) methodology which was developed by the World Bank on the basis of its experiences in Israel and Turkey. It was introduced for the first time in Asia in the early 1970s with World Bank-financed projects in a few states in India. Generally, T&V methodology involved the transfer of technology by stages from the technology generators (researchers) to the farmers. The researchers train subject matter specialists, who in turn train local workers. These local workers do most of the extension work and regularly visit farmers, particularly contact farmers, who are expected to train other farmers in turn.

The methodology, when it was implemented, was not perfect and had a good number of flaws. It was criticized for its top-down orientation, its failure to adequately encompass local social organizations and farmer participation in decisionmaking, and its

creation of rigidity in farmer-extension worker interaction because of its insistence on frequent, regularized contact. Despite its shortcomings, however, it inspired Asian countries to bridge the gap between research and extension and contributed to the development of alternative styles of management for technology transfer.

Successful Country Experiences

Individual conditions ultimately determine how the research-extension mechanism is adapted in each country. For some, the changes have not been abrupt, but for others they have been quite dramatic.

India. Some countries, such as India, wish to maintain the individual identities of institutions for research or extension, and so the system has not been disturbed too much. The research institution is usually a regional research station operated by an agricultural university, and extension work is done by personnel of the Ministry of Agriculture and Irrigation.

The T&V system is widely used and strives to integrate research and extension through regular training workshops conducted by the researchers for the subject matter specialists in the extension service. The worksnops are held in the regional research stations of the state agricultural university for several days every month. The researchers are selected by the university to participate regularly in the workshops, which cover topics from sowing to harvest and postharvest care. These workshops facilitate the transfer and exchange of information and provide the venue for feedback of field problems and quick responses. This linkage is strengthened further by joint field visits by the researchers and subject matter specialists.

Republic of Korea. The Koreans foresaw the coming of difficult times long before it became obvious to others. They had had to contend with difficult conditions very much earlier, after World War II and the Korean War. To take care of nationally strategic food commodities the Office of Rural Development was established in 1962. It develops new varieties, develops improved cultural practices, disseminates agricultural technology, and trains farmers. These activities are conducted by the bureaus of research, rural guidance, technical dissemination, and planning. In addition, the institutional structure includes twelve institutes and experimental stations and nine provincial offices.

At all levels, from national down to local, research and extension work for important food crops are completely integrated. Because the two service arms are under a specially created office, there is an uninterrupted flow from technology generation to technology verification (in demonstration areas and farmers' fields) to technology dissemination. This office is also involved in all stages of crop production, such as pest and disease control and soil fertility management. Because of the close interaction between the services, farmer feedback and rapid responses to field problems are made possible.

That the Koreans succeeded in solving the chronic problem of national food sufficiency is an understatement. In the mid-1970s they launched a green revolution and in a short time transformed Korea from a rice importer into a rice exporter.

The Philippines. The Philippines has always been beset by low agricultural productivity. It seems to have always had the potential to more than feed its people, but this has hardly been realized. The Ministry of Agriculture itself was not organized to properly promote an integrated approach to the planning and implementation of agricultural development.

Originally, the ministry was composed mainly of highly independent bureaus, which did not have much regard for common planning, prioritizing activities, and coordinating efforts in the field and even at the national level. This situation continued until it was realized that the ministry was lagging behind the needs of the times. The National Food and Agriculture Council had to be created to perform the coordination and central planning function and was largely responsible for making the bureaus of the ministry work together successfully to implement the Masagana 99 rice production program.

In 1980, a significant move was made to improve the situation. The ministry was reorganized and was decentralized down to the regional level. The regional staffs of the bureaus were separated from their national offices and were placed under a common regional director from the ministry. Previously, five line bureaus had operated autonomously at all levels. Now services are provided in a single chain of command from the minister to the regional, provincial, and local levels. A modified form of T&V was introduced under an extension delivery system, which was developed to suit the Philippine situation.

Research and extension linkages are being forged through the Regional Integrated Agricultural Research System, which has established a technology verification network conducted in farmers' fields. Extension workers are trained to handle verification and are closely supervised by researchers based in the research system stations, which are research centers.

This arrangement has led to a more "bottom-up" approach to the diagnosis of problems and to the design of programs. It has hastened the feedback on problems from the field. The new system has also promoted better coordination between the research and extension services.

Normally, technology is passed on to the extension service after it is verified by researchers. In this research system, however, extension personnel work together with farmers and researchers in conducting the verification work. Strict boundary lines, which used to be observed, are now done away with because of the meshing of the people of the two disciplines. We now find extensionists doing research and researchers doing some extension work. It is in the regional verification trials that the linkages between research and extension are occurring in the Philippines.

Prospects for Effective Linkages

The current efforts exerted by the developing countries in bridging the technology gap are not seen to be final solutions, because in a sense they are dealing with human attitudes true to current times. As situations improve and societies become more sophisticated, we can expect further changes. Other schemes may prove to be better at some future time.

Diverse setups have stabilized in different places. The Korean experience saw the advantages of a total fusion between research and extension. In the United States research and extension are undertaken by different institutions: research by academic institutions and extension by the federal and state governments. But the two services have achieved a highly satisfactory relation since extension workers are frequently assigned to the university to carry out adaptive research, while the university research personnel may also be intimately involved in the state's extension activities.

A total integration appears to be becoming the vogue. Egypt has already resorted to such a scheme. It has made the extension service a part of the research council, with

research, extension, and experimental stations under one director. The current experiences in the Philippines have indicated that it is possible to integrate research and extension under one regional director, but the Ministry of Agriculture has yet to effect integration at the national level. The ultimate goal seems to be a system in which professional staff in direct contact with the farmers will not only be qualified to do extension work but will also be competent to undertake applied research in farmers' fields. These personnel would be known as technology transfer specialists.

For the present, it is enough to be able to recognize the internal problems that restrict the links between extension and research and to be adept and innovative in seeking corrective measures. In an international workshop on the T&V extension system held in Thailand in 1982 by the World Bank, the participants suggested several conditions that would help to improve the relation between research and extension:

- A strong, unified leadership to resolve differences between research and extension workers
- A clearly stated strategy of cooperation to make each service aware of how each fits into the general scheme of things
- A common commitment to the goal of serving the farmers in a more direct manner
- Jointly agreed upon national programs and annual work plans
- Regular orientation training for the staff of both services to help each understand the other's purposes and programs
- Staff exchange between research and extension services (Cernea, Coulter, and Russell 1983).

Keeping these suggestions in mind will move us significantly further along in forging the desired synergism of an integrated research and extension strategy to assist our farmers.

COMMENTS BY PARTICIPANTS

Robert Picciotto (World Bank)

The World Bank has tried to arrange marriages between research and extension. In Asia it is just a matter of fine tuning, but Africa is a different matter.

We find that it is easy to agree in principle about what must be done to coordinate research and extension, but the problem is what really goes on. Making any changes in a research and extension system is actually very difficult. The implementation of the T&V system is an example. It is essential to start on a small scale, with perhaps one project, where success is almost assured, to gain the political support. Then you must plan to replicate the experience. Thus, when you expand, you will have a solid base as well as people who know the methodologies and the institutional setup.

Even in instances where there have been successful T&V projects, constraints still exist, such as lack of good subject matter specialists, problems in monitoring and evaluating the management of research and extension, and difficulties in linking research and extension with the work going on in the universities.

Samsundar Parasram (CARDI)

An important question is whether to organize research-extension linkage along commodity-oriented, multidisciplinary groups or along more disciplinary lines, with agricultural research, extension, mechanization, and so forth as separate entities. In many small developing countries, only a few extension personnel are required to service the entire sector. I believe that the extension of technology, as distinct from other extension functions, should be integrated into the technology generation units, where such exist.

Jacques-Paul Eckebil (Cameroon)

For us, research and extension are split, and we also have separate agencies for crops and livestock. We do, however, have a Ministry for Education on Scientific Research, which is trying to bridge the gap, working along several lines. The Committee of Programs, including the various parastatals as members, meets to discuss the plans for the year. The research stations organize field days where farmers come to see the trials. In addition, within individual projects, such as the National Cereals and Extension Project, sponsored by AID (U.S. Agency for International Development), we have a testing and liaison unit, which includes an agronomist and an agricultural economist. The unit's mandate is to find ways to transfer the results of research to farmers, by conducting a regional survey, giving training courses for extension agents, and conducting on-farm trials, with farmers involved at every stage from sowing to viewing results.

The extension sector is very weak and both understaffed and undertrained. We are therefore giving the parastatals responsibility for dealing with farmers in all aspects of production, not just the one cash crop of the parastatal's mandate, but also for food crops. We also have an AID project to create a land-grant type college, with a combination of research, extension, and training.

Robert Picciotto (World Bank)

Where you are dealing not only with the problems of the farmers, but also with the need to rebuild existing structures and to change them, the task is very complex and requires an institutional approach.

Mohamed Bakheit Said (Sudan)

In Sudan, we have two approaches to research-extension linkages. The first is in the irrigated subsector, which is very large, encompassing about 2 million hectares and including the Rahad irrigation and other projects. In this sector the relation between research, extension, and the farmers is managed by four national technical committees on crop husbandry (cotton, groundnuts, sorghum, and wheat); pests and diseases; cotton varieties; and propagation. Production schemes are thoroughly researched for three years at the experimental station and for one year on tenants' farms. The results are presented to the committee, which either passes or rejects the plan based on recommendations of the crop task forces. Every June there is an agricultural education meeting at which researchers, administrators, and tenants discuss the previous seasons's results. The tenants have a big input at these meetings. Even though

the situation is somewhat satisfactory in this sector, there is much room for improvement. In a new project, partly financed by the World Bank, we hope to improve the linkages among research, extension, and training.

The second approach is used in the rainfed, traditional sector, where the situation is far from satisfactory. This includes a very large area, about 1 million square kilometers, of which about 200 million hectares are arable. There are also special projects such as that of the International Center for Agricultural Research in Dry Areas (ICARDA) on fava bean production, conducted by scientists from the center as well as national scientists. This project involves farmers in on-farm production trials. The production constraints include time of planting, frequency of irrigation, and control of pests. The project has been a great success, and yields have increased by more than 50 percent.

Both approaches face infrastructural and staff problems caused by the size of the country. This poses transportation problems, which are expensive to solve, and presents a large variety of agricultural problems because of different geographic and climatic factors. The latter requires extension agents and researchers with specific and widely based education and experience. This, in turn, poses the problem of salary.

Jonah N. R. Kasembe (Tanzania)

We have institutions specializing in cash crops, with divisions for coffee, tea, sugar, pyrethrum, and livestock. Within them are divisions of breeding, entomology, agronomy, sometimes agricultural economics and agricultural engineering, and water management.

In a farming systems project to study both research and extension our food crops are being grouped by zone rather than by commodity. We are thinking of creating more such groups throughout the country, but there are problems in this approach also. For example, maize was researched on a national basis and coordinated in one central region, but it is grown in several agro-ecological zones and as part of many farming systems. It is a very complex situation, and we need a subject matter specialist; a general agronomist is not equipped to deal with this. Still, we think this approach is better for our programs, since the shift from a commodity basis to a farming systems basis has shifted the emphasis from cash crops to food crops.

Samsundar Parasram (CARDI)

The Bean Development Project of the Interamerican Institute for Cooperation on Agriculture (IICA) has used a successful methodology to develop better production technologies for farmers in Guatemala who grow beans under widely different conditions. Not only are the farmers at different elevations—on the slopes and level plains—but some are growing beans as their only crop and some as part of a mixed cropping pattern.

In this scheme, the researcher is still in control during the on-farm test, but the process can occur at many locations. For the on-farm verification, the farmer is in control and is assisted by the researcher and the extension agent. Any problems at any stage are referred back to the station. If there is a problem at the station, it goes back to IICA.

Edgardo C. Quisumbing (Philippines)

The research and extension linkage for rice, as a single crop, worked very well. But if there are many extension agents in the field, each specializing in a different crop, they get in each other's way and confuse the farmer.

John J. Ondieki (Kenya)

We had a similar approach with maize in the late 1960s and early 1970s. The system works quite well when introducing a new crop or to achieve a certain purpose, but it is less successful as a continuous program.

Roberto Martinez Nogueira (Argentina)

Our National Institute of Agronomy faces a very complex situation. There are many different regions, and the institute works in all of them. Also, the institute has evolved under two very different sets of circumstances. Before 1970, it was the only institution in the country working on research and extension. There was a period of high growth, and, after 1970, many public and private institutions worked in the field, collaborating and competing with the national institute.

In the earlier period, the objectives were clear. Research was done on the main regions and emphasized export crops. Then the objectives, strategy, priorities, and communication within stations became complex and unclear. Now we are thinking both of reorganizing the whole system to give more autonomy to local stations and of organizing the research-extension linkages along agro-social systems, as is done for research on farming systems.

Eliseu R. de Andrade Alves (Brazil)

In Brazil, the situation is very complex. For example, for cocoa, there is an integrated project where extension and research are being carried out together. For sugar cane, the private sector is doing very intensive research. In the universities, teaching and research are done on a large scale. In Vicosa University alone there are perhaps 500 doctorates doing teaching and research. In the Ministry of Agriculture, EMBRAPA (Brazilian Agricultural Research Corporation) is responsible for research based on the model of the international centers. EMBRAPA also works with the states, which have their own research organizations, and finance. The extension service is centralized, consisting of a small coordinating agency and the state offices. The private sector, including some farmers' co-ops, is very strong in extension.

There are two main problems in extension. The basic problem is the lack of good research results to extend. Successful extension work depends on having good research results. For example, twenty to thirty years ago soybeans were not produced in Brazil. Now we are the second largest producer in the world. Research from the southern United States and our own research combined with the extension service have worked very well in developing this crop. The problems we have in bean production are due, not to extension failures, but to a very serious technological bottleneck.

The second main problem is that there can be a tremendous difference between the social and private benefits of most technology created by research. Sometimes there are high social and relatively low private benefits. For example, irrigation technology has a very high social benefit, but if the government does not build the irrigation, the farmers

will not do it. Another example is that in Brazil we could produce three times as many beans as we do now. The problem is that there are three bean diseases, which are transmitted in the bean seed and which seriously reduce yields. It is too expensive to conduct private research on these diseases, so the private sector will not do it. The government must do it, or it will not be done.

In my opinion, you can organize the links between research and extension any way you like, but what you need most is good technology combined with a way to bridge the gap between the social and private benefits. We criticize the extension service for lack of success, but these are the real problems.

M. V. Rao (India)

The extension system in India is also very complex. Education and training in agricultural research are part of the university system. There are twenty-three agricultural universities, based on the U.S. land grant system. The state is responsible for implementing policies in agriculture, coordinated by the Ministry of Agriculture. The Indian Council of Research coordinates research and university curricula, and the Department of Agriculture extends the knowledge, in coordination with research. There are currently about seventy agricultural projects in process, some organized by crop and some by discipline.

Forty-two extension stations are working on wheat and seventy-two on rice. All the various disciplines are represented at each station, and many include basic research activities. We give the highest priority to demonstrations on farmers' fields. In the projects aimed at the entire country, we develop and test new varieties, and within three years we produce a package of practices to give to farmers.

National demonstrations are held, at which the extension agents pose questions to the scientists in the field. Every university also has field days twice a year, which the farmers attend. We train subject matter specialists and stress the importance of a cropping system approach, because it is more helpful for the farmers to try to increase their total farm income. In one program, we train village farmers for six months. In our "back-to-the-land" program, the researcher must work on the farmers' fields for six months. We have a program of "village adoption" where a university adopts a village, as well as operation research projects to attack specific problems, such as brown leafhopper in rice.

There are eight regional committees in which politicians, administrators, and scientists meet to discuss problems every year. In our Production Commissioners' meetings, twice a year, all the managers come to Delhi and then pass on information to the countryside. Parliament members also pose questions raised by farmers.

We have had some considerable success stories, such as the World Bank cotton project. Some significant problems persist, however, such as:

- A shortage of mid-level technicians, graduates, and undergraduates to work in the villages
- The use of improved technology more in the irrigated areas than in the dryland farming areas
- The unwillingness of extension workers to live in the remote villages.

The T&V system has worked very well in some projects. We have taken yields from 27 tons per hectare to as high as even 97 tons per hectare. Radio, TV, and newspapers all help to extend the improved technologies. What we still need is mid-level technicians to live in the villages. Also, it is true that farmers will figure out their own economics. If the nation benefits from a new technology, but the farmers do not, they will be hesitant to adopt it.

Robert Picciotto (World Bank)

In the socialist countries, the government seems to recover the costs of the transfer of technology. How does that work?

Balint Szalocry (Hungary)

In Hungary, we have about 1,400 cooperatives and 114 state farms. The average farm is 5,000 hectares, and each has its own technical and extension experts, a team varying from 10 to 200 university graduates. Usually about 200 to 250 units belong to a major production system and about 30 to a small system.

Research is disseminated in different ways. In the traditional way, the universities and the research institutes extend technologies through training, demonstrations, and contracts with state farms or cooperatives for problem solving.

Twelve years ago we began a new production advisory system, which cooperative and state farms join voluntarily. The headquarters of the system provides the technology, including special services, such as soil analysis, seeds, farm machinery, and fertilizers, and guarantees certain results if the recommended production system is followed. If the yield increases, for example, from 5 to 6 percent, farms will pay 1 to 2 percent of the value of the surplus production. If the contracting unit fails to achieve its goals based on a five-year average, it pays the farm compensation.

The headquarters of the production system collects research findings from all over the world. There are now about fifty production systems competing, and farmers can decide which ones to use. There is no need for extension work between the farmers and the researchers because of this production system.

Papa I. Thiongane (Senegal)

We have a system of multidisciplinary teams in the field, which began ten years ago and which we tried to improve with the help of the World Bank two years ago. The teams consist of agronomists, microeconomists, sociologists, and so forth. They follow a set procedure.

First they go to the field to survey the farm situation. They analyze their data at the station, to understand the traditional system before they attempt to change it. The team then works with scientists to develop an improvement plan, which is tried at the station and in the farmers' fields. The plan is popularized by the extension service, and special units in each region meet to decide upon the next year's program. Finally, an internal team review identifies new priorities of research and extension. Some problems arise with this system because research and extension are not in the same ministries.

Dominic E. Iyamabo (Nigeria)

We have subject matter specialists who integrate the work of researchers with that of extension agents. This was done in our international food project for maize, cassava, and sugar, which was very successful. Our research institutes have annual recommendation conferences, in which agricultural extension workers and farmers participate.

We have proposed, although it is not finalized yet, a reorganization on an ecological basis, with crop research institutes for each zone, which will be responsible for research applicable to that zone, including genetic research, and for conducting training and other services.

The nature of the recommendations made by the extension service is very important. Farming is a business, and the economic, social, and cultural aspects are as important as the biological improvements. Therefore we should involve farmers more in defining the problems.

Amir Muhammed (Pakistan)

We have at least a dozen distinct agro-ecological zones, and we are now also planning our research on the basis of these zones. Within each zone, the level of adoption of agricultural technologies varies tremendously among farmers. In addition, the farmer working 100 to 200 hectares will use a very different technological package than the one with 1 to 2 hectares, who uses family labor and perhaps no fertilizer and for whom the straw is an important part of the grain crop. We are conducting an inventory of agricultural conditions and socioeconomic systems, and the results so far are excellent.

Robert Picciotto (World Bank)

The responsibility of researchers to farmers is an issue. Poor researchers blame the extension agents, but the researcher must be in touch with the farmer to know what the farmer needs. This is an organizational problem.

Eliseu R. de Andrade Alves (Brazil)

In Brazil, we originally considered extension as a bridge between the researchers and the farmers, but we found that the communication from farmers to researchers through the extension service did not work. We now believe that research workers should have direct contact with farmers, visiting either each farm or a sample of farms, because the extension agents do not have the theoretical training to translate the message to the researchers. Extension work is needed to diffuse research results to farmers, not to define the problem.

Jacques-Paul Eckebil (Cameroon)

But you cannot achieve good contact between researchers and scientists when farmers are dispersed all over the country.

Yookti Sarikaphuti (Thailand)

The extension agent is a jack-of-all-trades. The researchers may go to the fields, either from the central research station or from a satellite station, but in Thailand, when they go to the field, they contact the extension agent.

Samsundar Parasram (CARDI)

The extension agent by himself cannot be expected to define the problem. One solution is that multidisciplinary teams of researchers be required to spend time in a specific area with farmers and extension agents, to identify constraints and priorities, to research the problems, and to propose solutions. Afterwards, these proposals are disseminated by extension agents.

Carl Pray (Observer)

In the United States, there are several links between the farmer and the researcher. The research priorities of the Department of Agriculture do not all come from the extension agents. Some come from the farmers' commodity organizations. In diffusing technology, extension plays a relatively minor role because the private sector and the cooperatives play a major role. Farmers will pay farm management companies to get the information they need.

Samsundar Parasram (CARDI)

In the developing countries, however, the public sector is dominant, and we still need traditional extension, although this may be delivered in traditional or nontraditional ways, such as by radio, visits, or written material.

Amir Muhammed (Pakistan)

There is an urgent need for agricultural research councils to do research on extension methodologies best suited to the special ecological regions, different crops, and various socioeconomic groups of their country. Extension departments in several developing countries are unfortunately not organized to transfer knowledge effectively to the farmers. Most farmers feel that even if the extension services were abolished, agricultural production would not be adversely affected. This is not to say that extension itself is not important, since there has to be a way to transfer knowledge from research to the farmers, but the organization of the extension services and the methodology used to communicate information need a close look and should be an important subject for research in most developing countries.

John J. Ondieki (Kenya)

But passing out information about new research results to the farmers is only one function of the extension workers. They also look at loans and evaluate how the farmers are doing.

Amir Muhammed (Pakistan)

The extension workers perform all kinds of administrative activities and often do very little extension, that is, transferring knowledge. Because extension personnel are often used by all other agencies of the government to do odd jobs, their linkage with research is very poor. Therefore, they are neither knowledgeable nor geared to transfer whatever little knowledge they may have to the farmers. The whole setup needs to be reorganized to clearly identify personnel for extension work exclusively; their only responsibility should be to transfer the latest knowledge from research to the farmers

and to communicate the farmers' problems to the research scientists. The routine administrative functions, such as mounting special campaigns, enforcing government laws concerning agricultural activities, and coordinating the distribution of inputs should be done by persons other than extension agents.

Ibrahim Manwan (Indonesia)

In our system the responsibilities for the various functions are shared in different proportions between the extension agents and the researchers. In generating the technology, researchers have most of the responsibility, but there is some input from the extension service. During verification, the technology comes from the researchers, but the extension service also does some research. In the dissemination stage, the researchers still provide some help, but the extension agents have most of the responsibility. If we have something good to transfer, it is very easy to coordinate.

Eliseu R. de Andrade Alves (Brazil)

We distinguish between extension and research. Extension is meant for diffusion, but it also has been used for general education. The role of extension in the United States is the model for this. In the early days of the extension system, transfer of technology was only one part of its role; general education and creating a general feeling for science was an important element.

Robert Picciotto (World Bank)

Agricultural extension has changed to the point where the workers now are full-time agriculturalists, not "jacks-of-all-trades." The T&V system uses specialists, because the researchers are not really equipped to diffuse technology. Radio, TV, and input suppliers will diffuse it to some extent, but a good extension service will do so faster.

Fernando Gomez Moncayo (Colombia)

The research-extension process, which we call research-technology transfer in Colombia, is really not two processes, but one. We have the problem that our specialists have become so specialized that they cannot communicate with each other, and the one who is shortchanged by this is the farmer. We all must speak the same language to participate in multidisciplinary work to make research and technology transfer a success.

One of the most important elements in this process is on-farm research. The critical advantage here is that the new technology or knowledge is tested under actual farm conditions and is compared with the farmer's current treatment, not a "zero" treatment. This implies, for instance, that the planting will be done, not by researchers and their workers, but by whatever labor the farmer normally employs.

Summary

There is a degree of consensus about the kinds of difficulties faced in arranging these marriages between research and extension. But there are strong differences of opinion about the best policy and structures needed to achieve the desired results. Different

structures are appropriate for different situations, and the question of a methodology for research and extension is itself a subject for research.

There are three main issues:

- Macro issues that center on the structure of the organization doing research and extension within a country.
- Micro issues that concern the roles of the various groups within the system such as researchers, extension workers, subject matter specialists, and farmers, and the mechanisms needed to coordinate their roles.
- The constraints that keep research and extension systems from functioning as envisioned.

Macro issues. On a national scale are the questions of who provides research and extension; who oversees it; and how are priorities generated, the results analyzed and evaluated, and adjustments made. There are many structures in, and degrees of satisfaction with the workings of, specific country systems. No one type of organization works better than the others, and the enormous differences among national situations—historical, geographic, demographic, and economic—dictate that different systems be established.

In most developing countries the main responsibility for both research and extension and their linkage is considered a function of the public sector. Ministries of agriculture and other ministries, research councils, national technical committees, and delegations for scientific and technological research, land-grant type universities, and special project units all play a role in public sector research and extension. In some countries parastatals and private sector groups—from farmer-producer cooperatives to agrobusiness companies—play a large part in providing research and extension. Interestingly, the private sector plays a large role both in countries where the national research-extension system is poorly developed and in countries, such as Brazil, where the public sector research and extension systems are very strong and the private sector is also very strong in research and extension. Although the mix of public and private sector research and extension may vary, it is important for the public sector to engage in research and extension where there are significant differences between the social gains and the individual gains.

There are many circumstances in which private companies and farmers, singly or in cooperatives, can and will pay for the products of research if they have access to inputs, management help, and so forth. Certain kinds of research and extension, such as certain kinds of public works (for example, irrigation projects), have usually been done not by the private sector, but through government funding and management. Historically this was true for countries, such as the United States, in which the land-grant system with its research and extension was a critical element. Today multinational corporations and private companies provide some of these services in developing as well as developed countries. In Hungary, where the farming is done on a large scale with cooperatives and state farms, research and extension are, of course, public sector activities, and yet, within that context, the cooperatives contract with research institutes and pay the institutes for their part in increasing production. However, on the whole, the private sector plays only a very minor role in research and extension.

The degree of centralization versus local autonomy depends on the size of the country, its economic status, and its historical development. A major element of this issue is the question of how to organize research and extension:

- Along commodity lines (for example, corn)
- By discipline (for example, crop breeding)
- By a farming system (for example, small farmers, multicropping patterns)
- By ecological zone (for example, a dry land region).

Various combinations of these options are used by different countries, and some countries are switching from one system to another or developing a new emphasis. All of the options for organization are appropriate and successful in some situations.

Micro issues. Some of the liveliest and most interesting discussions centered on the question of the proper roles for extension agents and others who form the links between the generation and the application of research. In general the process is considered to be a sequence of activities which must take place and which must be linked in some way so that information flows freely among participants:

Research (basic and applied) → Generation of technology → Testing of technology → Validation of technology → Dissemination of technology

There are great differences of opinion, however, as to how these linkages should be achieved, particularly who should perform which aspects of the activities, and what structures and linkages would make the process function as a whole.

The simple idea of seeing the extension agent as a two-way link between farmer and researcher has undergone some modification. Some believe that it is imperative that researchers actually go to the farmers to understand their needs and to decide what research they can do. An extension agent cannot do this job for the researcher. What the extension agent can and should do is to diffuse the new technology after it has been developed. Others believe that this is an unworkable idea because of the large size of their countries and small number of research workers and that extension agents should retain that role. Still others believe that this linkage is properly filled by a subject matter specialist functioning as an adjunct to the generalist extension agent or that a multidisciplinary team, in conjunction with farmers and extension agents, should analyze situations and determine what can be done with available resources, after which the extension agent should disseminate results

Extension agents must take on a wide variety of functions, including supplying broad educational services, analyzing farm finances and performance to establish credit arrangements, as well as disseminating new technology. This view of the role of extension agents is contrary to the philosophy of the T&V system but, nevertheless, it was held by most of the participants—all high-level research officials. As economies develop, more of these services may be available elsewhere, but in the present state of many developing countries, extension agents will have to cover these functions.

Constraints. Many specific constraints are common to many countries, but to varying degrees. For example, many countries have trouble recruiting and keeping good researchers and extension agents to work in remote areas. This problem has been solved by providing strong incentives (higher pay, bonuses, free housing, educational opportunities, and so forth) to technical workers in remote areas, but often governmental and civil service policies do not allow this.

Other constraints are a shortage of specialists, particularly in agricultural marketing and horticulture; lack of trained research managers; inadequate economic infrastructure; and inadequate governmental support for research. Numerous problems of linkages include communication problems caused by different functions being performed by agencies under different ministries; inadequate ties with universities; lack of mechanisms to bridge gaps; and, specifically, the difficulties of reaching a very large number of very small farmers, especially in the poorer, rainfed areas where traditional technologies are predominant.

Above all, however, there are really only two reasons for the failure of extension:

- The lack of good, usable research results to extend
- The difference between social and private benefits of technology adoption, which can be very large. Farmers are business people and make decisions on the basis of the potential benefits they see for themselves. If the social benefit is high but the private benefit low, the technology will not be adopted. A way to bridge this gap must be found.

There is a great variety in the structure and performance of various extension systems. Some are in the process of construction or a major overhaul, whereas some need only fine tuning. The question of how to arrange a system to get the desired performance is very much open to debate.

Session 6

Agricultural Research Councils

Agricultural research in developing countries generally is more personalized than organized and depends largely upon the initiative, vigor, and level of training of individual researchers. In recent years several countries have tried to design a national policy for allocating scientific resources that would ensure a balanced program in which the needs of the economy are satisfied within the limits of the resources available. The organizational forms adopted for this purpose vary from country to country, but generally are based on two scientific coordinating bodies

- A central body that formulates national science policy and then organizes and implements research, usually under the authority of a special minister of science
- A central body that formulates national science policy, but then only coordinates the activities of the research bodies, which are under the direction of the ministries concerned.

A more or less common structure for the central body is an interministerial committee for scientific and technological research made up of those ministers who are directly concerned with research (such as finance, education, defense, industry, public health, and agriculture) and whose main function it is to advise the government about formulating research policy and allocating resources for research and development. They are usually assisted by an advisory panel on scientific policy, composed of senior scientists and department officials, who prepare the proposals for the interministerial committee, advise on the formulation of policy, attempt to define a balance of scientific effort between different fields of endeavor and between pure and mission-oriented research, and draw attention to deficiencies in the overall research effort.

At the next level are the national councils for research, which organize and coordinate scientific and technological research. These bodies are variously named Council of Scientific and Industrial Research (India) National Council for Research and Development (Israel), National Science Development Board (Philippines), Commonwealth Scientific and Industrial Research Organization (Australia), National Council on Scientific Policy (Belgium), National Research Council (Canada), and so forth.

In certain countries, the national research council functions in an advisory capacity only and coordinates research carried out by various agencies; in others, the councils also have executive functions and establish and administer national research institutes and laboratories. One of the first duties of a scientific council is to determine if all fields of scientific effort are adequately covered and to provide the means for eliminating any existing gaps. This requires an inventory of the country's scientific resources, in

particular its scientific expertise, and a study of the distribution of research in relation to the needs of the country.

In most countries the council is an autonomous body, most of whose members are scientists appointed as individuals and not as representatives of institutions. For the council to be effective in setting policy, it is essential that the members have ready access to political leaders and even participate in policymaking. It is therefore desirable to include in the council the directors of the government ministries that have an interest in the problems with which the council is concerned. The council thus provides a framework within which top scientific and political leaders regularly work together.

When the research council has no executive functions, it can influence research policy by allocating funds according to the priorities it has established, by having representatives on the boards of the research institutes, and by making recommendations to national policymaking bodies.

Agricultural research councils (ARCs) or their subsidiaries have five main functions:

- To advise the ministry of agriculture and the council for research and development on all aspects of policy and implementation regarding agricultural research. This includes reviewing research projects and setting priorities, irrespective of who finances and executes the research; financing research from governmental or other sources; allocating and training scientific and technical research staff; and organizing research, relations, and coordination among research institutions.
- To inititiate and encourage new fields of research, if needed
- To ensure that the research policy outlined by the committee and approved by parent bodies is implemented
- To organize and encourage the exchange of scientific personnel between countries
- To serve as a clearinghouse [illegible] all aid programs for agricultural research between developed and developing countries.

ARCs have three main advantages. They legitimize decisions and advice on agricultural research, because they include representatives of relevant ministries. The quality of decisions and advice tends to be more substantiated and detailed because of the variety of entities involved in agricultural research. Implementation is improved because several key people participate in the decisionmaking process.

The disadvantages of ARCs are related to deficiencies in their organization. It is very difficult to design a system that coordinates several agencies for united action given the political and financial constraints. Another disadvantage is that people who have the authority to sway opinions or influence policy usually do not have the time to participate in the council's meetings.

THE STRENGTHS AND WEAKNESSES OF AGRICULTURAL RESEARCH COUNCILS

Amir Muhammed, Pakistan Agricultural Research Council

The economy of most developing countries depends largely on agriculture. The area available for cultivation has decreased, however, because land and water have had to be used for nonagricultural purposes to meet the needs of the rapidly growing population.

During the past decade this situation has put considerable pressure on increasing the productivity of limited resources. The situation is going to continue to decline because of the increasing population and diminishing resources of land and water. The only solution is to improve the productivity of the available resources through the efficient use of land and the valuable inputs. This is possible only by using improved agricultural technology produced through well-organized and multidisciplinary basic and applied research.

Systems

Agriculture is practiced under different conditions in each country. In addition to a wide variety of agro-ecological diversities, there are different socioeconomic milieus and administrative-political setups, such as different tenurial systems, sizes of land-holdings, literacy levels, socioeconomic statuses, and attitudes of farmers, as well as several commodities being produced under different farming systems in different areas by various categories of farmer. As such the system for agricultural production is highly complex, and each country has to develop suitable agricultural research and production systems according to its particular needs and available resources.

The main purpose of agricultural research is to devise the production technologies best suited to different agro-ecological situations, to reduce the cost of production, to minimize the element of risk, and to maximize the income of the farmer. The various production technologies have to be incorporated into a sound agricultural production system capable not only of meeting the country's requirements for various commodities for domestic consumption, but also of generating surpluses for export to stabilize the national economy. Establishing a sound agricultural production system requires the strong backup of an extensive national agricultural research system linked with the central government ministries that deal with planning, commerce, industry, trade, science, and technology, as well as with agricultural production organizations at the grass roots.

The agricultural research systems in different countries have evolved in different ways depending mainly on the specific needs and resources of each country. Some countries, such as the Republic of Korea and Argentina, have highly centralized systems with a single federal body, which controls all agricultural research and extension in the country. In other countries, particularly those with a federal-state form of government, parallel research is carried out by the federal and state research institutions, or at least the responsibility for agricultural research is shared between the federal and state institutions. For example, in the United States, which has a federal-state form of government, the responsibility for national research is shared by the federal and state institutions conducting agricultural research. The federal government maintains its research organization, the Agricultural Research Service under the Department of Agriculture, which controls several regional institutions serving the interests of several states, but each state also has its own research establishment, which serves the interests of that state. Despite the divided responsibility for agricultural research, the U.S. research system has a built-in mechanism to coordinate the whole activity in the country to best utilize the resources expended on agricultural research.

In countries such as Pakistan, however, which also have a federal-state form of government, research systems are not well organized, and more than one ministry is

involved in conducting and managing agricultural research, at both the federal and state levels. Moreover, within each ministry, the research is either concentrated in a single department or fragmented in different departments, depending on the subject matter, or is vested in several semiautonomous institutions. As such, the provincial and state departments work in isolation and have no central organization to guide and coordinate their policies. Because of this lack of coordination, the cooperation between the center and the provinces in a vital field is weakened, and the utilization of resources is less efficient. There is an urgent need for a central organization to coordinate and direct agricultural research in the states and provinces. Efforts are being made in almost all countries to streamline agricultural research and to centralize the planning and coordination of agricultural research, education, and extension activities to improve the overall performance of the agriculture sector.

To achieve this objective, several countries have organized national ARCs, which usually have a charter to undertake, aid, promote, and coordinate all agricultural research, education, and extension activities in the country. ARCs in several countries have successfully improved the performance of their agricultural research systems and have proved particularly effective in organizing viable research systems in countries with few trained scientists, scarce financial resources, and meager infrastructural research facilities. The ARC concept has many strengths as well as some weaknesses.

Strengths

ARCs make possible the centralized planning, coordination, monitoring, and evaluation of all the agricultural research in a country. This system not only permits judicious utilization of scarce research resources, but also minimizes or eliminates the overlapping and wasteful duplication of research work. The ARCs are usually headed by the central minister for agriculture, and the governing body has representation from all concerned interests, such as scientists, farmers, planners, policymakers, and the various provincial or state governments, so that research programs and plans are developed and approved according to the national priorities as well as the requirements of the farmers in different parts of the country.

The councils also can strengthen research in provinces or states by implementing short- and long-term projects and nationally coordinated research programs on important crops and other commodities. The coordinated programs on wheat, rice, maize, and food legumes have proved highly successful in several countries including Pakistan. The ARCs provide a coordinator for the program and the necessary commodity experts. The coordinator prepares the national research and production plans for the particular commodity in consultation with the experts in different provinces or states working on the commodity. The federal coordinating agency provides germ plasm from national and international sources, as well as additional funds and other special requirements that the cooperating scientists may need to undertake the planned research. Every year the cooperating scientists meet to discuss the results of the previous year's experiments and to modify their research programs in the light of these results. This mechanism has worked successfully in countries in which the major commodities require a coordinated research approach but in which applied agricultural research is largely a responsibility of the provincial or state governments.

ARCs can undertake basic research to solve intricate problems for which facilities in the different provinces or states are not adequate or for which such research can best be done at a central institution. Although some developing countries have attained self-sufficiency in the production of food grains and some other commodities, there are periodic fluctuations and sometimes serious shortfalls in production. To improve and stabilize the production of various commodities, basic research on new diseases, insects, environmental problems, and socioeconomic aspects is required to back up the applied research in different parts of the country. Because of the high costs of the sophisticated research facilities required for basic research, it appears more feasible to establish central facilities under the control of ARCs. Such facilities would also cater to the basic research needs of the provincial or state institutions.

In addition, ARCs can formulate and implement well-balanced and comprehensive training programs. In most developing countries there is an acute shortage of qualified and trained scientists, even in important areas of research. The educational programs depend mostly on the training facilities from the developed countries, but these generally do not fulfill the needs of the developing countries. ARCs can play a vital role in coordinating and planning the development of scientific expertise to match the needs of each country by organizing training programs within the country and at carefully selected institutions in other countries.

Finally, ARCs help to develop international linkages and collaboration. It is more feasible to establish links with other countries and the concerned international agencies through a centralized national agency. This also helps to attract financial assistance from donors who find it easier to deal with one national organization than with many small provincial or state institutions.

Weaknesses

ARCs lack administrative control over provincial or state institutions. Because the ARCs do not directly administer all the research stations in different parts of the country and usually perform only the coordinating role, in many cases the provincial or state governments do not follow the plans prepared by the ARCs, often because of the vested interests of individual scientists. In such cases the ARCs do not have the authority to make and implement decisions, which results in overall inefficiency of the research system.

The ARCs usually have few links with the extension systems. This limits their ability to effectively transmit the research findings and the production technologies generated through research to the ultimate beneficiaries. Since extension in most countries is a provincial or state responsibility, the ARCs generally are discouraged from establishing links with extension services, and it is thus difficult for research to improve agricultural productivity.

The linkages of ARCs with educational institutions are also not encouraged by the provincial or state institutions. Here again, until the overall plans and programs of agricultural research are reflected in the teaching and research programs of the agricultural colleges and universities, the whole agricultural production system in the country will be ineffective. Therefore, there is an urgent need to link the agricultural education institutions with the ARCs so that the courses taught as well as the number of graduates in different disciplines reflect the needs of national agriculture research, teaching, and production systems.

In conclusion, the best way to organize agricultural research in a country is through a strong central organization such as an ARC. This has obvious merits, especially for the developing countries, which are short of financial and trained human resources. In establishing centrally organized research systems, however, ARCs must have the power to control, coordinate, and direct research, education, and extension systems in a country. It would be desirable to examine the successful ARCs in selected developing countries, particularly the problems faced and the measures taken to overcome the problems. This will reveal various patterns for organizing ARCs in different countries, which depend on their particular political system, socioeconomic characteristics, and available resources.

Agricultural Research in Pakistan before 1978

The Pakistan Agricultural Research Council (PARC) was reorganized as an autonomous body in 1978 in the wake of the worst wheat crop in history, caused by yellow and leaf rusts. Previously agricultural research had been done largely in many experimental statins, which were run by the provincial governments and which had very limited capability to undertake meaningful research. However, because agriculture is a provincial concern in Pakistan, the provincial governments tended to maintain their exclusive right to undertake agricultural research, so that no meaningful mechanism could be developed to have a national system. From the partition of British India, Pakistan inherited an agricultural college and research institute at Lyalopur (now Faisalabad) in the Punjab province and a provincial agricultural research station in each main province. In 1947 there was an Imperial (now Indian) Council of Agricultural Research (ICAR), with several prestigious research institutions including the famous Indian Agricultural Research Institute at New Delhi (the so-called "Poosa" Institute) and the Indian Veterinary Research Institute at Izzat-Nagar, but none of the central institutes of the ICAR were located in the areas that became Pakistan. Thus, Pakistan did not get even a nucleus of a central agricultural research organization and inherited only institutions in the provinces.

All efforts by various national and international organizations to create a counterpart of the ICAR in Pakistan were frustrated by provincial politics for nearly two decades. Subsequently, in 1968, when the country faced severe food shortages that necessitated massive imports, the government organized a Pak-U.S. Joint Agricultural Research Review Team to suggest measures for strengthening agricultural research to boost agricultural production. The team strongly recommended creating a network of central research institutes, including the National Agricultural Research Centre, in addition to strengthening the provincial experimental stations and linking agricultural research, education, and extension in a national network. The report could not be implemented for five years, however, in spite of its acceptance by the Cabinet.

In 1973 the second Pak-U.S. Review Team endorsed the earlier recommendations and concluded that none of the recommendations of the earlier team had been implemented. The second Review Team again strongly urged the government to develop a national agricultural research system immediately to avert major disasters to the country's agriculture. A sizable agricultural research project was also developed with the assistance of the U.S. Agency for International Development (AID) to implement the recommendations of the two review teams, and funds were committed in 1974. Because of the very cumbersome procedures for developing new research facilities and training scientists, however, the grant from AID could not be utilized for about four years

despite the approval of the highest authority in the country and the availability of funds. The situation was considered highly unsatisfactory by the AID Review Mission, which recommended that unless the government utilized the funds, the project should be terminated. Subsequently, in July 1978, PARC was reorganized into an autonomous body, and a professional scientist was appointed as a full-time chairman. The government procedures were also relaxed to enable PARC to utilize the funds placed at its disposal. Subsequently, the developments were quite rapid, and PARC has been established as a viable national organization, coordinating and promoting agricultural research in the country.

Organization and Role of PARC

The government has given PARC enough funds to carry out its activities and has delegated authority to make important administrative decisions and utilize the funds. The chairman of PARC is also concurrently appointed as secretary to the federal government agricultural research division, which is a unique arrangement in Pakistan. This measure has enabled PARC to play a significant role in making policy on agricultural research and has given a large boost to agricultural research in the country.

PARC plans and coordinates agricultural research in the country even though most of the applied research is done in the provincial research institutes and experimental stations. PARC has substantial funds for grants to research institutions and individual scientists for research on selected problems. In addition, several large development projects, especially with AID and the World Bank, have a liberal provision for training scientists within the country and abroad, which PARC is utilizing to build up research expertise at the national and provincial levels. In addition, PARC has established about a dozen nationally coordinated research programs on major commodities, which organize multidisciplinary research in close collaboration with the provincial scientists. This device has successfully provided farmers in different parts of the country with the appropriate production technology for improving crop yields.

The way an ARC is governed is quite important for its successful operation. In Pakistan, PARC has a board of governors, headed by the federal minister for agriculture. It includes representatives from all the provinces, agricultural universities, eminent farmers, and scientists, besides the chairman and full-time members of PARC. The board, in consultation with all the agencies, especially the provincial governments, approves the programs, policies, and budget of PARC. As a result PARC has been able to establish a system with good credibility with the farmers and the provincial governments. There is still a long way to go because there are large deficiencies in the research programs, but the system is well established and has been accepted by all concerned.

Efforts are currently under way to organize the agricultural extension activities in the country with a strong linkage to PARC. Extension will of course continue to be a provincial responsibility, but PARC will undertake research in extension methodology and provide the software to the provincial extension agencies to improve their programs. PARC has realized that the efficiency of the national research system will depend largely on the quality of both agricultural education and research in the universities and that the two have to work closely.

Thus, PARC is coordinating the activities of all the agricultural universities on the pattern of ICAR so that the curriculum is both improved and brought in line with the needs of the country and the research is coordinated and improved. Similarly, the close

association of the extension activity with research is a prerequisite for improving agricultural productivity. Several review missions have reported on this subject, and the government is currently considering what must be done to improve the coordination and linkages between agricultural research, education, and extension.

The funds for agricultural research should be adequate and not subject to frequent cuts from year to year because of the changes in the overall national economy. Previously, PARC got funds through the cess levied on agricultural exports, but the income varied with the production of different exportable commodities. The overall funds available to PARC for research used to be highly inadequate. Lately, the government has started giving enough grant-in-aid to PARC for all its activities. We have now requested that a sizable revolving fund be established to ensure that the critical activities are continued even if the country goes through a period of extreme financial stringency.

Last, PARC has realized the urgent need for well-trained research managers to efficiently organize and administer the rapidly developing network of research programs and institutions. Without such expertise, the large investments in developing research facilities are likely to prove inefficient. Because of these considerations, PARC has embarked on a program to train about 100 persons in the broad aspects of research management so that they can administer its various institutions and related activities in the coming years.

While every country has a unique set of circumstances for agricultural research, the experience of Pakistan in organizing its national system can be useful for other developing countries that are reorganizing their agricultural research into an effective national system.

COMMENTS BY PARTICIPANTS

Robert Picciotto (World Bank)

Despite our progress in agricultural research and in increasing agricultural output in the past two decades, we still have a global food problem because the population has continued to increase, and the demand for food has remained inelastic. More important, we have very severe regional food problems, particularly in sub-Saharan Africa, where the picture is very grim indeed. The need to develop the right kind of agricultural technology is critical, and yet there is no clear-cut model of how to do so.

More and more questions are being raised about the effectiveness of the present national and international organizations. The overall returns to agricultural research are high, but that does not mean that all the components are as efficient as they should be. The financial squeeze being felt by the developed as well as the developing countries means that we must do more with less. This is the mandate for the 1980s. There are three avenues of inquiry to attempt this.

The first is to determine whether agricultural research is a part of research generally. Is it too parochial? Intellectually and institutionally, agriculture has remained an island. This has ensured the efficiency of large-scale production, but it has been very costly. The question is how to combine the vigor of autonomy, which brings power, with the intellectual cross-fertilization of association with other disciplines.

Second, there is a significant private component to agricultural research. Before the twentieth century, most research was private. Socialization is necessary, since private parties can only make use of the benefits, but the inefficiencies in the public sector are

causing impatience. Some systems are just too large, and some have other weaknesses. An example of effective private research is the growth of biotechnology research and the patenting of biological life in the United States. This brings up the question of whether budget controls should be shifted to the users of research, rather than to the practitioners. Relatively little of this has happened in the developed countries. There is the model of the National Institutes of Health in the United States, which is autonomous and finances large-scale projects, or there is the other model of the land grant universities.

The third issue is the structural question. There are four distinct models for research and extension: the ministry of agriculture; autonomous institutes, particularly in Africa; the agricultural research council; and the integrated research and extension model.

Some countries have a combination of these institutional forms. There are problems of coordinating the influences of the various sources of funds. There are questions about how to make changes in the systems: is the gradualist approach better, or is a drastic change preferable? The answer appears to depend on the circumstances.

There are also issues of whether to organize research along disciplinary or commodity lines, with regional approaches, or as decentralized or centralized, and how to assure a steady flow of support. Ultimately, the real issue is how to liberate the inventiveness of the scientists.

Jonah N. R. Kasembe (Tanzania)

Tanzania's national agricultural research system is under the Tanzanian Agricultural Research Organization, which has a governing council. The council plans, controls, budgets, coordinates, and evaluates the research activities done in all agricultural institutes. This council is a semiautonomous body whose chairman is appointed by the president and which meets at least four times a year. Council members are chosen from various ministries, including natural resources, forestry, fisheries, land, livestock, agriculture (crops), regional development, and community development, so that its activities are totally coordinated. The council is now being changed to be more like a land grant institution. The dean of agricultural research has been appointed as head of the council. His job is to see that there is collaboration between research, training, and extension.

A council that collaborates with a university in training has several strengths. It has the power to plan, conduct, and coordinate all of the research, including that done by the universities and by the private sector. All research proposals pass through the office of the director general, who must consult with the council members. This gives the power to improve project preparation. The act which created the Project Planning and Monitoring Bureau established a program for farming systems research. We benefit from links with the IARCs and with local organizations. We have a memo of understanding which allows direct relations with The International Rice Research Institute (IRRI), Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), International Institute for Tropical Agriculture (IITA), and informal relations with ISNAR and International Board for Plant Genetic Resources (IBPGR), and we are seeking links with other centers. Finally, training has been increased.

There are, however, also weaknesses, and we feel the act should be revised or at least closely monitored and evaluated. There is a serious weakness in the institutional

separation of research, training, and extension. The Ministry of Agriculture does extension, and the only link between extension and training is in the farming systems research. The staffs have substantially different qualifications, and there are no links on the professional level. Research is fragmented among the ministries. This is a common problem among developing countries, and the World Bank dropped a project in Tanzania because of this. In farming systems research, all the relevant ministries must work together with the Ministry of Finance because every ministry has a division of research. Finally, since it is an autonomous body, our council cannot always mobilize enough resources because even though local funds are available, foreign exchange is not; staff are in short supply; and our information management is limited because we have a very small documentation unit.

Edgardo C. Quisumbing (Philippines)

Extension is outside the scope of many research councils, and inside that of some. Both systems work, but the latter works better.

Amir Muhammed (Pakistan)

There are big differences among the ways in which ARCs are structured. The Philippines is unified, but in Pakistan, our four provinces are almost like separate countries, and we cannot put extension under the research council.

Edgardo C. Quisumbing (Philippines)

There is another difference, also. Some ARCs are purely coordinating, and some do their own research. The Philippines council just coordinates, but the Pakistani and Indian councils both coordinate and undertake research in their own stations or in farmers' fields.

Mohamed Bakheit Said (Sudan)

Our ARC has four functions: policymaking, financing, coordination, and documentation.

Amir Muhammed (Pakistan)

There is no reason for having conflict between the ARCs and the ministry of agriculture. The overall objectives of the agricultural sector in the country should be set by the planning commission in close consultation with the ministry and cleared by the cabinet, after which the ministry should lay down government policies to implement the cabinet decisions. ARCs should support the ministry by providing the latest technology for achieving the objectives set for the agricultural sector. It is advisable to have the minister for agriculture as the head of the governing board of the ARC, along with representatives from other related ministries to improve coordination and reduce friction.

Often the conflict is between the ministry of agriculture and other ministries and commissions. Thus, there can be a conflict with the ministry of finance in fixing the prices of the inputs and outputs and in giving subsidies to the farmers, since the two ministries usually have opposite views. Similarly, the ministry of agriculture must have

a close liaison with the ministry of commerce to plan the imports and exports of agricultural commodities in view of the national requirements and indigenous production.

J. Price Gittinger (World Bank)

It seems clear that there is an effort here to find a way to treat agriculture as a system and to integrate research, extension, and the mobilization of resources. The interaction may be easier to arrange when there is an ARC.

There is a considerable variation among the forms that the councils can take, from those which are mostly advisory to those which have allocative responsibility. Despite such circumstances, everyone evidently feels that ARCs are generally good things. The form of a council provides a way to draw together many strands: the scientific, the political, and the user-farmer concerns. The councils plan and coordinate and sometimes allocate finance. They may or may not address private research issues. They appear to be suited to federal systems. In any case, they offer a degree of autonomy, and this is favored by the group.

It is quite clear that this is not a meeting of extension people, and few compliments have been offered to extension work. The group appears to feel that we must move away from multipurpose extension, that extension services should not have a monopoly on diffusion of research results, and that they cannot reduce the need for the scientists to get out into the fields. Councils may facilitate somewhat the connection between research and extension, but this is not often certain.

There is, however, a problem of fragmentation if an ARC does not coordinate well. The theme here has been one of groping for a way to relate the knowledge, inputs, and marketing aspects of agriculture in one system, and the research council structure is seen as a way to achieve this.

Summary

The discussion on ARCs focused on their functions, structure, advantages, and disadvantages. ARCs have been set up quite differently in various countries, and not all countries have one. The concept of ARCs and their degree of autonomy, however, are generally endorsed.

Some ARCs are largely advisory in function, some coordinate research in the public sector, and some have a degree of control over research done in universities and the private sector as well as at national institutes. Some make policy, allocate resources, control budgets, and evaluate research results as well. Some do their own research, and some include extension functions and are in charge of documentation, but most do not. The amount of control held by the ARC thus varies widely. Generally all are charged with coordinating research, increasing its efficiency, and ensuring that its planning is consistent with overall government policies.

Since the functions of different ARCs vary, their structures do also. Membership may include various ministries and sometimes university staff and agricultural producers. Some incorporate the extension service. Some are multilevel, such as a national agency coordinating with consultative committees based on regions and on commodity groups. ARCs vary in their degree of autonomy and therefore in both their influence within the government generally and their ability to act independently in concert with IARCs.

The advantages of ARCs are largely those coming from an improved ability to coordinate research throughout the country and to coordinate scientific, political, and user or farmer concerns. This provides a way to improve the functioning of the research system as a whole—from better project preparation to better coordination with the international research system.

The disadvantages of ARCs are largely the opposite of the advantages: when the ARCs do not coordinate well, the system does not benefit. There are problems with systems in which research, training, and extension are separate and the ARC has no role in training and extension, or in which the research activities are fragmented among too many ministries. If an ARC has no strong links to the ministries or to the appropriate levels of government, it may be unable to mobilize resources.

PART IV

Programming and Budgeting

The one task that seems most disagreeable to most research scientists is programming and budgeting. Considering the complex data computation that most scientists do, it is surprising that the comparatively simple arithmetic of budgeting is considered almost an anathema by so many.

According to Hulse (1977, vol. 3, p. 38):

> A budget is simply a means of assigning cash values to a sequence of planned future activities. A budget is an extremely useful management tool in that it indicates the level of emphasis placed upon different components of a research program and shows the rate at which an institution and its program intend to proceed and to grow. A regular monthly comparison of forecast against actual expenditures provides a useful indication of how well the system is under control, and whether each project is progressing on schedule.

Programming and budgeting track the acquisition of funds for, and the allocation of resources among, various areas of research. These tasks may be done in various ways under the auspices of different governmental arrangements or under the direction of boards of the various regional and international centers. Nonetheless, good management and specific procedures are needed in all cases. Likewise, issues such as how to balance investments and recurrent costs, how to document research, how to handle financial planning, and whether to use microcomputers are of concern to research managers everywhere.

In the publicly funded research in the United States, Tichenor and Ruttan see a historical progression in the overall approach to management (Fishel 1971, p. 6).

> Agricultural research nationally and locally bears the marks of a general trend toward a "planning" orientation exemplified by some form of a planning-programming-budgeting (PPB) system. Compared with half a century ago, the planning approach represents an evolutionary, if not revolutionary, change in budgeting procedures. The initial approach to public sector budgeting in the United States had a "control" orientation, which emphasized central control in spending. Prime concerns were to locate responsibility, maintain close scrutiny of departmental work, and prevent administrative improprieties. With the New Deal, however, there came a gradual shift to a "management" orientation. With many previous administrative abuses now under control, budgeting could be freed from many of its watchdog activities and directed more toward efficient performance of work. The performance budget introduced by the Hoover Commission was a major contribution of the management orientation.

Note: Donald Pickering chaired the two sessions in Part IV.

A third stage in budget evolution is the planning organization illustrated by the PPB system, with roots in Keynesian economics and systems-analysis technology. The main goal of program budgeting, with its planning orientation, is to rationalize policymaking in two principal ways. First, it provides data on costs and benefits of alternative ways of attaining proposed public objectives, and, second, it measures output to facilitate attainment of chosen objectives. Whereas prior approaches and classical accounting might assume a fixed objective, the systems-analysis approach of PPB would treat the objective itself as a variable. Full-scale analysis might lead to a new statement of objectives.

Session 7

Financial Management of Research Programs

The financial management of agricultural research programs is one of many aspects of management of research and is not easily separated from the other management functions. It is essential, for instance, that planning and budgeting projections and documents complement each other. Financial management is one of the research manager's strongest tools and is one of the most effective ways to direct, monitor, and measure the activities of the researchers. Even though managers may operate under strict financial constraints, such as "5 percent increase over last year's budget and no more," research managers can accomplish a lot with careful financial management.

Budgeting can be defined as a process that systematically relates the expenditure of funds to the accomplishment of planned objectives. Planning is not the only function of a budget system, however; management of ongoing activities and the control of spending are also implicit in the definition. Every budget system contains components for planning (what are the objectives of the organization, and how will they be achieved?), management (is the organization itself functioning as efficiently as possible?), and control (are specific tasks being done when and as directed, and within the prescribed guidelines?). Different budgeting systems may emphasize different aspects of these processes, but all are present and important to financial management (Fischel 1971, pp. 261ff.).

Financial management has been revolutionized by the availability of computers, particularly microcomputers, which are both reasonable in cost and easy to operate. Many programs that could be used by agricultural research institutions are readily available. Micros are ideal for the movement of costs—especially the all-important variable costs—against budget, the levels of personnel against budget positions, and the status of projects and orders. Carefully managed computer operations can help research managers and scientists analyze data and quickly produce relevant reports.

Proper training for financial and management staff is an important issue and is easily overlooked in the more common concerns of educating the scientists and training the support staff. Most research administrators are scientists who have become administrators. Their understanding of scientific research and their experience may make them excellent administrators, but such individuals usually have not had management training, particularly financial management. Now that most administrators face the necessity of first budgeting and then revising budgets downward as the year progresses, tools such as microcomputers and explicit training in financial areas are even more valuable.

Program and project leaders at various levels can also benefit from financial training. Successful management, including financial management, implies delegating responsi-

bility. If all decisions are made at the top, then the research director's time is not well spent.

FINANCIAL MANAGEMENT OF AGRICULTURAL RESEARCH

Hugh T. Murphy, International Rice Research Institute (IRRI), Philippines

There are specific areas in which agricultural research managers must pay special attention to financial management, and some specific mechanisms have been used for this at the International Rice Research Institute (IRRI). Conditions are different at every research institution, and thus the way in which this issue is addressed must relate to the conditions at each institution and in each country. There are general principles, however, that can be universally adopted, with perhaps only minor modification.

There is a natural separation, which occasionally degenerates into suspicious isolation, between general and financial administrators and the overall research administrators. Good rapport is essential between the research, financial, and general managers and must be actively fostered; all must understand the roles, responsibilities, and restrictions of the others. This seminar cannot be expected to produce skilled resource allocators, personnel specialists, or financial managers, but it can focus attention on common problems and alternative solutions.

Financial management, whether in personal lives, in business, or in agricultural research, is always critically important. In times of worldwide budget constraints this importance increases and can have immediate and severe program implications. When does financial management start? It must start in the first stages of planning and then continue through at least the following five stages, no matter how long the project or program lasts.

Planning

The planning stage can be subdivided into long-range and short-range parts and must involve the scientists, those who know and appreciate the needs and desires of the client community, the political or economic body providing the financial support, and the institution's management. The short-range plans are much more specific, for they are distilled from the longer-range plans of the institution. Both plans seek to set priorities for utilizing scarce human, physical, and financial resources. Good planning will allow an institution to gain the maximum benefit from capital, staff, research, extension, and training. Strategies for implementing these priorities must be established and must become more specific as actual implementation approaches, since they give the management the mileposts against which to monitor progress and are thus critical to the ongoing evaluation process. Realistic, quantifiable interim and long-range goals should be established for all plans. IRRI's most comprehensive planning document, "A Plan for IRRI's Third Decade," was published in 1982 and is a thoughtful and carefully documented work. It subsequently led to the publication of another document, "Organization 1983," which details how IRRI has organized itself to meet its stated strategic objectives. Well-defined and well-presented plans make the job of the board of directors or trustees easier and allow them to be more knowledgeable and supportive of the institute and its management.

Budgeting

Budgeting is a very specific exercise, and the local budgeting and accounting procedures must be carefully followed. It is essential that the planning and budgeting documents complement each other. IRRI budgets on a rolling two-year basis, with projections for five years, to meet the guidelines established by the Consultative Group on International Agricultural Research (CGIAR). It is essential, however, that research managers give their institutions some flexibility through the budget. This will require the help of the budgeting and accounting staff and those who may critically inspect the budget. These flexible or contingency funds are critical and, if they can be secured, must be spent even more wisely than most. Such funds may give the biggest payoff in research or cause the most trouble. IRRI spends some 50 to 55 percent of its budget on salaries. In some national research programs 90 to 95 percent of the budget is spent on salaries. If the discretionary element of the budget is small, husband it carefully and use it as imaginatively as possible; in personnel appointments, perhaps hire someone with greater skills than are specifically required so that they can provide new initiatives; in planning new physical facilities, try to use maintenance-free materials; and, when purchasing equipment, standardize so as to reduce maintenance costs.

Implementing

Agricultural research managers are in the most challenging, rewarding, and important of positions. The implementation stage is the test of management skills, because all the constraints come to bear. Proper planning and budgeting provide a good foundation, but the manager must remain focused and also flexible to deal with conflicts among scientists, shortages of supplies or materials, delayed or inadequate funding, political interference, or change of priorities. How is this accomplished? Peters and Waterman (1983) cite eight basic practices that characterize successfully managed companies.

- A bias for action—do it; try it; fix it.
- Close to the customer—provide quality, service, reliability.
- Autonomy and entrepreneurship—encourage innovation; allow mistakes.
- Productivity through people—stress teamwork.
- Hands on, result oriented—know what is happening in laboratories, the field, and in administrative areas.
- Focused—know the mandate and pursue it.
- Simple form and lean staff—keep administration small.
- Simultaneous loose-tight properties—stimulate and allow autonomy to proven producers; maintain high standards.

In addition, delegate both authority over, and responsibility for, project components to save time for managerial supervision.

Reporting

Reporting should be divided into reports on all specific components of the institution's program and reports to the supporting government or funding agencies. First, a research manager must determine what records are necessary and the specific purpose they will serve. Then, with the scientists concerned, the manager must develop the form of the reports, agree on the frequency of completion and submission, and decide how they will be posted and by whom. The manager then must use these records in decisionmaking, modify the reporting so it will be useful, or discontinue it altogether. Reports should be formatted to develop comparable data for all projects and programs to facilitate eventual computerization.

The more general reporting documents are books, monographs, and the annual report prepared by the institution and its scientists. In preparing these documents and subsequently distributing them, the objectives of the research projects and the institute and also of the institute's national or international mandate should be carefully reexamined. Does the progress fit within this mandate? Is this publication meant to persuade policymakers to allow further work on an especially promising, but underfunded area? So much work goes into preparing these documents that they should be used to the fullest. They are an excellent medium for informally getting an institution's message to the decisionmakers. Appropriate reports should be sent to those whose power and influence are valued. Keeping political and financial supporters informed will help both them and the institute and will be an added incentive for the scientists to produce results.

Evaluating

The evaluation of research productivity is extremely difficult but must be done continuously, even if by sympathetic peers, to ensure that a reasonable and rational focus is maintained. All general and financial managers should evaluate all projects to ensure that the planned objectives and schedules are being achieved or to recognize when a problem exists and indicate the remedial action being taken. The original planning documents should establish a schedule for these evaluations, which the research manager then maintains.

There are also bound to be formal evaluations conducted by institution staff and frequently by outsiders. The earlier and more systematic the internal evaluation, the better. The art of constructive criticism must be developed in the staff members, however, if these peer reviews are to be meaningful. Annual informal peer evaluations chaired by a knowledgeable research manager can highlight minor problems, refocus straying work, and produce valuable recommendations for improvement. Likewise they can head off or make unnecessary external reviews, which tend to be very time consuming, costly, and frequently of little value.

The board of directors or trustees has an important role not only in the planning stage, but also in the evaluation of ongoing work. This body can be very influential in helping to form policy and then getting the necessary political and financial support for it. (Evaluation is discussed in greater detail in Session 8.)

Auditing

Well-directed audits can be very beneficial for management. This is especially true of internal audits conducted by a member of the institution's staff who reports to the head

of the institution. Areas in which institutional policy is not being followed can be highlighted so corrective action can be taken before it becomes an issue for the external or government auditor. The internal auditor should know the institution's purpose and mandate and be positive and supportive of its research goals, while protecting the scientists and managers from violating institute or government policy. Any discussion of the management of agricultural research must continuously stress that the management exists to serve the scientists and the research program. Financial and general management must strive to facilitate, not control.

The ultimate goals of agricultural research are to increase the food available and to improve the welfare of mankind. While individual research managers may complain of insufficient funds, the resources being directed toward these goals are considerable. Annually more than 5 billion dollars are spent on agricultural research worldwide, with 1.25 billion dollars of that being spent in developing countries. For the most part this money has been well spent in the developing countries. The economic annual returns on such research typically range between 20 and 40 percent. The returns on rice research have been even higher. In most developing countries the social benefits of agricultural research are impressive. Therefore the dilemma is, since the rates of return from agricultural research are two to three times higher than that from most alternative investments, how can research managers get the government and international funding agencies to more adequately support agricultural research as a potent mechanism for growth and national development? This can be achieved by following and expanding on the six stages just discussed. Research managers must make these issues their own, set realistic and obtainable goals for each stage, develop the commitment of all the people in their organization, carefully monitor progress, and then sell the work of the institution.

Role of Microcomputers

There has been an evolution in financial management, and the immediate driving force has been the computer. This is a tool ideally suited for financial and general management. Hundreds of computer programs exist, which could be used in almost all agricultural research institutions. Research managers should take every opportunity to train their staffs in microcomputer applications. Micros and their associated programs are the most potent tool available for improving financial and general management. The technology is here, the prices are falling, and a manager does not have the luxury of procrastination. Because of the low cost of labor accounting, IRRI has not been a pioneer in the use of micros, but now it is racing to catch up.

Importance of Training

Financial and general management training is another area that needs attention. Most grants contain no funds for training second- or third-level managers. A recent exception was Indonesia, where five rice research station managers were sent on a month's visit to several research stations to observe the administrative practices so that they could improve the management of their own stations. These managers were enthusiastic and very inquisitive; they had excelled as researchers and had become research station managers. Training at all levels is critical and an urgent requirement. Blanchard and Johnson (1983) state:

> Most companies spend 50 to 70 percent of their money on people's salaries. And yet they spend less than 1 percent of their budget to train people. Most companies, in fact, spend more time and money on maintaining their buildings and equipment than they do on maintaining and developing people.

National institutions should be the first place to seek extra help in training. Frequently cooperative and mutually beneficial projects can be developed with national universities or even the personnel of other ministries and development agencies. Then there are regional institutions such as the Asian Institute of Management, the Asian Institute of Technology, WARDA, educational institutes such as the University of São Paulo, and the IARCs.

EDI and ISNAR, have the experience, the commitment, the facilities, the personnel, and the funds to help with training. More workshops, regional seminars focused on specific issues, books and periodicals, and computer programs for agricultural research management problems are needed. In addition, it is necessary to determine what else is needed and how it should be packaged and delivered.

In conclusion, the improvement of the financial management of agricultural research is a critical and common goal, which can be achieved by focusing on several basic guidelines.

- Train all levels of staff continuously.
- Plan and budget carefully, yet imaginatively.
- Monitor and evaluate all programs at all stages and be willing to redirect where necessary.
- Report on all projects to maintain and expand the support needed.
- Introduce new processes and procedures to encourage all segments of the organization to work better.

COMMENTS BY PARTICIPANTS

Donald Pickering (World Bank)

The agricultural research process is not normally well understood by bureaucrats and politicians, but programming and budgeting are not often well understood by agricultural researchers. Therefore, it is necessary to plan carefully and to perform the following functions: planning, programming, budgeting, monitoring, evaluation, and control.

Papa I. Thiongane (Senegal)

There are five steps for doing the budget in Senegal. First, every year, we evaluate the finances that are available and determine the allocation to each region. The plan is established for three years and accepted by the government and by external funding agencies. The financial plans are elaborated upon by the scientists themselves, and then the department heads verify that all the programs will fit into the budget. The

Committee on Science and Technology, which includes scientists from universities, extension personnel, and some international scientists, reviews the results of the past year and then comments on the plans for the coming year. Finally, the first draft of the budget is presented to the Ministry of Agriculture for approval.

The implementation also involves problems, principally because budgeting the funds does not guarantee that they will be disbursed. Sometimes we do not get the funds, and sometimes we cannot get the necessary national part of the funding for a project backed by international funding agencies, which is very frustrating.

Another problem is that of reporting the results. All programs, departments, and institutes must write reports, sometimes every three months, and this can become a burden.

M. V. Rao (India)

Systems of budgeting differ substantially among countries, but two points are central in all cases: the sources from which resources are acquired, and the process by which the acquired resources are used to get results.

In India, the National Planning Commission decides our budget. There are four sources of funding for the Indian Agricultural Research Council (IARC): the Indian government, 0.5 percent of the value of exported commodities, the sale proceeds from projects, and external funding from the World Bank and other such institutions. The funds go into research, extension, and education. Most are used for salaries and the rest for recurrent and nonrecurrent expenses as well as for expanding programs.

The budgets of all of our institutes, universities, and so forth are prepared at least two years in advance, discussed, and approved. The minister of agriculture has to plead for funds in Parliament, and then they are allocated. All funds revert to the treasury if they are not used in the year for which they are allotted, except for the cess on exports, which does not lapse and provides a measure of flexibility to the director general of research.

Financial controls are very important. The scientists' schemes are analyzed by a panel of various experts, a standing financial body, and the governing body of the IARC. Each university has its own board for funding. The financial manager in each ministry keeps a tight control on the monthly and the annual budgeting. The director general, however, has considerable emergency powers and also flexibility of operation.

Eduardo Vasconcellos (Brazil)

There are several ways to assess the financial system. Some preliminary questions need to be asked about various aspects:

- Information: what is needed, in what format is it needed, and how frequently should it be updated?
- Level of financial decisionmaking: are important decisions made by the head of the institute and less important ones by project directors, or are all decisions made high up in the chain of management, perhaps wasting higher level management time?

- Appropriateness: is the financial system adapted to the type of research done—applied or basic, government funded, or internationally supported?
- Size: is the financial organization the right size for the benefit it gives? Is the administrative support service too big?

In designing the structure of the organization, budget and auditing systems should be completely separate, the system should be decentralized, and there should be one key person who helps the researchers to budget.

Donald Pickering (World Bank)

There is an unquestioning rush into computers, and managers run the risk of using investments and staff time to develop systems that are not appropriate for their needs.

Hugh T. Murphy (IRRI)

Computer costs have come down, the programs have become more "user friendly," and it is no longer necessary to think in terms of mainframe computers and spending a quarter of a million dollars. It is possible to get a good complete system for about 5,000 dollars and to form a network of users. Initially parallel systems—manual and computer—are needed. The computer, however, can provide a tremendous amount of analytical capacity. Reports can be updated easily, and more time can be spent doing analysis, rather than manipulating numbers. There are also some machines that can be used in the field by researchers, but there are more programs and more uses for managers than for researchers at this point.

Henry Kanjobe Mwandemere (Malawi)

In Malawi the government has decided that scientists will use microcomputers to analyze their data, and a training program is being started to encourage scientists to do so. Until now, there has been a separate, central unit of biometrics for data analysis, but scientists will have a better feel for analyzing their own data.

Budget analysis revealed that only 37 percent of our funds were actually spent on research and that much was spent on overhead. The scientists resisted filling in budget forms, but it is a lot easier with microcomputers.

Samsundar Parasram (CARDI)

Where geographic areas are far apart, such as islands or large territories, computers can provide communication linkages, as well as reliability and speed. Decisionmaking capability is greatly aided by micros.

Edgardo C. Quisumbing (Philippines)

Computers will not provide a sound financial management system. After five years of discussion, computers are now beginning to be used in Philippine research, but there are problems with them. For instance, the communications lines in developing countries are what computer people call "dirty," with fluctuating voltage and static, which can erase whole computer programs, jumble data, and generally cause headaches. The

Harvard Business School has documented case studies of U.S. companies going out of business because of overreliance on computers.

Mohamed Bakheit Said (Sudan)

Many points of planning and budgeting are easier in theory than in practice in a developing country. In the Sudan there are three stages in the budgeting process: the proposed budget, the approved budget, and the actually released amount, and the figures for each are usually different.

It has been suggested that allowances be made for researchers to make some mistakes and to give them autonomy, but our resources are so limited that we cannot afford to make mistakes. There must be a balance, which allows the researchers some autonomy but also keeps them from making too many mistakes.

Hugh T. Murphy (IRRI)

IRRI has numerous budgets: the first fallback budget, the second, and so forth. We make commitments to our staff and to others, and then do not have the cash to pay them during the early part of the year. Then, in the last month of the year, we may get substantial funds that we cannot carry over into the next year. All of this means that you have to have imaginative accounting procedures and that you need to be flexible to survive.

IRRI probably has had at least twelve budgeting systems in its twelve years of operation, and now we have a consultant looking into ways to improve the process. In addition, a minister of agriculture may be very generous, but clearances come from the minister of finance. Part of the process of having successful programs is educating politicians and getting them on your side.

Philip R. N. Chigaru (Zimbabwe)

A problem arises with external funding. When the country must spend its own funds first and then be reimbursed, the minister of finance must be persuaded to release the local funds. Sometimes this has not been possible, and externally supported projects have been stopped because of lack of local funds.

John J. Ondieki (Kenya)

It is also a problem if the external funding agency does not release the funds directly to the project. There is often an intermediary level built above the project, which actually holds the funds and decides subjectively when to release them. If money is to be given to a country, the country should be able to decide for itself when to use it and not have the external funding agency, through the intermediary level, decide when to do it. In addition, tenders and purchasing take too long. Schedules are thrown off by these problems.

Jonah N. R. Kasembe (Tanzania)

It is difficult to convert local funds into foreign exchange. This often takes a long time, and at the end of the year funds have to be returned because the government never provided the needed foreign exchange.

Samsundar Parasram (CARDI)

With some donors, it is possible to build waivers into contracts, which allow for slow tendering. In addition, autonomous or semiautonomous agencies can sometimes set up a foreign exchange account to avoid the problem of governments not passing on foreign exchange to the executing agency.

Donald Pickering (World Bank)

The World Bank believes that the directors of organizations should be members of negotiating teams to persuade their own governments and the funding sources to set up usable procedures.

Samuel Freiburg (World Bank)

The World Bank also has set up a "special account procedure" to combat the problems caused by delays. A certain amount is deposited in a local bank and is used as a revolving fund until all funds are exhausted.

Jacques-Paul Eckebil (Cameroon)

It is difficult to assess the needs of the various programs for the coming year. The allocations to individual programs tend to be based on what was actually spent during the preceding period.

During implementation, funds are dispensed according to the budget. Is there some kind of a standard format for this? All research managers have basically the same needs: inputs, fuel, per diem, and so forth.

Hugh T. Murphy (IRRI)

The standards for disbursement depend largely on what the ministry of finance requires. IRRI develops proportional budgets, with one twelfth of the local expenditures to be disbursed each month, but procurement is held off until the end of the year, because that is when funds are available. It is particularly hard to allocate funds on a new project, which has no historical precedent, although similar programs may be used for comparison.

To cut the budget, one can cut proportionally from all programs or cut according to priorities. Sometimes, however, the highest priority projects are the slowest to get going.

Ibrahim Manwan (Indonesia)

We are responsible for implementation, and mostly we get together and solve the problems. When funding is cut, projects can still be saved, sometimes by renegotiating terms with the external funding agencies.

In 1974, agencies for research and development were established in each ministry in Indonesia. In the Ministry of Agriculture, the board is chaired by the minister of agriculture, and this gives research directors a very strong policy link with the allocation of funds.

We operate two kinds of budgets. Routine funds are allocated by the Ministry of Finance; are meant to cover salaries, maintenance, utilities and so forth; and are based

on the number of staff and on recruitment. Development funds are provided mostly by external loans and are allocated by the Agency for National Development.

Local funds pay for the operational costs of research and for loans to build facilities. The determination of research priorities and funding is being monitored more closely. Unfortunately, it is difficult to allocate funds for training abroad.

Donald Pickering (World Bank)

In summing up, it is clear that financial management is an issue of considerable importance, and that Mr. Murphy's six points are very relevant. The length of the discussion about difficult procedures shows that proposals must be made well and comprehensively and that officials negotiating research projects must know not only the potential value of a proposed project but also the costs of not undertaking it. Microcomputers have the potential to be a helpful and valuable tool for managing resources, but the advice seems to be to "make haste slowly" with them.

Summary

Although various research systems throughout the world are organized in somewhat different ways and obtain and disburse their funds using different procedures, virtually all have the same needs and many of the same problems. Common themes are poor timing of, or midyear cuts in, funding; ballooning recurrent costs, particularly for salaries; and shortages arising because of difficulties in estimating costs. Financial management is a difficult process in the best of times. Most financial management systems could be improved. Even IRRI has tried at least twelve systems of budgeting in its twelve years of operation and now has a consultant looking into ways to improve the process.

The processes of budgeting and allocating funds are the sources of many problems. In most countries the budget process concentrates on submission of a budget proposal, which in turn is approved by various committees or ministries concerned with financing research activities and the final allocation of funds. Although this process sounds straightforward, the approval of funds does not guarantee that they will be made available or that considerable delays will not be experienced in receiving funds. In some cases the World Bank has set up special account procedures, which allow project funds to be drawn when funds from local authorities are delayed.

A disadvantage of fund allocation is the widespread requirement to use approved funds within a specified time. Since research is long term and many expenditures cannot be precisely projected, this requirement introduces waste and uncertainty, which impede the research process. Furthermore, most funds are very tightly allocated, which leaves little room for mistakes. In an experimental field such as research, this limits the development of new fields of science and technology.

The use of computers is strongly advocated by some, while others are more cautious. The time-saving possibilities of computers and the expansion in budgeting and control measures are generally recognized. The computer, however, cannot provide a sound financial management system if it has not been planned for. In addition, physical impediments, such as fluctuating voltage, seriously impair the efficient operation of the system.

Session 8

The Evaluation of Research Programs

Any public activity that uses scarce resources and that produces results of value must be organized, coordinated, and managed. The range of technical ways to generate knowledge is very large, and the amount of time, facilities, and funds for research is limited, so choices must be made. Monitoring and evaluation provide a regular and critical study of progress and help in this decisionmaking process.

When evaluating research, the first question is whether such evaluation is feasible. Evaluation is a very complex task because of several factors.

- Research programs usually involve specialized fields of work, mastered by only a few experts in any given country, and thus require evaluation by external specialists, which is more impartial but highly problematic.
- The effect of research results can only be evaluated over the long term.
- When a research program ends, countless indirect benefits or spinoffs are created, such as accumulated knowledge and experience, which are difficult to evaluate.

Despite these and other difficulties, there must be some kind of evaluation process because it is an important source of feedback to enable priorities to be more correctly set as well as programs and projects to be better planned and carried through. Evaluation helps to identify the most productive staffs, the most suitable methodologies, and the most effective ways to allocate resources.

Any evaluation process must be grounded in clear concepts and be able to address the main issues to be resolved. The term "evaluation" is taken here to mean both a comparison between what was planned and what was achieved and an analysis of the results obtained. Such an evaluation may tend to measure efficiency--how resources were allocated internally. Thus, the aim will be to improve the ability to generate maximum results with a minimum of human and material resources. A further dimension is to measure effectiveness—the ability to generate relevant results, which are opportune and have a large effect on the people for whom the research is intended. This dimension entails evaluating the usefulness and adoption of knowledge and innovations produced by the research programs.

It is generally easier to monitor and evaluate technical events and budgets than human activities and benefits. It is extremely difficult to evaluate the quality and value of a scientist's work. Evaluation is impossible unless all research workers know exactly what is expected of them and what are the limits of their responsibilities and authority.

To define these main areas for evaluation criteria, three important issues have to be decided:

- What is the unit of analysis for the evaluation?
- What criteria are to be used for evaluation?
- Who should do the evaluation?

The unit of analysis depends on the research program to be evaluated. It will be necessary to decide whether the evaluation will focus on the researcher, the research group, the research project, the research institution conducting the program, or the research program at a nationwide level. Each alternative offers advantages and disadvantages, so that it is sometimes better to combine two or more units of analysis in a single evaluation.

The second issue concerns the criteria to be used. Examples of criteria include the knowledge created; the increases in agricultural productivity; the innovations resulting from the program; improvements in the technical and scientific skills of the researchers; the number of publications—despite the danger of measuring performance by the number of papers published, rather than by the benefit delivered; and the number of times publications by the researcher or research group have been cited. These criteria vary from one type of research to another, depending on whether it is basic or applied. For basic research, the criteria should evaluate the knowledge created through dissemination in publications of acknowledged worth. For applied research, the effect on the agricultural or industrial environment takes on decisive importance. These criteria should preferably be decided at the start of the program, so that those involved will know the standards which will be used for evaluation and which must guide their work.

Evaluating a program entails comparing a commitment with the results and with the reality achieved after a period of time. This is best done by people who are not directly involved in the research. There are methodologies for self-evaluation, but it is preferable to have evaluation done by peers from within the actual institution or, if necessary, from other institutions or even from other countries. The experience with visiting committees of specialists has been generally recognized as acceptable, and such committees can clearly analyze the results of either a program or a research institution. The higher the degree of specialization, the more important it is to bring in people from abroad or from outside the institution to evaluate the results. In addition, although it may not be easy or comfortable in assessing individual performance, it is essential that the opinion of the intended beneficiaries, or those who are to use the results, be obtained before any final evaluation is made.

In conclusion, the process of evaluation is complex and arduous, but it must be undertaken on solid conceptual foundations and using criteria that match the type of research being evaluated. Special attention must also be paid to the unit of analysis and to the choice of evaluator, so that the resulting information is useful as feedback for the next stage of planning and execution. Disseminating the results of these evaluations may also increase investment in agricultural research, since it will give greater social visibility to the cultural and socioeconomic contributions provided by such research.

EVALUATING RESEARCH PROGRAMS AND INSTITUTIONS: A MANAGEMENT PERSPECTIVE

E. Trigo
International Service for National Agricultural Research (ISNAR)

Traditionally, the evaluation of research programs and institutions has included documentation of the effect of research instruments, such as the rates of return to

agricultural research, as well as investigations into, and judgments on, the whole or specific components of the research effort by external authorities. At the same time, evaluation activities have been mainly seen as periodic efforts usually generated outside the research institution.

Little attention has been given to the process of evaluation and its relation to the management of agricultural research programs and institutions. Evaluation is not a series of periodic specific activities, but is a management tool, which provides essential information about the different stages of the research process and the different tasks that every research management team has to perform.

Concepts and Theories of Evaluation

Evaluation is a widely used term and has many different meanings, which often change in the context of its use. For this discussion, evaluation is considered to be the activities conducted to measure the (actual or expected) outcomes of plans, programs, projects, or activities under operating conditions and specific organizational contexts and to judge them in relation to their stated objectives.

As a management tool, evaluation is essentially a source of information and feedback. It permits events happening at different points in time to be linked together and related to their specific and common objectives. All managers need this information for day-to-day operations as well as for making decisions about the future. Thus, evaluation helps to reduce the uncertainty in decisionmaking and enables the manager to use the available resources most effectively.

Monitoring versus Evaluation

Monitoring and evaluation, although part of the same common functional area, are usually referred to as separate processes. Monitoring is a continuous day-to-day process, which assesses progress in relation to established targets, so that delays in, or divergencies from, planned patterns are noticed right away and corrective action can be taken. Evaluation, however, attempts to interpret results, contrast them to the relevant set of objectives, and determine whether these have been achieved and, if not, why not.

In reality, neither process is totally independent of the other, and their commonalities are clearly greater than their differences. Monitoring has components of evaluation, since raw information has to be set in some sort of context before it can be utilized for decisionmaking. At the same time, without the continuous flow of information produced by the everyday monitoring of activities, meaningful evaluation becomes very difficult. Monitoring and evaluation are different stages in the continuous process of generating relevant information about the implementation and effect of the research activities needed to manage research effectively.

Types of Evaluation

Effective management requires different kinds of information at different times and stages between planning and implementation. These different needs are, in turn, reflected in different methods for generating the needed evaluative information.

Depending on the timing, evaluation can be ex ante, generating information about the possible outcomes of different alternatives, or it can be ex post, recapitulating and analyzing the effect of given research processes. The effort can be internal, as a part of in-house operations conducted by the organization's staff, or external, performed by people outside the organization.

Managers need both a moving picture of the activities being undertaken and a running commentary about them. Two types of evaluation produce this information: formative evaluation and summative evaluation. These two types differ in the functions they perform, the type of information collected, and the way organizational structures carry them out. Each plays a distinct role in improving organizational and project effectiveness. Clear-cut distinctions between these two types of evaluation are often not possible; in practice, they overlap.

Formative evaluation focuses on tentative and in-process measures of a program or activity. It is a diagnostic tool for internal managers and involves the activities usually referred to as monitoring. Formative evaluation is mainly concerned with assessing needs and plans and with updating ongoing activities to detect any early tendency to stray from stated objectives.

Summative evaluation studies the demonstrated effects of a program. The external officials concerned with a program's continuation, discontinuation, modification, expansion, or curtailment use the information generated by summative evaluation to make such decisions. Traditionally, most evaluations are of the summative type.

The scope of the two types of evaluation varies in terms of the time involved, who conducts the research, and who uses it in future decisionmaking. Timing is an important aspect. Formative evaluation may be an intermittent activity throughout the life of a program. Often it begins before a project is implemented, in the form of needs assessment or planning analysis. During the operational stages, it takes the form of monitoring or observational actions. Summative evaluation tends to be an event or set of events rather than a continuous process and is conducted at specified time intervals before or after the program, depending on the subject matter being evaluated.

Formative evaluations are usually internal, carried on in-house by the organization's staff or specialists hired and supervised directly by them. Summative evaluations are more often—but not always—undertaken by an external agency, often engaged by the director, the sponsor, or some other monitoring agency. Thus, the results of formative evaluation are used mainly by program staff and managers, their colleagues, and immediate superiors. The information generated for summative evaluation is used primarily by those responsible for judging the program's performance as well as its future, such as upper-level decisionmakers, program sponsors, and policymakers.

Since formative evaluation tends to be generated at operating levels, its communication flow is horizontal and bottom-up. Information is exchanged among peers and may cut horizontally across various functional units. As a result, the data obtained in formative evaluation are used immediately in the local setting. In summative evaluation, by contrast, the data are analyzed and organized into reports for decisionmakers or external sponsors, who are at a considerable functional or geographic distance from program managers and operators. Unfortunately, there is often no direct communication between the external summative evaluator and the local managers of the activities being evaluated. Because of this, the data obtained in summative evaluation may not be of use at operating levels.

Evaluation in Agricultural Research Institutions

The absence of a traditional market for research results and, consequently, the impossibility of using profit to measure performance, have two important consequences for a research organization: the degree of centralization in decisionmaking and the competitive behavior of researchers.

In "for-profit" organizations, performance can be measured by profits in a clear-cut way. Thus, these organizations can develop highly decentralized decisionmaking structures based on the profit center idea: the "center" contribution to overall profits being both the basic supervision tool and the element linking the unit to the whole. In the absence of clear-cut measures of performance, such as profits, research organizations tend to have highly centralized decisionmaking structures. Since very few organizational levels participate in decisionmaking, it is difficult for managers to readily identify gaps or divergencies between planned and actual performance. In this environment, appropriate and timely evaluative information, especially of the monitoring type, about the different program components is an essential form of internal feedback.

A second consequence of the fact that research organizations generally do not operate under competitive market conditions is a lack of pressure for change and a dangerous tendency to select projects in the same way. This tendency is usually encouraged by budgeting procedures that use the previous year's budget as the starting point of the budgeting exercise. Under these circumstances, monitoring and summative evaluations can help to create and maintain a competitive, market-oriented environment.

Recently, some of the specific characteristics and requirements of the management of agricultural research have been recognized. In general terms, an agricultural research organization needs to have the same management functions installed and performed as any other kind of organization. Programs and resources have to be developed according to institutional objectives, activities have to be implemented, external linkages have to be designed and maintained, and so forth. However, some of the characteristics of the processes of research and technology transfer and the institutional nature of most research organizations determine particular management and evaluation needs. Appropriate evaluative information can help agricultural research managers to perform some specific functions more effectively. Two particular functions are crucial for the success of any research effort:

- Planning and program development
- The maintenance of appropriate external linkages combined with the mobilization of political support for agricultural research.

In addition, there are functions that are common to any kind of management system, such as monitoring and evaluating financial management, supervising budget execution, managing nonscientific personnel, and executing programs to develop the physical infrastructure. For these functions, the general discussions on evaluation and management processes apply.

Planning and program development. Planning and evaluation are two concepts that can hardly be discussed independently. Evaluation provides the basic feedback mechanism by which each implementation effort becomes a learning process from which valuable experience is accumulated for future use. This interaction, common to all organizations, is particularly important in research organizations because of the long-term nature of research and the high degree of uncertainty of obtaining the expected results. Because of the long-run nature of a research program, adjustments are essential to avoid large mistakes and misused resources. Evaluative information reduces the uncertainties involved and improves the effectiveness of management decisionmaking in the different stages of planning and program development.

Building political support. The development of an effective base of political support is essential for a successful research effort. Since most agricultural research is publicly funded, research organizations must have effective relations with the policy- and decisionmaking levels of government to establish and maintain a successful claim for current and future resources. Legislatures, foundations, and other donor agencies have to be convinced not only of the profitability of investing in agricultural research but also of its value and potential as a development tool. Summative evaluations of research programs provide essential information for the organization's external linkages. Most studies of rates of return have been done for just this reason.

The evaluation of how research results are adopted by the farmers and how these different aspects contribute to technological progress in specific situations provides a very powerful tool for research managers to use in briefing policymakers about what can be expected from the research system. But perhaps more important, it serves as a basis for helping to develop agricultural policy. In this way, evaluation directly contributes to one of the essential functions of the research system: providing relevant information to the government to help in making appropriate policies.

Evaluative information of this kind also helps agricultural research management in other important areas, such as the horizontal linkages with other service institutions in the agricultural sector. Lack of coordination among the different institutions serving the farming sector has often been singled out as one of the greatest weaknesses of agricultural sectors in the developing countries. Evaluative information in the form of specific recommendations about the interactions among the different services can improve communication and coordination. This would increase the effectiveness not only of the resources allocated to research but also of the whole of the development effort.

Two other closely related areas where evaluations of agricultural research efforts, including socioeconomic aspects, can have an important effect are in the linkages with farmers' groups and in the overall public image of agricultural research institutions. Evaluation of how research results have affected farmers will increase the understanding of their behavior and demands. This will both facilitate communication between researchers and farmers and orient programs toward the problems and environments of the farmers.

The issue of public image goes beyond the discussion of the accountability of research and researchers. A positive public image is essential for sustained long-run support. It is not easy, however, to educate the public about research and its relation to solving production problems. Evaluation can explain how research affects the implementation of new technologies.

Organizational Issues

The rather scarce literature about the evaluation and review of agricultural research programs and institutions—which covers mostly summative evaluations—indicates a general dissatisfaction with the process. This dissatisfaction is common both to the members of the review teams and to the staffs of the programs or institutes being evaluated. Staff feel that evaluations disrupt program operations, and evaluators find it difficult to address thoroughly what they consider the key issues. Under these circumstances, the worth of the evaluation is greatly reduced, and a tremendously powerful tool is regarded as a nuisance, rather than as an aid to decisionmaking at all levels.

A number of factors contribute to this situation. First, the value of evaluation in the broader context of management strategy is not recognized. Second, the objectives of the evaluation are not clear to both the evaluators and the staff of the institutions being evaluated. Third, relevant data are not available or sufficiently reliable. Finally, the selection of evaluation staff may lead to controversies and consequent inefficiencies in evaluation. The issue involved most is that of internal versus external evaluation. From the management point of view, this is a key aspect since it is highly related to the acceptance of evaluation as a useful tool.

Evaluation represents a threat to program staff. In general, it forces them to look critically at their work and to consider new alternatives. It introduces competitiveness in an otherwise safe and cooperative environment, and there is always the possibility of a negative evaluation. For these reasons, evaluation is not, and probably never will be, easily accepted as a basic element in the management philosophy and strategy of an organization.

What is the proper balance between internal and external evaluation? There will always be greater resistance to external evaluation; if nothing else, outsiders may feel that to justify the activity's worth, they must propose greater or more important changes than insiders would; at the same time, outsiders bring fresh ideas and a wider perspective, and evaluations will have higher credibility, an issue that is especially important if the goal is to build political support. Obviously, there are no clear-cut recommendations about which is better; however, the scanty available experience shows that both quality and utilization of the evaluation results increase when insiders participate. Consequently, whenever possible, research staff should help to design and implement external evaluations.

Evaluation is a tool, and, as with any other tool, it can be useful or not and can be put to a good or a bad purpose. It can be extremely useful to good decisionmaking if put in the proper context. The development of this context requires the continuing commitment of managers to use evaluations and the willingness to introduce the organizational adjustments needed for them to be effective. The dissatisfaction with past evaluations, in part, results from this lack of commitment.

COMMENTS BY PARTICIPANTS

Balint Szaloczy (Hungary)

For us, the aims of evaluation are to supervise collecting taxes, to supervise expenditures, and to supervise the conditions of research, including both personnel and technical matters. Evaluations are conducted on three levels: national, by program on the ministerial level, and by program on the institutional level.

There are three basic questions to apply to the evaluation procedure: who evaluates, how often, and what does it cover? As an example, we will use the National Research Program on Cereals.

Who. Three bodies do the evaluation. The Program Committee, which evaluates program-directed research, is chaired by the director of research on cereals and is made up of members of the Cereals Research Institute, the Ministry of Agriculture, and the National Committee for Technical Development. The Program Council is chaired by one of the deputy ministers of agriculture, and its members include three people from the ministry; three directors of research institutes; three farm specialists, mainly from the

production systems; a representative from the Committee on Science Policy; and a representative from the National Committee on Technical Development. The Committee on Science Policy is chaired by one of the deputy prime ministers, and its members include ministers, the president of the Committee on Science, and the president of the Committee on Technical Development.

When. Evaluations take place in the middle and at the end of five-year plans.

What. Evaluations cover three areas:

- The accomplishments of the research in relation to the plan, for example, breeding one or two varieties of winter wheat each year and determining, for each variety, the production capabilities, the disease resistance, the technology needed, and so forth
- The amount of research expenses and the balance between expenses and results
- Decisions to adjust the research, if necessary.

The Program Committee can only make suggestions to the Program Council. The Council can make decisions and suggestions to the Committee on Science Policy. The Committee on Science Policy makes decisions.

The value of the research is well known and appreciated because the centers are visited by evaluation staff every year. The Committee on Science Policy allocates all money for research among the various ministries, the National Academy of Science, and the National Committee on Technical Development, according to the long-range plan. It finances mainly applied research. The Committee on Technical Development also helps to introduce and to finance basic research.

Roberto Martinez Nogueira (Argentina)

I would like to first define "evaluation" and then to treat more specifically one kind of evaluation: institutional evaluation. The process of evaluation includes five concepts:

- Evaluation is an input to the decisionmaking process.
- Evaluation is a part of a continuous process of self-diagnosis.
- Program evaluation is only a part of the total process of institutional evaluation.
- Evaluation includes defining strategy, defining programs and projects, implementing objectives, establishing working relations with the social and political environment, and contributing to the learning process of the whole institution.
- Evaluation is not only part of the administrative process, but it is a consequence and an expression of the general philosophy of the organization.

Program evaluation has certain well-tested methodologies, which can be adapted to various situations. Institutional evaluation is not as well established but is very important, particularly in the institution-building phase.

There are several dimensions to be evaluated during an institutional evaluation:

- The strategic dimension includes the objectives of the research institution and the selection of research activities to achieve these goals, which may be defined by

commodity; by discipline, such as farming systems research; by basic or applied research; and so forth.

- The institution-building dimension includes constructing a resource base, producing results, and gaining credibility, as well as gaining allies among the scientific community, the farmers, and the bureaucracy.
- The operational dimension includes the relation between priorities and activities and their implementation.
- The resource dimension involves managing the financial, material, and human resources and evaluating the budgetary processes.
- The structural dimension covers the agricultural development plan, with specific questions on centralization versus decentralization, locational requirements, and the relation of the research structure to the task requirements.

Evaluation is not meant to assess the structural characteristics of the institution so much as to assess its capacities to deal with innovation, uncertainty, ambiguity, and conflicts. These capabilities relate to communication within the institution and with its environment and to decisionmaking—who participates, on what basis, and how. The decisionmaking process is not a rational or deductive process, but rather a political one. The design of the decisionmaking process is a product of political and technological engineering. To understand how it really functions is the goal of organizational analysis and evaluation.

The evaluation includes assessing the relation of the institution to the society. The institution has to generate knowledge, increase the productivity of farmers, and contribute to rural development. The perception of these tasks will differ from group to group, and probably among different levels of government. The question is, how do these concerns shape the social and political network in which the institute participates, and how does the institution fare?

Finally, there are considerations of how the evaluation must be made and what it requires. It must be a regular and systematic part of the planning process, involving social scientists working in the institution as well as the scientists, researchers, planning officials, and members of the organizations with which the institution has financial or hierarchical relations.

The evaluation process requires that the evaluators have a good knowledge of the economic, social, and political conditions as well as of the technical and scientific needs. They should know local conditions and understand the rational self-interest of the farmers and other affected parties, such as input suppliers and other private firms.

John K. Coulter (World Bank)

In the context of the international agricultural system, evaluations attempt several things. Ex post evaluations look at the accomplishments and effects of new technologies and how they are publicized. They try to pinpoint the limiting factors within the institutes, such as management or the quality of the scientists. The ex ante evaluation cannot be done by reviewers. It is necessary to have a good forward plan and to judge it against past performance to improve future performance.

Fernando Gomez Moncayo (Colombia)

An evaluation is a comparison made for a specific period of a certain plan and its execution. There are three types: the operational, which compares program goals and results; the impact, which focuses on the quality of the results and requires specially trained evaluators; and the institutional.

Amir Muhammed (Pakistan)

The quinquennial reviews of the international agricultural research centers are done very well. However, they require scientists of very high caliber and considerable funds. The developing countries need to organize the review and evaluation systems somewhat along the lines of these reviews, although at a much lower cost and largely using the national expertise.

There is urgent need to develop a proper methodology for reviewing research programs and institutions in the developing countries. The reviews currently made are superficial, highly subjective, and often not constructive. To establish a viable research program, it is important to develop a proper mechanism, based on a scientific method, for reviewing it. International organizations such as ISNAR and EDI should try to develop such a methodology, which national research programs can use to systematically review their research activities. Perhaps a course can be developed to train persons from national research programs in the review and evaluation methodology.

Eduardo Vasconcellos (Brazil)

The Management Institute at the University of São Paulo did a literature search on the evaluation of research projects and came up with the following factors: quality of research results; utilization of research results; meeting of deadlines; renewal of contracts with clients, a government agency, and so forth; generation of spinoff contracts; formation of institutional capabilities; and meeting of budgets for each project or program. One hundred people at the institute were asked which of the above were the most important in reality and which should be the most important. Their responses brought out five important factors.

- The criteria for judgments should be clear and consistent with the research goals, that is, what is said at one level in management should be consistent throughout the institution.
- There should be more formal evaluations.
- The criteria for basic and applied research should not be the same.
- Ex ante and ex post evaluations should not be the same.
- Comments of the users should be included in evaluations, especially for applied projects.

Samsundar Parasram (CARDI)

In the Caribbean, evaluation has been considered virtually the same as policing. If two or three people are trained as evaluators, they become the police of the institute, and that is not wanted. Perhaps groups could be involved instead, maybe including the

researchers themselves. Every research program should have an evaluation program built into it with goals to be met, year by year. In the early stages, evaluations should be done mostly by internal personnel; in later years there should be more external evaluations, perhaps by the funding agency. It is important to avoid setting up an "old boy network."

Donald Pickering (World Bank)

One should avoid both extremes: the good old boy network with no serious evaluation and character assassination by overly zealous evaluators.

John J. Ondieki (Kenya)

There are really two different aspects to this: evaluation of externally funded projects and of internal projects. Externally funded projects are evaluated every year or two, both locally and by the external agency. For internal projects, the station's program staff evaluates itself. There is no separate team, and everything is open for discussion.

Amir Muhammed (Pakistan)

The goal of the evaluation is to determine what the research has achieved, and then to close down the low-achieving projects and to reinforce the good ones. Even if a particular project is a failure, however, it may be very difficult to close down for political reasons. If this is true, the benefits from evaluation may be limited.

M. V. Rao (India)

It can be very difficult to close down a station. In that case, it is possible to keep a skeleton staff and strengthen something else.

We evaluate the institutions, the scientists, and the projects. It is important to be clear on objectives. Projects are evaluated at annual workshops where the results are discussed. Each scientist is a senior author of one project, and a junior author of others. Once every five years, an external team of experts evaluates the institutions and makes recommendations for improvement. The scientists are evaluated once every five years. On a special eight-page form, the scientist evaluates himself, his research director evaluates him, and a third more senior person also does an evaluation. Every six months a scientist must give a seminar on his work. Publications are a criterion in basic research.

The effect on productivity is not a good criterion for evaluating applied research, because productivity is a function of the availability of inputs as well as of the usefulness of a technology. Progress should not be expected too soon. Three to four years is too short a time to expect results from research. Another way is needed to evaluate research.

Donald Pickering (World Bank)

This is a very complex problem. In India the Bank now has two projects to develop a method to measure the effect of research.

Eliseu R. de Andrade Alves (Brazil)

It is most important that all systems do internal evaluations. If a specialist is used, the results will be predictable. Outside evaluations tend to be too much "once and for all" and of little practical help. When they discover that something is amiss, the time to solve the problem has already passed. Continuing internal evaluation is much better.

As a manager, I often reject the recommendations of an evaluation, but they are still useful. The goal is to improve a station, not to kill it. The process, therefore, must change as an organization changes. We must train people to help them change too.

Impact evaluation is a way to show outsiders—the authorities and the public—what is being done. It is used when we have a good story and we want some good public relations. This is different from the evaluation used to solve day-to-day problems, which is done from within as part of running a program.

Yookti Sarikaphuti (Thailand)

There are two kinds of evaluations in Thailand. In the first, the Office of Agricultural Economics evaluates the national agricultural projects as a whole, our national agriculture, and cooperatives policy. The second is an internal evaluation, which is up to every department. No one wants to be involved in an evaluation because it may produce emotional confrontations. Nevertheless, it is needed. A common goal and a common understanding are necessary for a good internal evaluation.

Edgardo C. Quisumbing (Philippines)

A strong monitoring system facilitates evaluation. It is especially difficult to evaluate projects on farming systems research. It was difficult enough with single commodity projects, but now we are working with both Cornell University and the Australian National University to develop appropriate procedures to evaluate the effect of farming systems research and extension. In one area, the incomes of farmers who adopted some of the components of a new farming system had increased, but the criteria for evaluating the project were the rates of adoption of the new technology. On this basis the project failed, although the yields and incomes of farmers had increased.

There is an evaluation component in most externally funded projects. It is easy to identify the indicators, but they are difficult to quantify.

Eliseu R. de Andrade Alves (Brazil)

An impact study is useful to get funds, to gain credibility, or to compute an internal rate of return. To do this requires an agricultural economist with a PhD and a computer. But his job is to sell the institution, not to evaluate it. Impact evaluations are expensive and are not of much use to an organization. Outsiders will not help much to eliminate bottlenecks in an organization. If the World Bank wants a project evaluated, it will hire a university to give the evaluation credibility.

There are serious methodological problems, however. How do you separate the influence of the research institution and the extension service from the effects of bad economic policy? When you evaluate a project, how do you decide who is supposed to benefit from it: the consumers, the producers, the large or small farmers, or the landless? You must select a method of analysis according to your goal. A good economist

can always determine whether a project is good or bad. In a very famous case in Brazil, a team calculated an internal rate of return of 70 percent for a project, but an economist who did not like the project calculated a return of 3 percent using the same data. There is no definite solution whatsoever from a methodological point of view.

Amir Muhammed (Pakistan)

Plenty of skeptics feel that investment in agricultural research is largely a waste of resources. Many farmers and others, sometimes in important positions, feel that good farmers know everything about agriculture from experience and that there is very little that the researchers can teach them, except in a very few cases. Such attitudes can harm the development of national research programs. Therefore, research systems need well-organized impact studies to survive and develop. The methodology for the impact study should be carefully worked out, however. It should have credibility with most categories of persons interested in agriculture and should clearly identify the economic benefits for the country's farmers and national economy. EDI and ISNAR should prepare a manual for organizing impact studies and develop courses to teach scientists from the national programs how to organize a successful impact study.

Summary

It is difficult to obtain a consensus on the purpose and content of evaluations. Evaluation of research is an input into the decisionmaking process and, as such, is part of the total process of institutional evaluation. Specific topics to be evaluated include the utilization of research results, deadlines met, expansion of research capabilities, and the relation between cost and benefits. These specific points can be covered under three types of evaluation: operational, which compares program tasks and results; impact, which focuses on the quality of results; and institutional, which is concerned with the overall improvement of the research establishment. A significant problem is that there are no methodologies or guidelines for carrying out such evaluations. Future seminars should address this issue.

There are many other problems encountered in evaluation, ranging from lack of experienced personnel to do the evaluations to political pressure to continue projects that evaluation has proved to be unjustified. The selection of evaluation personnel is a difficult issue. Considerable controversies and emotional problems are involved if internal institutional staff do the evaluation, particularly if opinions among scientists and evaluators contradict each other.

PART V

Managing Human Resources

There are two processes involved in managing human resources in agricultural research: getting trained people into research organizations and using them well once they are there. These two processes should ideally be linked. For example, the amount of training that new recruits have had will almost certainly influence how much further training they should receive later. The specific skills which they bring to the job will likely influence which ones will need to be developed as they take on new responsibilities. Starting salaries and posting will affect future career paths.

Human resources management includes at least five important areas: recruitment, career planning (including training), provision of salaries and benefits, performance evaluation, and labor relations. All five must be considered in any integrated approach to personnel planning. The need for such planning is clear in most national agricultural research organizations. During the past two decades, these organizations have employed substantially increasing numbers of scientists, technicians, administrative support staff, and field workers. This has occurred, and almost certainly will continue to occur, because of the expansion of research programs as well as political pressure to absorb the products of educational institutions, particularly universities.

To manage future increases in personnel, periodic exercises in manpower planning are essential. Such exercises can serve at least three related purposes:

- To update information on the educational and professional characteristics of current personnel. Many organizations have never systematically analyzed such characteristics and therefore cannot predict accurately their future personnel needs. The minimum data required for such analysis include educational qualifications (degrees, institutions, subjects, and years) and career history (entry point, promotions, and salaries).

- To strengthen the case for more resources. National governments are not likely to allocate more staff to agricultural research unless it can be clearly shown that there are too few staff to carry out desired programs. The only way to make such a case is on the basis of the type of analysis described above.

Note: Montague Yudelman chaired the two sessions in Part V.

- To argue the case for reforming personnel rules and procedures. Once again, civil service authorities are unlikely to look favorably on requests for improved conditions of service for agricultural research personnel unless such requests can be supported by empirical data.

Unlike the previous sessions, there were no papers written for Sessions 9 and 10, so the comments follow directly after the introductions to each topic.

Session 9

Manpower and Financial Constraints

How many scientists and technicians does a given agricultural research organization need? What kinds of qualifications should they have? How much will they cost, both when they are recruited and in the future?

The way in which an agricultural research organization answers such questions tells much about how it views personnel planning. If such planning consists mainly of describing the quantity and quality of personnel it would like to have, without also analyzing manpower and financial constraints, the result will be little more than a wish list. The pressures to adopt such "unconstrained demand" approaches are strong. Scientists with postgraduate qualifications want to emphasize their special status by requiring that new recruits have similar qualifications. They want their organizations to be recognized by similar organizations both inside and outside the country. In short, they want to have as much "professional" status as possible.

But planning in this way usually neglects the educational, fiscal, and political constraints that affect the recruitment of research personnel. Research organizations are often under pressure to hire individuals who may be either overqualified or underqualified. As a result, scarce financial resources may be committed both now and into the future.

What qualifications do research organizations set for entry into various positions and why? There has been a change during the past fifty years in the way in which young people are recruited for scientific jobs. In the past, there was a much greater emphasis on in-career training, and most new recruits learned the bulk of their professional skills on the job by working under experienced scientists and managers.

Today, however, this pattern has been altered by mass formal education. Most managers of agricultural research institutions now expect recruits to have already acquired their basic skills at educational institutions. Degrees are important. Indeed, educational prerequisites for employment have been continually raised as the number of graduates from various training institutions has grown.

There are at least three main reasons why recruitment is a crucial issue for agricultural research managers. First, recruits with greater qualifications command higher salaries. If such people are hired in substantial numbers, either recurrent budgets for research will have to be increased, or salaries and benefits will tie up increasing proportions of available funds. In periods of financial stringency, the latter situation seems the more probable. Even now, many national agricultural research organizations spend more than 80 percent of their recurrent budgets on personnel costs. Second, because the more highly qualified recruits are placed in higher job levels, they also reach various salary and job ceilings faster. Such rapid progression increases the probability of early stagnation and, therefore, the likelihood of lower motivation and

greater movement to jobs outside the organization. Third, because higher-level jobs are largely closed to recruits without the required degrees, employees in lower grades face career stagnation.

COMMENTS BY PARTICIPANTS

Montague Yudelman (World Bank)

The World Bank considers manpower a significant constraint. In the developing world it is also tremendously difficult to meet recurrent expenses. The short-run problem is a cash shortage and the difficulty in meeting salaries. External financial agencies have helped to persuade governments that research and extension services are important, and the World Bank is also financing them. If the World Bank were to withdraw its financial support in some quarters, the whole sector might collapse. Bank support has been very service- and manpower-intensive. The longer-run problem is a shortage of properly trained and skilled manpower.

Dominic E. Iyamabo (Nigeria)

Personnel and funds are the two most important resources. Arranging for their availability and their judicious use for maximum results is the greatest challenge for research managers. In addition, managers tend to think only of scientists and to underestimate the need for field and laboratory support staff, accountants, secretarial staff, and so forth. The level of support staff affects the productivity of the research work dramatically.

There are two kinds of manpower constraints: the number of qualified people and the disciplines available. There is intensive competition for trained personnel among universities, research institutes, and sometimes the private sector. Among the scientific disciplines, it has been relatively easy for Nigeria to get pathologists, plant breeders, entomologists, and physiologists. It has been harder to get agronomists, particularly for tree crops; soil specialists; irrigation specialists; biometricians; and animal breeders. Equipment technicians and researchers capable of being team leaders are scarce too. We tended to overlook sociologists, economists, engineers, planners, and communications experts for research staff and to hire only biological scientists, but this was a mistake. An effective staff must be multidisciplinary, and there must be enough scientists working on a problem to constitute a "critical mass." Scientists trained abroad take some time to readjust to local conditions when they return home, and it is essential that they be willing to work on local problems, even if they have to work somewhat outside their area of expertise, as Norman Borlaug did so successfully in Mexico. It is also difficult to fill posts at rural substations.

The recruitment process causes problems, particularly where the appointments must first be approved by the Public Service Commission. Recruits have been lost to other institutions and to private industry because of the delays and difficulties involved. This suggests that in comparing the functioning of an agricultural research council with an agricultural research department within the government, a research council has more autonomy and therefore an advantage in recruiting staff. There are times when a specialist is needed for a limited time, and there is a tendency to hire specialists for every task, even when they are not needed permanently. Consultants, perhaps from

universities, or people on sabbatical could be used instead, although this may be very difficult to arrange.

It is important to keep a balance between the numbers of upper- and lower-level staff. Sometimes there is pressure to employ more people than are actually needed. Personnel costs among developing-country research institutes tend to run between 60 and 90 percent of the total budgets. When they reach 80 or 90 percent, it is difficult to have enough operating funds for research materials, vehicles, and so forth. The funds for research materials even drop as low as 1 to 2 percent of total costs in some cases. In general, expenditures on equipment maintenance and on staff development are lower than they should be. We put funds into capital goods, such as research buildings, but not enough into research equipment.

Timing the release of funds is often a problem, as allocations often come at the end of the year, when they are not useful. On one hand, it is frustrating not to have as much control as we would like in some areas, such as the power to terminate staff, but, on the other hand, we tend not to delegate responsibility to our own staff in such matters as allocating funds. We need to learn to delegate financial and administrative responsibility so that our staff learn how to deal with these matters in different national situations.

Ahmed Hirabe Hassan (Somalia)

The main bottlenecks in our research institutions are shortages of trained personnel, limited internal funding, and lack of long-term commitments from assistance agencies. External funding directly for research has been available through short-term projects, which probably now amount annually to less than 0.5 million dollars, including the cost of experts, imported equipment, and other external services. This level of assistance and the manner of commitment are highly unsatisfactory. Long-term support, over seven to ten years, is very important to build up research capabilities. ISNAR, FAO/UNDP, and AID are assisting Somalia in this direction.

At present, there are about thirty to thirty-five scientists doing crop research in Somalia, most of whom are at the Central Agricultural Research Station. Most of these have only a bachelors (BS) degree in agriculture combined with a few years of experience. In the faculty of agriculture, the situation is somewhat better, with sixteen out of twenty-six staff members having advanced degrees, but they can devote only limited time to research. A few people have been sent abroad to study with the use of international funds, but a suitable training program has yet to be worked out. We recently developed a research planning and manpower allocation program and projected that in the next fifteen years a minimum of fifty-five people with masters (MS) and doctorate (PhD) degrees will be needed for crop research.

Inadequate salaries, lack of career structure, and lack of reward structure for research experience and good performance are significant constraints on research staff productivity and continuity. There are no pay increases either for experience or for having higher degrees. Staff management procedures need to be improved.

Philip R. N. Chigaru (Zimbabwe)

The competition for personnel is fierce, and our private sector will pay almost any salary. Research and extension institutions act more as a training ground for private

industry. The salaries are about the same as those of the universities, so the universities are not competing for our staff.

Zimbabwe is reluctant to treat agricultural researchers preferentially over other professionals. We are trying to create a scientific civil service, as technically trained people often feel frustrated when they get the same salaries as those without training.

Those who are sent abroad for training are often snapped up by other institutions with higher salaries. Therefore, for every year spent abroad, students have to return and work for one year in Zimbabwe. Some individuals, however, pay their way out of this obligation.

When funding for programs is severely cut, research projects suffer, and frustrated scientists who cannot continue their research then resign.

Amir Muhammed (Pakistan)

The availability of properly trained personnel in different disciplines is an essential prerequisite for organizing a meaningful research program in a country. Not only do scientists have to be trained in carefully selected disciplines, but adequate arrangements have to be made to attract scientists already trained. It is also important to provide a proper working environment to retain the scientists. Sometimes the job opportunities and career structure within a country can distort the availability of expertise in different disciplines. Pakistan has an acute shortage of trained agricultural economists and horticulturists because of the career structure within the agriculture departments in the country. Until recently, agricultural research institutes had no positions for economists even though they had well-organized sections for breeding, soil science, entomology, pathology, and so forth. Thus, economists were used only as support staff for very elementary treatment of the data obtained by biologists and had very little chance of career advancement. Similarly, although there were excellent job opportunities for breeders, soil scientists, and entomologists both in the government institutions and in the private sector, there were very few opportunities for horticulturists. As a result, the bright students never specialized in horticulture. This of course caused horticulture to deteriorate to such an extent that there is no single expert for several important horticultural crops. Such distortions have to be rectified to have a balance of expertise in all aspects of agriculture.

Eliseu R. de Andrade Alves (Brazil)

Brazil has a very difficult set of problems. There is an excess of people with BS degrees in agronomy, and many are unemployed. Brazil has made a large investment in higher training also, and the problems now are more how to keep people already in institutions, other than universities, abreast of progress in their fields.

Ten years ago, only 5 percent of EMBRAPA staff had MS or PhD degrees; now more than 70 percent do. At least 200 people a year are sent outside Brazil to get PhDs, and other Brazilian institutions are doing the same thing. I think this is enough. Brazil now has at least twenty-four universities with graduate programs. It is very important for a country to have and use its own training programs. There should be at least one good university with a graduate training program in every country.

EMBRAPA has three levels of staff, determined by the highest degree the individual has attained: BS, MS, or PhD. Vertical movement within each level is completely by merit, and there are special fringe benefits, including high retirement salaries. Because

EMBRAPA is autonomous, it produces more than 40 percent of its operating costs by selling various services, including computer services, seeds, and patents, and it also buys and sells farms and cattle.

Edgardo C. Quisumbing (Philippines)

The key effort should be to strengthen agricultural universities because they produce both new researchers and new technology, whereas institutes produce only the latter.

Staff retention is a problem in the Philippines too. There is little flexibility because we belong to the civil service. The Ministry of Science has created a scientific career service, however, which will allow deserving scientists to receive adequate remuneration. Unfortunately, this career service is still limited to the Ministry of Science.

Montague Yudelman (World Bank)

If trained people stay within the country, they still make a contribution, whether it is in the university, the research institute, or private industry.

Ibrahim Manwan (Indonesia)

In 1974 a significant constraint for the Agency of Agricultural Research and Development was the lack of trained staff, as there were only fifteen PhDs spread among more than twenty research institutes. At that time, the agency started a program to increase the number and capacity of staff. It now has 1,500 researchers who are university graduates, about 25 percent of whom have MS or PhD degrees. The agency has a reentry program for scientists and students returning from abroad and is also sending people to management courses to help better formulate and manage the research needs of Indonesia.

Balint Szaloczy (Hungary)

Hungary does not have a shortage of trained personnel. It has six agricultural universities and began thirty years ago to train people. There is, however, a shortage of support staff and skilled workers in experimental stations. Also, the cooperatives and the state farms can pay higher salaries than the research institutes, and they are doing their own research.

Byran Mook (ISNAR)

The issue may not be how many scientists an institution needs, but rather how many it can afford. In 1982 ISNAR conducted a study to assess how many scientists Kenya could afford. Starting from the agricultural gross domestic product, the study determined first the percentage spent on research and the percentage of that spent on scientists' salaries. The question was then asked how this ratio would change given certain assumptions about growth in agricultural output, salaries, and research funds.

It was assumed, optimistically, that the agricultural gross domestic product would increase by 4 percent a year, the amount spent on research by 1.5 percent, and the amount on salaries by 5.5 percent. Based on these assumptions, the net annual increase in staff was about 5 percent. If more than this percentage was recruited each year, say 10 percent, then recurrent costs would quickly increase to the point where 100 percent

of the budget would be spent on salaries. This analysis does not allow for an increase in technical support staff for scientists, which is an important issue affecting productivity.

Dominic E. Iyamabo (Nigeria)

This is a period of institution building for many of us. Much has been spent for capital investments, and yet not much research has been done. Also the economic and political climate has been unstable, and there have been many institutional changes. Recurrent costs have grown considerably. What is current thinking about this in the external financing community?

Samuel Freiberg (World Bank)

The general tendency is to finance recurrent costs where foreign expenditures are involved.

Montague Yudelman (World Bank)

This is true in the more developed countries, where there is a foreign exchange problem. In poorer countries, there has always been a tendency to finance some recurrent costs during the development period, but not thereafter. In a special program, the Bank will pay a large proportion initially, which decreases in later years. Because of the global financial crisis, more governments are having trouble meeting their recurrent costs, and the World Bank is becoming more liberal in this respect.

Summary

The discussions on manpower and financial constraints centered around three main themes: the availability of funds, staffing problems, and employment conditions and education.

There is often a shortage of research funds, which results in actual cash shortages or insufficient resources to guarantee a long-term research program. Both limitations discourage potential researchers from entering the service or force them to leave because research activities are curtailed. The World Bank recognizes that shortages of funds is a serious problem and therefore has increased its lending for research with components to finance recurrent expenditures.

There are shortages of both research scientists and research technicians. This condition results from a general lack of trained staff as well as from conditions of employment that do not encourage people to enter research services. Because an increasing number of future scientists receive training in developed countries that is often not completely appropriate for the developing countries, more emphasis should be given to training at local universities. It is difficult to enlarge universities to take account of this need, however, because of shortages of funds.

Research services generally provide low financial rewards and few material incentives. This is partly so because the researchers are part of the civil service, which does not provide generous salaries or reward outstanding performers. In most developing countries competition for well-educated people is usually strong, particularly from private industry, and the lure of higher salaries attracts scientists as well as those in other professions.

Session 10

Staff Retention, Motivation, and Training

Successfully recruiting good people to positions in agricultural research is only half of the job of managing human resources. Once the people are hired, they must be used well. Even if new recruits are well prepared for their new jobs, their job satisfaction will almost certainly be low unless they are adequately rewarded and directed.

A persistent problem for many research organizations is the discrepancy between highly qualified staff and low civil service salaries. If scientists are paid regular public sector salaries, they often leave for jobs in the private sector or abroad. But if special arrangements are made to pay scientists more (such as through semiautonomous public sector organizations), then the gap between research and the rest of government (such as extension) is emphasized.

As a result, a challenge to good personnel management is to devise better packages for research employees within the existing public service regulations. What flexibility does a research organization have in assigning salaries and benefits? How can careers be made more attractive? How can benefits such as housing, transport, work schedules, special allowances, and the informal use of facilities be creatively manipulated?

Improving such conditions of service is almost certainly one way of motivating research personnel. Another is improving the general atmosphere of the work place. Although there are numerous variables that affect job satisfaction, two considerations stand out:

- How do good managers evaluate subordinate performance? What scope do they have for recognizing merit, as opposed to being bound by seniority? Answers to these questions are often pessimistic. Many public sector researchers deplore the overemphasis on seniority, and yet, at the same time, they fear a more subjective evaluation system, which might be influenced by politics.
- How do good managers exercise direction and control? What use do they make of reports, meetings, and on-the-spot inspections? Subordinate personnel often complain that they are asked to submit more reports than they can possibly prepare. They avoid frequent meetings, which disrupt routine, and they resent superiors who make field visits for no apparent reason other than to demonstrate their own authority.

These issues are clearly linked with those of recruitment and careers, discussed in the preceding session. But a problem, again, is initiative. Top-quality research management is necessary if required reforms are to be conceived, pushed, and then implemented. Too often such management is in short supply. When scientists with inadequate management experience are promoted into senior positions, both science and management suffer. Management training is one possible solution to this problem.

COMMENTS BY PARTICIPANTS

Amir Muhammed (Pakistan)

Unless educational capabilities are built up within the country, there is no point in even trying to build up an agricultural research system. Having buildings and a few trained experts is not sufficient. Pakistan's experience in this area has been mixed. Thanks to the support given to its university by the World Bank, there are modern buildings and equipment and about 100 scientists trained to the PhD level. Research, however, has not taken off. There is no established tradition of research, and we are trying to discover why not.

People say that the Punjab Agricultural College and Research Institute was doing research that was more relevant to the needs of the country before it was upgraded to a University of Agriculture with foreign assistance. One possible reason for this situation is that buildings, equipment, and manpower training were emphasized, but the development of textbooks and syllabuses was totally neglected. Even now, textbooks from developed countries are being used. For example, the horticulture books describe strawberries, a fruit not known in Pakistan, in great detail, but not mangoes or other native fruits. The old college was part of the Agriculture Department, and therefore the educators knew the problems in agriculture. The new university was transferred to the Education Department, but the research activities remained under the Agriculture Department, and so now there is not much connection between the two activities.

Most research directors have been conditioned to think that the number of staff with PhD degrees determines the quality of the research system. I find that those trained to the MS level work on problems better. Staff with PhDs often want to do research that is too sophisticated for local circumstances.

Samsundar Parasram (CARDI)

In the Caribbean it is very useful to have a well-trained PhD with experience as a senior researcher supervising a lot of people with BS degrees who work rather as graduate students do. It is much cheaper to recruit and maintain staff this way, and a lot can be accomplished with good cooperation. It is a good framework for starting a research program.

Fernando Gomez Moncayo (Colombia)

There are two problems in measuring the quality of research by the number of PhDs: if they are educated abroad, it is very expensive, and, when they return, they require higher salaries.

Eliseu R. de Andrade Alves (Brazil)

I'm concerned about the attitude here against PhDs. There used to be great resistance to the BS, then to the MS, and now it is to the PhD. There are two ways to produce good scientists. Let them get an MS and train themselves to become good researchers; this will take time, and they will make some mistakes, but, in the end, they may become very good scientists. The alternative is to pay for them to get a PhD abroad. The costs will be obvious, but they may be lower than the hidden costs in the first scheme.

In Brazil, there are very good examples of people who did not have graduate degrees and were excellent, but it took them fifteen years to get to that level. When EMBRAPA started, part of the staff were sent to study abroad for three years.

When an organization is in the institution-building stage, it may be important to have PhDs to talk to the PhDs within the government. People with only MS degrees will not be as effective. Furthermore, because there are more complex problems in the developing countries, the best scientists are needed, and they are usually those with the most training.

Philip R. N. Chigaru (Zimbabwe)

The situation in many developing countries is not like that in Brazil. There are BS-level people available now, and if they are sent away to study for a few years, there is no one to replace them. Therefore, in Zimbabwe, only a few people are being sent overseas to study in special fields, and they go for the MS only.

Amir Muhammed (Pakistan)

The formula for Brazil cannot work for small developing countries with severe constraints on funds and on scientific expertise for research.

PhDs are trained in research methodology, problem solving, and so forth, but some problems are very simple, and specialists can cause other problems. Pakistan prefers to send people abroad to do their graduate course work and then have them come back for their thesis research. It is all right if they take four years to finish the thesis, because they are working on national problems, and they convince themselves that it is possible to do research in Pakistan. If they stay abroad for their thesis research, they are likely to decide that it is impossible to do research at home. This is not good for them, and their discontent will spread to others. If necessary, an important professor is paid to come to Pakistan for a month to oversee the research. If the scientist's heart is in the country, he will stay, too.

It is also important to train technicians who can keep equipment in good shape and to train public relations professionals who can speak, write, and do radio programs to promote scientific research.

Edgardo C. Quisumbing (Philippines)

It is important that people doing PhD research in their own country be freed from other duties so that they can concentrate on their research. The Philippines has a scheme in which a graduate student is sent abroad for only one year of graduate study, and then returns to research the thesis and complete the degree.

Henry Kanjobe Mwandemere (Malawai)

In Malawi, there is a three-part system for training. If particularly promising scientists who have a clear strong commitment to their work are recruited, they can be sent for training to the PhD level immediately after joining the institute. More frequently a scientist will be sent for training only to the MS level immediately on joining the research institute. The scientist then returns to the institute for at least two years before leaving again to study for the PhD. In the third case, the individual joins the

institute soon after completing the BS and works for two years before proceeding to study for two years for the MS. After another two to three years of work, the person can study for the PhD. The years spent working at the institute allow management to judge if the individual is ready for the higher-level training.

In the long run, it is preferable to train people at home rather than abroad. It is more cost-effective, takes less time, and reduces the risk of losing them. When the students study abroad and then return home, they need some time to reorient themselves to the needs of the country.

The problem with local training at present is that it takes too long. When people continue to work while studying through cooperative programs with U.S. universities, their ministries give them too much other work to do, and they are too busy to complete their studies. Also, the individuals tend to be more involved with their domestic problems when they stay at home. If they go abroad, the separation from their families causes hardships for which they should be compensated.

It is also necessary to train research administrators and leaders. This can be done somewhat through the use of interdisciplinary teams at the research station and at the national level.

It would be helpful if the international centers offered more than just on-the-job training. More should offer MS or PhD training with affiliated universities.

Samuel Freiberg (World Bank)

It takes a very long time to develop a university, especially if it is started from scratch and the faculty is trained abroad. In the United States, the land grant system was started in the 1850s and 1860s, and it was fifty years before the effect was evident.

Anthony Pritchard (World Bank)

In most of the agricultural research projects, training has been overseas rather than local because this attracts the more intelligent students to the project. When only local training is offered, few scientists apply for the vacant positions.

Amir Muhammed (Pakistan)

That may be all right in such subjects as computers and genetics, which are not location specific, but not in applied agriculture. If students are trained in applied subjects such as agronomy and entomology in a totally different environment than that in their own country, then it creates severe problems of determining priorities and attitudes toward problems. If they do not work on problems of their own countries for their graduate research, then they are likely to opt for working in the developed countries on problems related to their area of specialization. Even if such trainees are brought back by pressure, only the body comes back, leaving behind the soul. They may not even come back at all. That is a very serious problem with sending individuals overseas for all developing countries. When the brightest students are sent abroad, they also become the most employable in the international market.

Samsundar Parasram (CARDI)

In the Caribbean, the governments are constantly asking whether the research done to get advanced degrees is relevant. They are looking for lesser institutes to give certificates of training which will equip researchers to do field work. They feel that these people may be more valuable. Also, there is the possibility of sending people to study for higher degrees in other developing countries.

Jonah N. R. Kasembe (Tanzania)

To improve agricultural production, we believe that locally based research is necessary. Tanzania is considering the land grant system and the Punjab system as models for a university of agriculture to be formed next year. So far, local general education and specialized studies abroad have been stressed. Local institutions are needed to train technicians for the field and the laboratory. We are also training trainers, those who rub shoulders with the farmers. The new agricultural university will also train those who train the farmers.

Samuel Freiberg (World Bank)

Based on its experience in agricultural projects so far—and thirteen years is really a very short time—the World Bank has come to some conclusions about what are currently the most limiting constraints on agricultural research in the developing countries. The specific needs are very different in each country because of the differences among societies, cultures, infrastructures, and institutions that they do and do not have, but there are two common needs. First, all countries need efficient links between research and extension. Second, all countries need to develop and retain a cadre of personnel who will focus on national problems. It is one thing to develop this staff, but it is another to retain and motivate them to do research of high quality in appropriate areas. To do this, some common constraints must be overcome, primarily inadequate salaries and inadequate operating expenditures for materials, such as seeds, chemicals, and vehicles. Brazil is now paying its scientists well enough that there is no problem keeping them in the country; in fact, U.S. scientists are being attracted to Brazil.

Amir Muhammed (Pakistan)

When the head of the country makes only the equivalent of $1,000 a month, it is not possible to offer scientists salaries that are internationally competitive. Scientists need to have an element of patriotism, idealism, and some concern for humanitarian issues. Also, if the prestige of an institution is built up, people will want to be a part of it.

Eduardo Vasconcellos (Brazil)

Basically, researchers will stay until their needs are met better elsewhere. What are the researchers' needs?

- The opportunity to discover things through research

- Self-development and growth
- A salary to maintain one's family
- A good work environment
- Recognition by peers in the scientific community.

To discover whether researchers are satisfied or not, the university has developed a questionnaire called the "Organizational Climate Instrument," which has been used for the last five years with some good, sometimes unexpected, results. It can be used to measure policy effects if it is administered both before and after policy changes.

Fernando Gomez Moncayo (Colombia)

Research has shown that there are elements which are more important to a scientific researcher than salary alone. The ability to do research, access to necessary materials and equipment, and a chance to go to an international conference at least once every two years are sufficient incentives to keep most scientists from changing jobs.

Ibrahim Manwan (Indonesia)

So far, the Agency for Agricultural Research and Development does not have problems retaining staff, but this could become a problem, and so the following steps are being taken to avoid it:

- Working conditions are being improved by measures such as buying better laboratory equipment.
- The reward system is based on merit, and individuals are eligible for salary increases when research projects are completed.
- Funds are allocated to send scientists to meetings.
- There are training programs, which attract people to work in the agency and help to develop an esprit de corps.
- Every five years a new minister of agriculture is elected, who has the power to remove an individual from a position but not from the system.
- There is a two-week training and orientation course for recruits, with an exam that must be passed.

When the agency was begun, the directors of the institutes had BS degrees and much experience. Now they have PhDs, but little experience. We offer a training course in research management to which twenty-five to thirty regional institutes and two central ones have sent staff. The course covers two main topics: project-program organization and the transfer of technologies.

Edgardo C. Quisumbing (Philippines)

One of our programs has been aimed at attracting scientists to the Philippines. It is called the Balik Scientist, or Return Scientists' Program. Scientists are offered free air fare for them and for their families and personal effects; they are allowed to bring in

in appliances and a car, tax free; and they are guaranteed research funding for their projects within the national research system.

The costs of this program are high, but not as high as the cost of a PhD scholarship. A prospective candidate usually receives a round trip ticket and an invitation to come and investigate the situation in the Philippines for two weeks before deciding to join the program. Our success rate is adequate, and the program is operative.

William K. Gamble (ISNAR)

Similar programs have been tried, mostly without such success, in other countries. Some countries, such as Mexico, have countered the problem of sending researchers to distant stations by giving them substantial bonuses. Some have also had a policy of "go or you're fired."

Amir Muhammed (Pakistan)

In Pakistan, there is a handsome allowance of up to 50 percent of the salary—called an "unattractive areas allowance"—in addition to a free trip home once a year, to persuade scientists to serve in remote areas. That seems to work.

Mohamed Bakheit Said (Sudan)

We have tried to institute such policies without success, except in one project which was funded by the World Bank. Many ministries are unwilling to take such measures because it will distort pay scales.

Yookti Sarikaphuti (Thailand)

We have instituted such policies, and one other as well. Only those who work in the remote areas are allowed to go for their MS and PhD degrees; those who stay in Bangkok cannot.

Hugh T. Murphy (IRRI)

It is important to select staff carefully, not only researchers, but also administrative staff. Administrative and support staff are likely to stick around longer. Responsibility for selecting staff cannot be completely delegated to personnel officers, or they may end up hiring a lot of relatives and townspeople. Additional forms of remuneration are needed. It is important to try to learn the personal problems and ambitions of individuals and to try to help them realize their goals.

William K. Gamble (ISNAR)

One key issue is how do you get rid of staff? There should be some turnover.

Mohamed Bakheit Said (Sudan)

The good researchers have a high market value, and it is generally not the best ones who stay behind. In our system, it is somewhat a question of self-respect. An individual must apply to be promoted. Those who are never promoted are trapped, and this encourages them to leave.

Philip R. N. Chigaru (Zimbabwe)

In our system, staff are evaluated annually by senior officers and do not get an increment unless recommended by the senior officer. If there is a negative report, the staff member must read it, sign it, and register any complaints.

Eduardo Vasconcellos (Brazil)

One activity of the Management Institute of the University of São Paulo, is a Program of Management in Science and Technology, which develops and transfers techniques of managing research relevant to developing countries. We conduct training programs to transfer information to users; have consultancies to utilize techniques that have been developed to gather information; and conduct research into management problems that organizations are facing.

Our areas of special competence are institutional strategy in the science and technology system, organizational structure, project and program planning and control, management information systems, human resource management, management of financial resources, managerial behavior (leadership, motivation, group dynamics, and personal communication), organizational development, industrial property, technology transfer, technology marketing, and technology forecasting.

We have conducted programs with universities, engineering companies, research institutes, technology centers of public and private enterprises, government agencies with links to scientific and technology policy, and enterprises with an advanced technology base. Most programs have been with research institutes.

There are some problems in implementing management programs, mostly because among researchers, management and control of research have a bad name generally. It is very important to have a researcher sitting in on meetings so that a research manager who has good ideas meets acceptance.

We have published several teaching materials and we can give courses in other countries, as well as our open courses in Brazil, which are usually supported by the government and are given in Spanish or in Portuguese.

Carl Pray (Observer)

At one time, EMBRAPA was small. How did you get the government to approve the various measures you took, such as getting the scientists hired outside the civil service?

Eliseu R. de Andrade Alves (Brazil)

In the early 1970s, people realized that it was necessary to increase agricultural production. It took pressure from below to do this, primarily urban unrest, but the farmers' needs were felt to a lesser degree. It was understood that the way to increase agricultural production was to stimulate agricultural research, and as a result EMBRAPA was created.

The government may have allowed us to take some of the measures we did because EMBRAPA is not a part of the civil service, and Brazil does not have a homogeneous pay scale. However, there is a limit. The directors pushed for the highest wage scale possible, and now some people say that it is too high, but once something is in place, it is hard to change.

Once EMBRAPA was established, we tried to prove that it was good for the country. For instance, research results are not simply announced. First, we explain that Brazil has a problem, and then we announce what our research has done to solve that problem. It is very important for any research institution, particularly in its early stages, to achieve results and to have good public relations ability. Once credibility is established, funds will be available to strengthen research, and the institution can continue to do more and better research.

Summary

Most discussions on this topic center around the required level of training and the education of future research scientists. The location of training very much determines the retention level.

It is important to advance education up to the PhD level, but this objective should not become a goal in itself. Staff with less advanced degrees are needed, since experience in many cases makes up for the lack of a degree. Likewise, scientists should keep abreast of new developments in their fields through short courses, library services, and so forth. Support staff also need to be trained. The ratio of support staff to scientists is often less than one support staff to one scientist, compared with four or more technicians to a scientist in developed countries.

The system to provide education and training should be well planned, but, unfortunately, in most cases it is not. This is partly because of the vagaries of finding funds and partly because of different opinions about local training versus training abroad.

Experience shows that in many cases students get a good or excellent education abroad, but often the training does not meet the demands at home. Students may get an excellent education in, say, the natural sciences, but they are ill prepared to establish and manage a research system in their own country. Students from developing countries rarely study management skills abroad.

Training up to the PhD level abroad involves other dangers; for example, the students may be reluctant to return to their native countries. The situation is not so serious at the MS and BS levels, so some countries allow their students to study abroad only up to the MS level. Other countries try to combine training abroad and at home. They encourage students to take courses abroad but insist that they write their theses on a local topic in their own country. Still other countries offer incentives, such as free air fares, to get students to return. Apparently the incentives are not completely effective.

The alternative to training abroad is education at local universities, but there are doubts about quality education and the willingness of students to participate. In addition, part-time students are often overburdened with activities not related to training.

In general, foreign versus local training is a controversial and unresolved issue which requires further study. Training funds are usually provided for training abroad since this attracts the more intelligent students to research projects.

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