

A Self-learning Course

Planning and Managing Forestry Research

Volume III

Module 5

Developing the Research Program

Module 6

Implementing the Research Program



The initial version of this self-learning course was developed by Dr. Allen L. Lundgren, Mr. Scott J. Josiah, Dr. Hans M. Gregersen, and Dr. David N. Bengston at the University of Minnesota, College of Natural Resources, Department of Forest Resources, in collaboration with the International Union of Forestry Research Organizations (IUFRO), Special Programme for Developing Countries (SPDC), and with the advice and assistance of experienced forestry research managers around the world (see the course guide for more detail on the course development).

The course is available from:

IUFRO SPDC
Seckendorff-Gudent-
Weg 8, A-1131
Vienna, Austria

¹Dr. Allen Lundgren is Research Associate, Scott Josiah is Research Assistant, and Dr. Hans Gregersen is Professor, with the Department of Forest Resources, College of Natural Resources, University of Minnesota, St. Paul, Minnesota. Dr. David Bengston is Ecological Economist with the U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota.

Complete List of Modules

October, 1994

PLANNING AND MANAGING FORESTRY RESEARCH: A SELF-LEARNING COURSE

VOLUME I

A Guide to the Course

Module 1

Forestry Research Planning and Management: An Introduction

VOLUME II

Module 2

Initial Steps in Strategic Planning

Module 3

Identifying Key Issues for Forestry Research

Module 4

Producing and Disseminating the Strategic Plan

VOLUME III

Module 5

Developing the Research Program

Module 6

Implementing the Research Program

VOLUME IV

Module 7

Financing and Budgeting

Module 8

Providing Support Functions

VOLUME V

Module 9

Managing Human Resources

Module 10

Monitoring and Evaluating Research Programs

VOLUME VI

Module 11

Developing Research Linkages: Learning from Others

Module 12

Communicating Research Results to Users

Planning and Managing Forestry Research
A Self-learning Course

Module 5
**Developing the
Research Program**



International Union of Forestry Research Organizations
Special Programme for Developing Countries
Vienna, Austria

Table of Contents

Module 5 - Developing the Research Program	1
Introduction to the Module	1
Initial Skill and Knowledge Assessment	2
Study Unit 5.1 - Developing an Effective Organizational Structure	3
The Organizational Structure of the Research System	3
Basic Organizational Options	4
Desirable Features of the Organizational Structure	9
Growing Trend Toward Privatization of Forestry Research	11
Research Advisory Committees	13
Improving Organizational Performance	13
Activities - Study Unit 5.1	15
Summary	27
Study Unit 5.2 - Research Program Planning	29
What is Research Program Planning?	29
Why is Research Program Planning Needed?	30
Structure of Research Programs	30
Research Planning Levels	32
Activities - Study Unit 5.2	39
Summary	49
Study Unit 5.3 - Links Between Strategic Planning and the Research Program	51
Linking Program Planning and Strategic Planning	51
Evaluating Staffing Requirements and Availability	53
Incorporating Monitoring and Evaluation into Program Planning ..	53
Including Both Internal and External Input in the Planning Process	54
Blending Researcher Interests and Organizational Goals	56
Involving Stakeholders in Program Planning	57

Recognizing Existing Knowledge and Information	58
The Logical Framework: A Useful Tool for Program Planning	58
Activities - Study Unit 5.3	65
Summary	71
Final Skill and Knowledge Assessment	72
Literature Cited	73
Readings for Module 5	77

Developing the Research Program

List of study units covered in this module

Study Unit 5.1.
Developing an effective organizational structure

Study Unit 5.2.
Research program planning

Study Unit 5.3.
Links between strategic planning and the research program

The development of a strategic plan for an organization (discussed in modules 2 to 4) should not be viewed as an end in itself. Rather, strategic plans are only a necessary first step in developing plans that will guide the ongoing work of the organization. Strategic plans provide a well-thought-out sense of direction, a shared mission, and a set of goals for the organization. They outline a set of broad strategies for achieving the organization's goals. However, they typically contain little specific information about how the organization will carry out its mission and achieve its goals.

Once a strategic plan is developed and approved, there still remains the task of developing and implementing a research program to achieve the objectives and goals outlined in the strategic plan. This module addresses the task of developing the research program. The task of implementing the research program is covered in Module 6.

Research program plans provide a framework for guiding research activities of the organization to ensure that they are directed towards the critical issues and objectives identified in the strategic plan. Program planning outlines how those goals are going to be achieved and the mission accomplished over a period of several years. Such plans, which can be developed at various levels in the organization, help managers systematically organize research programs and identify and justify resource needs. They can range from plans for broad research program areas, covering work planned for many scientists over a period of several years, down to narrowly defined individual research studies that may cover the work of one scientist for only a few months. Research program plans help managers anticipate future resource needs, and thus are useful in preparing budget estimates for future years. Research program planning is discussed in some detail in Study Unit 5.2.

In this module you'll review some of the strengths and weaknesses of various types of organizational structures. You also will learn about research program planning and the importance of linking research programs to strategic planning. Although relatively short, this module is important because it describes the planning that is needed to guide the implementation of the forestry research being conducted by the research organization.

Skill & Knowledge Assessment

Module 5 - Developing the Research Program



If you would like to find out how much you improve your skills and knowledge by studying this module, we suggest that you complete this exercise before beginning the module. This will establish your current level of skill and knowledge about the topics covered in this module. At the end of the module there is an identical skill and knowledge assessment form which you can complete once you have finished the module. By completing and comparing the before and after assessments, you can determine the extent to which you have improved your skills and knowledge.

Below are listed a number of skill and knowledge statements derived from the objectives of the study units in module 5. These are identical to those listed for this module in Study Unit 0.3 - Self-assessment of Training Needs, which you may have completed initially to guide your course of study. Please read each statement carefully and indicate with a checkmark the level that best describes your current skill or knowledge, from 1 to 5, using the following descriptions:

- 1 I cannot perform this skill, or I have not been exposed to the information.
- 2 I cannot perform this skill, but have observed the skill or have been exposed to the information.
- 3 I can perform the skill or express the knowledge with assistance from others.
- 4 I can perform the skill or express the knowledge without assistance from others.
- 5 I can perform the skill or express the knowledge well enough to instruct others.

Skill or Knowledge Statement	Your Level of Skill or Knowledge				
	1	2	3	4	5
a) Identify and describe the various organizational models commonly used by public and private sector forestry research organizations.					
b) Identify three key desirable features of a forestry research organization's structure which enhance forestry research capacity, and explain how these three features contribute to improved efficiency and effectiveness of research implementation.					
c) Explain what research program planning is and why it is needed.					
d) Describe three program levels commonly encountered in a forestry research organization that play important roles in program planning.					
e) Describe five factors that are essential when conducting program planning, and describe how they can be incorporated into the program planning process.					
f) State the importance of linking program planning to strategic planning.					

Developing an Effective Organizational Structure

Objectives

When you have completed this study unit you should be better able to:

- *identify and describe the various organizational models commonly used by public and private forestry research organizations;*
- *explain how the structure of a research organization can either enhance or limit the management and implementation of forestry research;*
- *identify three key desirable features of a forestry research organization's structure which enhance forestry research capacity, and explain how these three features contribute to improved efficiency and effectiveness of research implementation; and*
- *evaluate how your own organization's structure affects its performance in the planning and implementation of forestry research.*

The structure of your organization can influence its ability to conduct forestry research. It provides a framework that links research to the external policy environment and guides the processes of research management. This unit will give you a better understanding of how an organization's administrative structure affects its research capacity, and thus its ability to produce quality forestry research. You'll learn about different ways in which research institutions are organized and structured, and the advantages and disadvantages of each. We'll also point out several key features important to building research capacity in any research organization. Finally, we'll help you to review your own institutional environment and identify improvements which can enhance the research capacity of your organization.

The Organizational Structure of the Research System

The way in which a research system is organized can significantly affect its productivity and effectiveness. Organizational structure refers to the institutional forms and mechanisms that govern how a research organization sets research priorities and mobilizes resources for implementing its research program.

The organizational structure thus provides a framework that

links research to the external policy environment. It also guides the processes of research management (e.g., human resource development, establishment of scientific linkages and linkages with users, etc.). Organizational structure strongly influences a research institution's ability to use resources effectively and efficiently to generate information, and to promote vital interaction among scientists and between them and client groups. It should be viewed as an additional resource in research, which can either enhance or limit the

effective use of other resources (human, physical, financial, and information resources) to achieve the goals of the research organization.

Basic Organizational Options

There are three basic models for organizing public forestry research (Ruttan 1982, Jain 1989): (1) the ministry model; (2) the autonomous or semi-autonomous institute; and (3) the university model. In addition to these public sector models, we can add private sector research organizations. These models differ mainly in governance structure or degree of autonomy they have, and in funding mechanisms. While these organizational models represent ideal types, each type can be found among the forestry research institutions included in the FAO "World compendium of forestry and forest products research institutions" (Hilmi 1986). The basic organizational approaches are briefly described below, highlighting differences in governance structure and funding.

The ministry model

Governance structure: In the ministry model, forest and forest products research responsibilities are placed within one or more line departments of a ministry. This is usually the ministry of agriculture or forestry, although other ministries such as natural resources, education, or science and technology could also be involved. This organizational approach is common in small countries and is usually a component of the integrated federal-state (or national-provincial) research systems in large countries (Ruttan 1982). For example, it is the model used in Zambia (figure 5.1.1). The essentially bureaucratic nature of the ministry can create problems for a research organization—research managers may have a low degree of control over policies and procedures concerning the management of personnel, finances, and other resources.

Funding: Direct allocations in the national budgets are the usual source of funds in this organizational form. Funding instability has been a common problem in many countries according to Trigo (1986). In times of financial crisis, the ministry's research budget is often the first to be cut. Jain (1989) notes that some of the larger agricultural research systems of this kind have been successful in introducing reforms into the existing organizational framework, without severing their links with the government ministry. For example, the Department of Research and Specialist Services in the Ministry of Agriculture and Land Development in Zimbabwe has its own line budget.

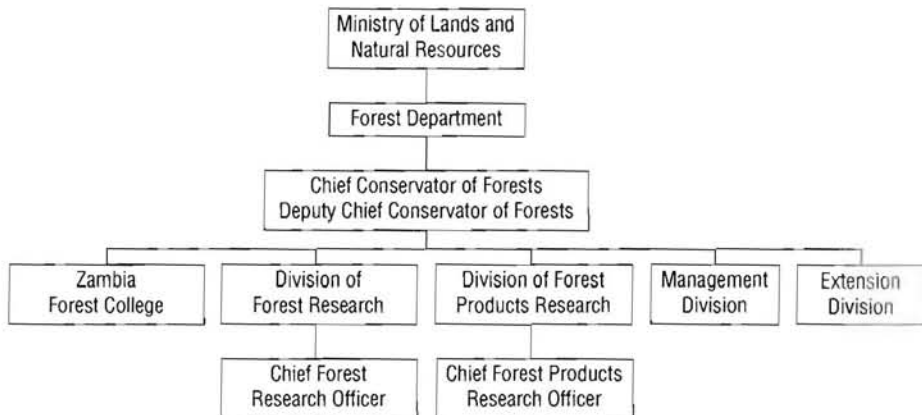


Figure 5.1.1. Organizational chart (simplified) for forest and forest products research, Forest Department, Ministry of Lands and Natural Resources, Zambia, illustrating the ministry model of research organizations.

Source: Adapted from Zambia Forest Department 1987.

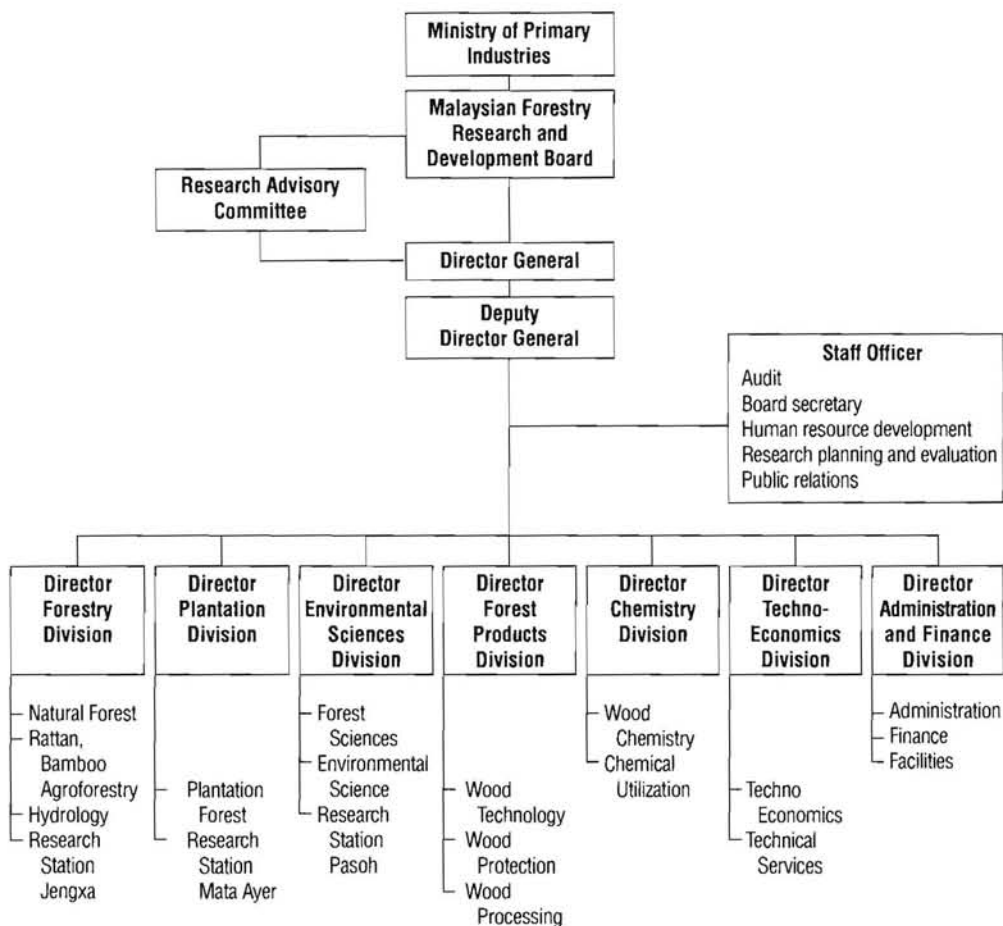
The autonomous or semi-autonomous institute

Governance structure: The autonomous or semi-autonomous institute is an administratively independent research organization. An example is the model used in Malaysia for the Forest Research Institute Malaysia (FRIM) (figure 5.1.2). A board of directors or trustees typically oversees the execution of the institute's mandate and has responsibility for policy guidance and management control. In some cases, a director general or chief executive officer may fill the role of the board of directors. In either case, the institute typically has formal reporting obligations to some public body (e.g., a ministry or research council) but it is legally independent of this body. A relatively high degree of independence results in greater control over internal organization, including criteria for recruitment, employee incentives, conditions of service, and separation from service, which are likely to differ from the country's civil service system.

A semi-autonomous research institute is legally independent of a line division of a ministry, but does not satisfy all of the criteria for definition as autonomous. The powers of the governing board of a semi-autonomous institute tend to be limited and basically advisory in nature. Semi-autonomous institutes are more directly linked with a particular ministry, which exercises considerable influence on policy (Jain 1989).

Funding: A special budget line in the national budget is the most common source of funding for this type of research organization. In some cases, funding may be tied to specific revenue sources

Organizational Chart of FRIM



Source: Adapted from SISTEM ARAHAN PENGURUSAN DAN PENTADBIRAN FRIM, Part A: Organisation and Research Management. 1 July 1993. Kuala Lumpur, Malaysia: FRIM. - Organizational Charts.

Figure 5.1.2. Simplified organizational chart for the Forest Research Institute Malaysia (FRIM), illustrating the autonomous institute model of forestry research organizations.

such as a tax on timber production or exports. The autonomy of the institute results in greater control over the management of funds, and has allowed some institutes to attract significant support from international donors. Fully autonomous institutes have complete control over their research budget, while semi-autonomous institutes depend more on the ministry for budgetary support. However, neither autonomous nor semi-autonomous institutes are totally independent of the financial

norms and audit requirements set forth by the government for publicly funded institutions. Further, by being independent from action program agencies within the government, an autonomous or semi-autonomous research institute runs the risk of losing the support of these agencies unless a special effort is made to develop research programs tied directly to their needs. An independent research institute may have a much harder job developing political support to obtain the government funding it needs for its research programs.

The university model: Integrated research and education

Governance structure: The key feature of the university model is the integration of research and education. Extension activities are sometimes included in the same organizational structure, as in the U.S. land-grant university system. This organizational form has a high degree of autonomy and decentralized decision making due to the nature of university systems. The university model is a researcher-oriented system, with a great deal of decision making power resting with individual researchers, who are often expected to take the initiative in developing and securing funding for their own research programs. A simplified outline of a typical research system in a land grant university in the United States of America, indicating the emphasis on research activities by individual professors, is shown in figure 5.1.3.

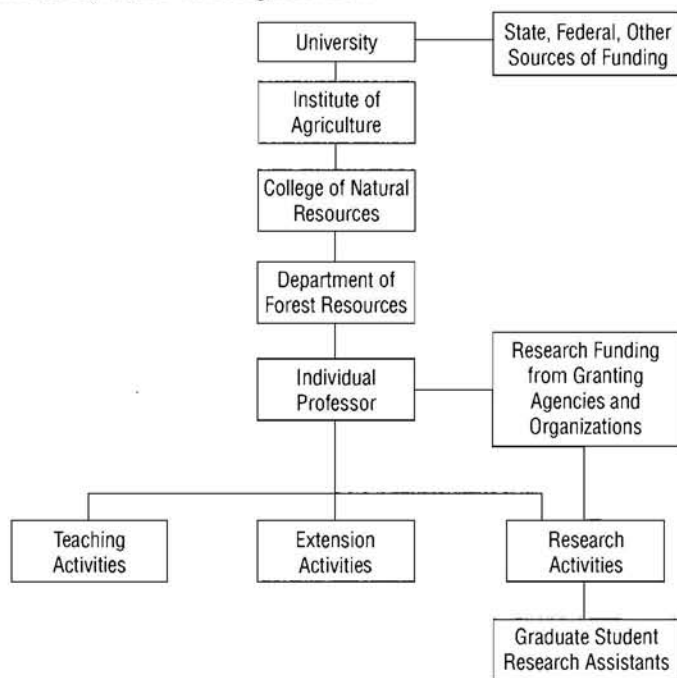


Figure 5.1.3. Typical research system in a land grant university of the United States of America, with responsibilities for teaching, research, and extension.

Funding: Funding flows through a variety of mechanisms from public and private, national and international sources. Some core funding may be available for research projects from regular university funding sources, or from special government programs designed specifically to encourage and support the development of forestry research capabilities. However, much of the funding for research projects may depend upon the ability of individual researchers to secure funding from various regional, national, or international granting agencies and organizations by submitting proposals for specific research projects. The amount of funding available for research may vary greatly among individual researchers and from year to year, depending upon the availability of donor funds, the types of research programs they choose to support, the number and size of the proposals submitted by the research staff, and the acceptability to the donors of the individual proposals submitted.

Private sector research

Forestry research in the private sector is currently very limited, yet is growing in importance in many developing countries. In developed countries, responsibility for certain types of research and research-related services has been transferred gradually to the private sector over the past 50 years. Jain (1989) states that developing countries will likely follow the same evolutionary route over time to achieve greater economy, accountability, and relevance in their research programs. In the developed countries, most adaptive research is carried out in private firms, which enables public research organizations to focus their limited resources on basic and applied research.

Governance structure: There are two basic types of private sector involvement in forestry research, although the second is very limited in developing countries: (1) research departments of forest products or related firms, and (2) research in industry associations or cooperatives. In both cases, research mandates tend to be narrowly focused with program policy subordinate to the firm or industry association. Research departments of firms have limited autonomy in setting program agenda and in administering programs. Research is closely linked to the firms' production and marketing strategies.

Funding: In some private firms, at least part of the research budget may be provided independently of the various operating divisions of the firm. Often research budgets are linked closely to company sales or profits, and research is the first area to be cut in a recession, creating instability in the research programs. In some firms, the source for research funding may be the various operating divisions within the company. Research may have to

develop and present proposals to particular operating divisions in order to win their financial support. Operating divisions within a company, under constant pressure to cut costs and increase financial returns, are unlikely to support long-term or basic research. The research they support is likely to be applied and directed towards solving immediate operational problems.

Desirable Features of the Organizational Structure

The fact that one organizational model has certain advantages over other models (e.g., greater autonomy) does not imply that it is superior in all circumstances. For example, a high degree of organizational autonomy may not fit well with a nation's system of government or culture. No one organizational approach can be considered optimal across all countries. The organizational structure of a forestry research institute should be consistent with the country's forestry conditions and a host of other national characteristics. Moreover, the most effective way to organize research within a country will likely change over time as the political system changes, the economy grows, the educational system develops, the private sector develops its own research capacity, and other changes take place. Flexibility and an ability to respond to change are thus important characteristics of the research organization.

Three desirable features of an institution's organizational structure are discussed here: (1) a sufficient degree of organizational autonomy; (2) an appropriate degree of centralization; and (3) congruence with national characteristics.

Sufficient degree of organizational autonomy

To be effective, research organizations need policies and procedures that are consistent with the special characteristics of the research process. It is highly desirable that research organizations have enough autonomy to establish such procedures. Because the ministry model has a relatively low degree of autonomy, research systems organized in this way usually are forced to use an unmodified civil service system that rewards researchers primarily on the basis of length of service and punctuality instead of the quality, creativity, and relevance of their research. The use of unmodified civil service systems for scientists in public forestry research institutes in some Asian countries has resulted in dissatisfaction among scientists and low research productivity (SEARCA 1982, Putti 1986).

Financial management practices is another area in which a degree of organizational autonomy is desirable. Practices designed to provide a high degree of financial control in large bureaucracies

are likely to be too rigid for a research organization, where timeliness and flexibility are essential. A lack of autonomy in financial management and control can create decision making bottlenecks, including delays in training programs, complex accounting systems that require considerable effort for what should be simple transactions, and lengthy delays in building programs (Iyamabo 1976).

Appropriate degree of centralization

Warnings against too much centralization in the organization of research are often heard. A research system with strong “top down” direction may be insensitive to local priorities. Since forestry research is often highly location specific, decision making should be responsive to local needs and priorities. Centralized research systems also may impose excessive bureaucratic constraints and burdens on researchers and managers.

On the other hand, some degree of centralization is necessary to coordinate programs, direct research toward national priorities, and efficiently provide support such as library and documentation services. It is generally recognized that a trade-off exists between the flexibility and responsiveness of a decentralized research system, and the stronger national budget support, more effective coordination and planning, and more efficient provision of support services in a system with a strong central direction. The appropriate balance between these opposing forces will depend largely on various national characteristics.

Congruence with national characteristics

Finally, the organizational structure of research should be consistent with a country's characteristics, especially the availability of resources and institutional and cultural characteristics. Resources devoted to forestry research must be in line with the importance of the forest-based sector and what the country can afford. Generally, administrative costs are likely to be proportionately higher in independent organizations that are highly autonomous. Trigo (1986) notes that decentralized research systems are more management intensive than centralized organizational structures. Therefore, an organizational structure with a relatively low degree of autonomy—as in the ministry model—may be most appropriate for small forestry research systems in small countries. Obviously, there may be a trade-off between congruence with national resources and desirable organizational features such as a high degree of autonomy and decentralization.

Congruence with social and cultural characteristics and with the existing political-administrative structure in a country also are

important. Ruttan (1981) contrasts the organization and management of public agricultural research in the Philippines and South Korea. Both systems have substantial research capacity. But the Korean system employs a "concentrated" management style and highly centralized administration of research, while the Philippine system is more decentralized. A relatively centralized organizational structure for research might work well in hierarchical cultures, but may be less effective in countries in which vertical social relationships are not stressed.

Growing Trend Towards Privatization of Forestry Research

Although considerable research on forest products and utilization and some research on other aspects of forestry have been conducted by private firms and organizations, much of forestry research throughout the world has been conducted and supported by national and international public agencies. In recent years there has been a growing trend towards what has been termed the "privatization" or commercialization of forestry research. By this is meant the decreasing dependence on government or internal core funding to support broad programs of forestry research, and the increasing reliance on outside sources of funds to support forestry research programs. This includes seeking funding for specific research projects from national and international foundations and other donors, or from the clients that the research is supposed to benefit, or from the sale of products, new technologies, and special services produced by the research organization. There may be increasing use of joint funding of research projects and programs, with cost sharing between governments, private industry, and other donors.

In extreme cases, such as in New Zealand (see box 5.1.1), government forestry research organizations have been turned into government corporations that are expected to be essentially self-supporting through the sale of research services and results. In New Zealand, the two new forestry research institutes are not supported by a direct appropriation, but must compete with other scientific research institutes for funding from a central science funding foundation, and find other outside sources of funding. In a number of other countries, such as Nigeria (see Odeyinde and Abu 1992 in the readings for module 7) and Tanzania (Murira 1993), government support of forestry research has been declining over the past decade, and forestry research organizations have been forced increasingly to rely upon outside funding to support their research programs, and upon the generation of research funding through the sale of research results, technologies, goods, and services to the private sector.

Box 5.1.1. The privatization of forestry research in New Zealand.

"Since 1990 New Zealand's science sector has undergone major reform, which has dramatically changed the organization and funding of science. The creation of a new Ministry of Research, Science and Technology to provide policy advice, a Foundation for Research, Science and Technology to allocate government funding for research, and ten research companies or Crown Research Institutes (CRIs) to do the research, were key elements of the reforms.

Until the 30 June 1992 more than 85% of New Zealand's forestry and wood products research was carried out by the Forest Research Institute (FRI). On 1 July 1992, the FRI was transformed into two research companies or CRIs. In future, most of the R&D concerned with the growing, harvesting, processing, and marketing of radiata pine and other production species, will be carried out by the New Zealand Forest Research Institute (NZFRI) based in Rotorua. Those parts of FRI concerned with environmental protection and ecological forestry research have been transferred to another research company called 'Landcare Research New Zealand' (LRNZ).

"The CRIs were established under special legislation ... and are set up as companies wholly owned by the government. They are to be run in a business-like manner and earn an adequate return on shareholders' funds. Compared to the old government department FRI, the new CRIs have more financial powers and are able to borrow, invest, and form joint ventures with other organizations and businesses to develop and commercialize new technologies. The CRIs are also free from many of the constraints and compliance costs associated with government department rules and regulations. The CRIs will pay tax on any profit they earn.

The CRIs will submit research program bids to the new Foundation for RS&T for funding from a 'Public Good Science Fund' totaling about \$280 million. Funds will be allocated on the basis of a set of priorities set by the government."

Source: O'Loughlin 1993.

The increasing commercialization of forestry research raises questions concerning the degree to which information generated for sale to private firms will be made freely available to other researchers through the media of scientific journals and other publications (O'Loughlin 1993). It also raises concerns about the funding of research, such as social forestry research, that is intended to benefit large numbers of poorer people in society, who cannot afford to pay for the use of research results. Such research cannot be easily commercialized, because the research benefits are likely to be relatively small and too dispersed to be easily captured by any formal market arrangements. If such research, aimed at individuals or small firms, is to continue, it will have to be supported primarily by public or philanthropic funding.

The trend towards privatization of forestry research is likely to force managers of forestry research organizations to learn new managerial skills involving salesmanship, marketing, and fundraising activities. Survival of the organization will require its managers to develop these entrepreneurial skills. Managers may

discover that some scientists find it difficult to accept and work under these conditions, which can strongly influence the selection of research topics.

Research Advisory Committees

Some forestry research organizations make use of a formal research advisory committee (RAC) to provide independent advice on research priorities and directions. For example, the Forest Research Institute Malaysia (FRIM) has an advisory committee appointed by the Malaysian Forestry Research and Development Board (MFRDB). The RAC is charged with providing independent advice on the planning, execution and extension of research in FRIM (see box 5.1.2 for the RAC's terms of reference).

Box 5.1.2. Terms of reference for the Research Advisory Committee (RAC) of the Forest Research Institute Malaysia (FRIM), as outlined by the Malaysian Forestry Research and Development Board (MFRDB).

Terms of Reference:

1. to advise the MFRDB on the research programmes and projects of FRIM, especially to identify research priorities and future directions.
2. where practical, to examine in detail the research proposals of FRIM and advise on their appropriateness.
3. to advise the MFRDB on the outputs [research results] of research carried out by FRIM.
4. to advise the MFRDB on other R & D matters referred to them by the MFRDB.

Source: SISTEM ARAHAN PENGURUSAN DAN PENTADBIRAN FRIM, Part A: Organisation and Research Management. 1 July 1993. Kuala Lumpur, Malaysia: FRIM. (page 15-2).

Such research advisory committees vary widely in structure and function from country to country:

- They may be established by statutory authority, or formed at the discretion of the research organization.
- They may be advisory only, or exert strong direct control over the direction and conduct of research programs.
- They may make recommendations to a board of directors, or report to the director of the research organization.

Improving Organizational Performance

It must be recognized that a research manager within a given research organization may be able to do little to change the basic organizational structure of that organization. This is rarely an option available to the research manager. However, by understanding the basic strengths and limitations of the different types of organizations, and particularly those of the organization

you manage, you may be able to better identify areas where it may be possible to improve the performance of your research organization. For example, if you manage a research organization within a ministry of the government, and must adhere to personnel policies that adversely affect the morale of your research staff, there may be ways to overcome the adverse effects of these policies by providing special incentives or by other means. Some of these will be discussed in **Study Unit 9.2 Creating an Appropriate Environment and Incentives.**

Activities

Please read the situation analysis below and answer the questions that follow.

Situation Analysis

A developing country in the South has been conducting a modest but growing forestry research program for nearly three decades. The program is currently part of the Department of Forestry in the Ministry of Natural Resources and is funded primarily through the national budget. The research program has grown rapidly over the past few years, as public policymakers have recognized the growing contribution that forests make to national economic development. The nation has advanced quickly in most aspects of development, with a better educated, healthier population, a recent shift toward more democratically-based government, and an open, export-oriented economy.

The Division of Forestry Research is part of the overall bureaucratic structure of the government, being a division of the Department of Forestry. The Ministry of Natural Resources also has a number of other divisions, including personnel, purchasing, accounting, and facilities management, etc., which provide centralized support services to the forestry department and the Division of Forestry Research. Like all other divisions and departments within the ministry, the Division of Forestry Research must closely adhere to the extensive and complex procedures and paperwork in order to access the services provided by these support divisions. While these procedures were instituted over time to discourage the illegal use of government resources, they have become unwieldy and ponderous. Further, the heavy emphasis on monitoring and accountability has been adopted by the forestry department as well, with the imposition of extensive reporting requirements for all research division staff. Finally, the increased activity, funding (some of which comes from international sources), size, and visibility of the Division of Forestry Research has caused some of the top administrators of the forestry department to feel jealous, threatened, or view the division as an effective means to meet their own political and career aspirations. As a result, they have imposed even stricter administrative controls over the division, and have begun to seriously meddle with the internal operations and research agenda setting within the division, attempting to direct research efforts toward more politically visible and rewarding activities.

The gradual program expansion and increased forestry research activity by the division has exacerbated long-simmering organizational and administrative problems, creating something of a crisis in the division and the department. The manager of forestry research of the division has received a mounting number of complaints from field professionals that the research agenda is increasingly irrelevant to adequately address local needs. Scientists within the organization feel seriously hampered by what they describe as excessive financial reporting requirements, slow and inefficient hiring and purchasing procedures, and a lack of freedom to determine topics for research. Rumor has it that a number of scientists are advocating radical changes in the organization and direction of the research program to reflect the dramatic changes in their country, and to achieve more independence in forestry research agenda setting and implementation. International donors are also expressing concern over the lack of independence of the division, and the subordination of the research agenda (toward which the donors contribute) to the political needs and desires of certain administrators within the department.

Activity 1

How do you think the organizational structures of the Ministry of Natural Resources, the Department of Forestry and the Division of Forestry Research contribute to the problems described above? Circle the letters of all responses that you think best apply.

- a. The support services provided to the research organization through other departments within the ministry are too centralized, and are overly bureaucratized.
- b. Scientists are getting caught up with the rapid economic and political changes around them, and simply want change for change's sake.
- c. Upper level ministry and department administrators view the scientist's desires for more freedom in setting the research agenda as a threat to their traditional areas of responsibility and authority. It seems the more the research staff pushes for change, the more the administrators resist.
- d. Under the present system, division administrators have limited autonomy and authority in decision making and logistical matters.
- e. While the research program has grown over the years, the supporting services of personnel, finance, and procurement have not grown nor have they been modernized to any significant extent.

***Comment 1***

- a. This is correct. The service departments in the ministry are overly centralized and bureaucratized. The organization's structure was established when the ministry was a much smaller institution. This organizational structure worked well for many years. However, with the changing economic and political environment, and the rapid growth in the forestry sector, the ministry model may need some degree of decentralization to better address the needs of its departments and divisions.
- b. While the spirit of change is pervasive and contagious, this is clearly not the driving force behind the requests for more efficient application of research resources to the solution of local problems. The loss of control over research agenda setting, mounting organizational and administrative bottlenecks, and increasing irrelevance of the research results are better motivators for change.
- c. This is quite true. A great deal of resistance can be encountered whenever institutions which have been in existence for some time are pressured to change. People in upper level positions may fear a loss of stature or power, or even for their jobs, resulting in the system reacting too slowly to societal and economic changes. Further, forestry department officials have come to view the research division as a means to increase their political power, and will not relinquish this resource lightly.
- d. Decentralization of authority and responsibility in areas of personnel, finance, and procurement can be an important means to energize a research organization, improve morale and performance, and enable more efficient delivery of research services.
- e. Financial accountability, personnel, and procurement procedures put into place in the distant past may have outlived their useful lives and may need significant modernizing and streamlining to enable more efficient research management and implementation.

Activity 2



How would you suggest modifying (in a general way) the organizational structure of this research institution to address the stated concerns of field professionals and scientists, and to improve research efficiency? *Circle the letters of all responses that you think best apply.*

- a. Change the ministry's administrative support service structure to modernize and streamline the personnel, finance, and purchasing divisions so they can provide better service to departments and divisions.
- b. Take steps to decentralize the decision-making authority of the organization to enable the research institution's staff to better match their research programs to local needs.
- c. Insist that responsibility and authority for forestry research be shifted from the Ministry of Natural Resources and the Department of Forestry to a newly established autonomous or semi-autonomous institute for forestry research.
- d. Drastically decrease the extent of financial reporting requirements (which were originally instituted as safeguards against illegal use of funds) which scientists are currently required to meet.
- e. Appeal to top ministry officials for help in reducing meddling from administrators in the Department of Forestry.

**Comment 2**

- a. Changing the ministry's support service to provide better service would address concerns regarding the excessive reporting requirements and slow procurement, and would improve personnel procedures. However, as the manager of only one (perhaps small) unit within the ministry, you may have little or no authority to make changes in the administrative operations of the ministry. You can, of course, document any problems with current operations, and call attention to the need for change.
- b. While updating services as described above (a) is an important start, concurrent actions to decentralize the overall organizational structure of the research institution would also be necessary to allow decision making to be made on a more local level. When programs are allowed to address local needs, they become much more efficient and effective.
- c. This is a rather drastic change! Remember that the research institution's organizational structure must be congruent with national characteristics, particularly regarding the availability of resources, and the institutional and cultural characteristics of the country. While the country in this exercise may be headed in this direction, it might be better to slowly evolve towards this type of organizational structure, rather than abruptly switch to a new structure. People usually respond better to and will be more likely to cooperate in managing gradual change (see response 1c). And politically speaking, accomplishing gradual change within a complex organizational system such as this, with many actors and stakeholders, is more likely to occur than abruptly changing the entire system. On the other hand, organizations have built in mechanisms that strongly resist significant change. Thus, gradual, superficial change may do little to enhance the effectiveness of the organization, and thus more drastic measures might be warranted. There is clearly no right answer to this question!
- d. To drastically reduce financial reporting requirements would most likely be warmly welcomed by most scientists. Financial managers might think otherwise, however, and would likely object to radical changes in financial reporting requirements. Thus, some sort of compromise reporting system might be agreed upon, utilizing a more streamlined approach which meets the financial officer's needs, while at the same time removing some of the reporting burden from the shoulders of scientists. Transferring financial accounting responsibilities to other nonscientific support personnel is also a common response to this problem.
- e. Appealing to top ministry officials to gain relief from internal meddling by forestry department administrators may ignite major high-stake political battles. It might be better to first deal directly with those causing the problems, discussing the situation with them, clarifying your own position, and examining alternatives. A difficult task, to be sure!

STUDY UNIT ACTIVITIES

Activity 3



Based on your own experience and knowledge, how would you expect the ministry's upper level administration to react to the actions you selected under activity 2? Circle the letters of the response you think they are most likely to take.

- They would welcome such changes with open arms, and would quickly implement the changes requested.
- They would resist the changes with all the means at their disposal.
- There would be disagreements between the upper level ministry and departmental administrators as to the best course to follow. Thus, they might decide to do nothing for the moment, and instead take a wait-and-see attitude.
- They would decide that the problem needed further study, and would request that members of the ministry, the Department of Forestry, the Division of Forestry Research, user groups, and policy makers, form a task force to examine the issues in depth and to make recommendations for change.

STUDY UNIT ACTIVITIES

Activity 4



In the space below, list the three organizational models most commonly used by public sector forestry research organizations, and identify the model upon which *your own organization* is based. If it differs from the three types described in the text, briefly describe your organization and how it differs.



Comment 3

- a. This would be a rather doubtful response, as there is too much personal power and influence at stake. There are few obvious incentives for upper level ministry administrators in this situation to quickly implement major structural changes in their organizations.
- b. This may be more likely to occur, particularly if the ministry administrators feel that their power, prestige, or influence will be threatened, or in some way diminished.
- c. Some organizations might decide that this is the best approach, or in effect, decide not to decide. Of course, this lack of action just aggravates the problem, and will make it much more difficult to deal with in the future.
- d. If top administrators clearly understand that there is a growing problem (that is, if the research manager has successfully communicated to upper management her or his assessment of the problem), they would be likely to choose to further study the issue. Such action will furnish them with a better picture of what their options are, and buys more time for them to carefully analyze the situation, prepare for eventual change, and maneuver so that they might be in a position to gain from the changes that might occur.



Comment 4

Just for review, here are the three organizational models described in the text:

1. the ministry model;
2. the autonomous or semi-autonomous institute; and
3. the university model: integrated research, education, and (perhaps) extension.

More than likely, your organization is based on one of these models or is a hybrid of several organizational approaches.

Activity 5

List below the three desirable features of a forestry research organization's structure that enhance forestry research capacity, and briefly explain how they contribute to improved research program implementation.

1.

2.

3.



Comment 5

The three key desirable features of a forestry research organization's structure are:

1. a sufficient degree of organizational autonomy;
2. appropriate degree of centralization; and
3. congruence with national characteristics.

These criteria are all rather broad, using words like “sufficient” and “appropriate.” This is because cultures vary markedly between nations, resulting in differing relevance and appropriateness of the different organizational approaches. Further, the size of the research organization, its primary source of funds, and the length of time it has been active in forestry research all affect how the organization will embrace these three organizational features.

Nevertheless, these features are key to organizational success, and can be considered principles of organizational design. If you feel your organization has structural problems (as you may discover in responding to **Activity 6**), consider how these principles are being incorporated into the organization's administrative and managerial structure.

How does *your* organization's structure limit and enhance the implementation success of your forestry research agenda? Use the guide below to rate your own organization.

Activity 6



Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Decision making is too centralized.					
I cannot make important day-to-day decisions without asking my superiors.					
There are too many layers of decision makers in the organization.					
Scientists are not allowed to make their own day-to-day decisions in the field.					
Scientists are often bogged down with financial and accounting paperwork.					
Scientists are often bogged down with administrative reporting.					
Scientists are often too busy with meetings to schedule field visits.					
Information does not flow freely and easily through the organization.					
There are many extensive, complex, and confusing reporting requirements to funders and the government.					
The organization is not addressing local needs very well.					
When pressed, scientists are unclear of what users really need from forestry research.					
The research organization has little internal autonomy over hiring or firing of personnel.					
Information resources are scattered throughout the organization, and are not centralized.					
There is always a shortage of vehicles, and those that are available are poorly maintained.					
Constraints of cash flow often restrict research activities.					
There are turf battles over resources and activities within and between divisions and departments.					
Job assignments and responsibilities are unclear.					
Scientific equipment ordered takes a very long time to arrive, is often not what was ordered, and sometimes is missing parts.					
Scientific equipment is poorly maintained and thus is rarely available for continuous use.					

How did your organization rate? We hope you checked the “disagree” and “strongly disagree” columns most often, and thus have few structural or administrative problems affecting your forestry research activities. However, if you have many checks in the “strongly agree” or “agree” columns, your organization has some severe structural and administrative problems that need immediate attention!



STUDY UNIT ACTIVITIES

Comment 6

This was your chance to really look at the structure of your organization, and think about how it helps or hinders your efforts at implementing the research agenda. For instance, is decision making too centralized, restricting your ability to craft a relevant and appropriate research agenda? Do scientists and research managers have the freedom to act as they deem necessary to advance the goals and objectives of the organization? Does the organizational structure limit flexibility to respond to rapidly changing conditions? Does the administrative structure permit efficient resource use, and promote interaction between researchers and user groups?

Again, we hope you checked the “disagree” and “strongly disagree” columns most often, indicating few structural problems within your organization. However, if you have many checks in the “strongly agree” or “agree” columns, your organization is probably not functioning very well, and should address some of its structural problems.

Summary

The way in which an institution is organized strongly influences its ability to produce high-quality forestry research. Forestry research can be structured within a governmental ministry, as an autonomous or semi-autonomous institute, within a university (which integrates research and education), or as a research unit in a private sector corporation. Each type of organizational structure has certain advantages and disadvantages, and should be consistent with a country's characteristics, especially the availability of resources, and institutional and cultural characteristics. Three of the more important and desirable features of an institution's organizational structure are: an adequate degree of organizational autonomy, an appropriate degree of centralization, and congruence with national characteristics.

If you would like more information about organizational structure, we encourage you to obtain and review the interesting references identified in the literature cited and other references listed at the end of the module. A key article directly related to the topics covered in the module, and cited in the text, is reprinted for your use in the section on readings at the end of the module.

Research Program Planning

Objectives

When you have completed this study unit you should be better able to:

- *explain what research program planning is, and why it is needed;*
- *describe three program levels commonly encountered in a forestry research organization that play important roles in program planning;*
- *describe three planning levels that correspond to the three research program levels; and*
- *develop outlines for project/work unit plans and study plans.*

Program plans for a forestry research organization outline the program of research that the organization plans to conduct in order to carry out its mission and achieve its strategic goals and objectives. Program planning provides a linkage between strategic planning (which is long-term and broad in perspective, and provides an overall sense of direction for the research organization) and annual planning (which is short-term, very specific, and is closely tied to the budget process). The output of strategic research planning is a key input to program planning; the output of program planning is a key input to annual planning and budgeting.

In this study unit you'll learn why research program planning is needed, how it is carried out, and some special factors you need to consider when planning research programs.

What is Research Program Planning?

Research program planning encompasses a series of research plans that describe and justify a program of research that an organization plans to carry out over a period of time, often several years. Research program planning can be carried out at several levels in the organization. Three research planning levels are frequently encountered: (1) plans covering research program areas; (2) plans covering the research projects

included in each program area; and (3) plans for each individual study included in the research project. McLean (1988a) has defined programs and projects as follows:

“Programs are coordinated research activities whose combined scientific output addresses national research objectives. Programs are long-term and somewhat continuous, and are composed, in some cases, of sub-programs, and of projects. Projects address

specific research problems, and have explicitly defined timeframes, resources, and targets.”

These planning levels are closely allied to the way in which research programs are frequently organized within forestry research organizations. These will be discussed more fully later in the sections on the structure of research programs, and research planning levels. At each planning level there may be several plans, each covering a specific research program, project, or study. Not all research organizations will develop plans at all of these levels. However, regardless of the size and mission of the organization, some sort of research program planning is needed to help organize research activities.

Why is Research Program Planning Needed?

The impact of a research organization on society is largely determined by the relevance of its research program. If a research program addresses national development goals and important high-priority problems in the forest-based sector, then the organization has the potential to make a significant contribution to the development of that society. Of course, to do this, the program must have adequate resources, a favorable policy environment, and other factors that influence the effectiveness and efficiency of research. But without a relevant program of research, an organization has little or no chance for success in obtaining the resources it needs to carry out its proposed program of research. It is therefore worth spending a significant amount of management time and effort to ensure that a program of research is developed that is relevant to the organization's strategic plan.

A set of program plans can be used to inform legislators, policy makers, research users, and other stakeholders of the research that the organization plans to carry out, and the reasons why that work is being undertaken. Such plans also provide an approved framework and guidance for those planning and organizing research activities within the organization.

Structure of Research Programs

Most public research organizations, except perhaps for the very smallest, use a project-oriented approach to research planning and management. By this is meant that the researchers within an organization are organized under broad program areas, within subunits (often called research projects or research work units) that have the responsibility for conducting research on a particular problem area or within a specific scientific discipline. Each subunit typically has a project or research work unit leader, and one or more additional researchers and other personnel. There are

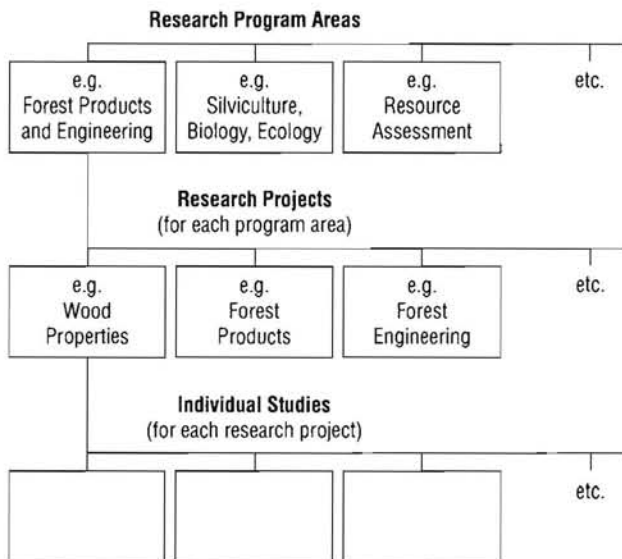


Figure 5.2.1. Generalized structure of a project-based research program.

many variations of the project-based approach, depending on the size and complexity of the organization and other factors.

As illustrated in figure 5.2.1, the structure of a project-based research program usually consists of three separate levels or components:

- a set of broad research program areas;
- a set of research projects or research work units under each program area; and
- a set of individual research studies within each project or work unit.

Research support services (not shown here) are also an integral part of the research organization. They often (but not necessarily) are administered separately from research program areas. Two types of research support areas, scientific support services (e.g., library and information services, computing and statistical services) and administrative support services (e.g., personnel services, budget and finance), are discussed in considerable detail in module 8.

Research program areas

Research program areas are broad subject areas or topics for research that an organization is pursuing or plans to pursue. They are often defined along disciplinary lines (e.g., forest products,

silviculture, ecology, plant pathology), although defining program areas by broad problems that cut across scientific disciplines may be a more desirable approach. The number of research program areas varies greatly between organizations: small research organizations with narrowly-defined missions may have a single program area; large organizations with broad mandates may define ten or more program areas to pursue.

Research projects

Research projects are often the building blocks of research programs. *A project is defined as a self-contained area of investigation with specific goals and objectives which relate to a particular program area.* Each research program area contains one or more projects. A research project is defined by its goals and objectives, and is strongly influenced by the individuals assigned to work within the project. These may consist of an experienced scientist designated as the team leader or project leader or director, who supervises other research scientists and support personnel attached to the project.

There is no set size for a research project. The size of a project or unit can vary greatly, depending on the scope of the project assignment and the availability of funding and qualified personnel. Under some conditions a project may consist only of a single person, the leader, with no additional staff. Other projects may consist of 10 or more researchers and a large support staff.

The duration of a research project may be fixed for a period of time, or it may be for an indefinite period of time, depending upon the outcome of periodic evaluations of its work. Depending upon the outcome of the evaluation, the project may be renewed for another period of time with essentially the same objectives, it may be redirected with new objectives, or it may be terminated.

Individual research studies

Finally, each research project, especially larger and more complex ones, may include a set of individual research studies designed to generate specific information needed to fulfill the goals and objectives of the project. The scope and duration of studies within a project are highly variable, depending on the type of research and the nature of the investigations being carried out. Individual studies may involve only one scientist, or it may involve several, together with teams of field, laboratory, and office assistants.

Research Planning Levels

The planning of a project-based research program usually includes the preparation of three types of key planning documents that

correspond to the three program levels outlined above—program areas, research projects, and individual research studies. The three types of planning documents are: (1) program area plans; (2) project plans; and (3) research study plans. The relationship between research program levels and planning levels is illustrated in figure 5.2.2.

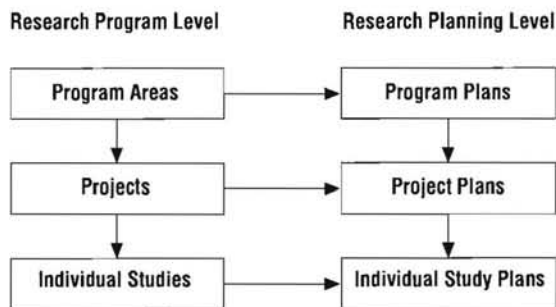


Figure 5.2.2. Relationship between program levels and planning levels in a forestry research organization.

Program area plans

Program area plans (sometimes referred to simply as program plans) generally provide an overview of what research is planned for a broad problem area or issue over a period of several years. They provide a framework for guiding more specific research activities by:

- describing the specific research areas and projects included within each program area over the planning horizon (often from three to five years);
- justifying why the research is needed, and what contributions the research can make to meeting the needs of science and society;
- defining the specific objectives and goals of the planned research, and indicate when they are expected to be achieved;
- summarizing the estimated resource requirements for the proposed research program; and
- outlining in general terms the expected accomplishments and outputs resulting from the research.

Program area planning at the research organization level has been called operational planning (Milne 1987), “level 2” planning (Dagg and Haworth 1988), medium-range planning (Bengston and Kaiser 1988), and mid-term planning. The scope of the program

area plan will vary with the complexity of the research area or problem area under study, and the size of the research organization or subunit. It may encompass all of the research areas and major problem or issue areas that the research organization or subunit plans to pursue over the next few years. Or, it may focus on only one particular research area or problem. Typically it describes in general terms all of the individual studies and other research activities that the unit or organization plans to implement within the scope of the program area covered by the plan. A program area plan also may include a description of the scientific and administrative support program areas such as library and information services, and personnel services that are needed for proposed program of research, or that are available to the organization. ISNAR (1987) provides an example of this type of planning document.

The typical planning horizon for program planning is three to five years. Program areas should be clearly defined, with goals and objectives explicitly stated and resource requirements (financial, human, and physical) specified to the extent possible.

To be effective, a program of research must be sufficiently focused, given the resources available for research and the capacity of the organization for conducting research. Research organizations that spread their resources thinly over too many program areas and projects will be less effective than one that is focused on critically important problem areas to which it can contribute solutions. A lack of focus in forestry research programs relative to research resources has been noted repeatedly (for example, Wadsworth 1968, Iyamabo 1975, Brunig 1982, Lundgren et al. 1986). This lack of focus may be due to the fact that in many developing countries, a single government institute often has responsibility for research on all aspects of forestry, including silviculture, tree breeding, pathology, soils, ecology, wildlife, forest products, and the social sciences, each with their own constituencies pressuring for targeted research. The combination of broad research mandates and severely limited resources implies the need for careful planning to develop an appropriately focused program of forestry research. The type of research program planning needed by an organization is closely tied to the way in which its research program is organized.

Program area planning should not be an isolated management activity. Effective research program planning is both a top-down and bottom-up process. Some guidance must be provided by top administrators to those preparing the program plan as to expected funding, personnel restrictions and opportunities, and other key strategic factors that are likely to affect the research program. Research program area plans are important documents, and require

the detailed involvement of the research unit's senior management team. Preparation of such plans cannot be left to junior staff members. While the ultimate responsibility for program planning rests with senior research management, particularly the manager of the research unit for which the plan is being prepared, external stakeholder groups, team leaders, and researchers also have important roles to play. External stakeholders can help identify, define, and set priorities on research needs. Staff members and researchers can provide a realistic appraisal of the unit's potential capacity to carry out the desired research program. A program plan based on unrealistic expectations will lack relevance and be of little use to the research organization.

Program area planning often is viewed as a recurring one-time task, as something to be done every few years, and then put aside. However, research program areas may vary over time, as priorities and information needs change. A program planning process that is built into the structure and operating procedures of the research organization, and is subject to constant review and updating as conditions change, is likely to provide a more useful guide to the operations of the organization. For example, repeated interaction with and feedback from policy makers, the research advisory board, potential users of the research, and external and international research organizations, can help identify research needs and ensure that the program remains relevant, even as conditions change.

An important use of program plans is to provide a solid basis for monitoring progress and evaluating performance of the organization. It can be used to help determine if specific objectives outlined in the program plan have been accomplished on schedule, and if the anticipated impacts have been achieved. If they are to be used for this purpose, it is important that the objectives and goals and expected timing of accomplishments are clearly described in the program plan. A useful tool for this purpose is the Logical Framework, which provides a systematic framework for helping to describe goals, outputs, and inputs, and the indicators by which they will be measured. The Logical Framework is described in some detail in Study Unit 5.3.

Project plans

In addition to broad program area plans, detailed descriptions for each of the individual research projects that fall within the program are also important program planning documents. Project descriptions usually are prepared by the project team leader, in consultation with team members and with higher administrative levels, and should include:

- a statement of the project's mission;

- the justification for the project;
- identification of key problems to be addressed within the scope of the project and the approach to solving these problems;
- objectives and planned outputs;
- a plan of work that defines responsibilities of project members;
- staffing, equipment, and other resource needs;
- anticipated sources of funding, and approximate levels required for the work planned; and
- a reporting schedule that identifies indicators or milestones that reflect progress.

The Logical Framework, described later in this module, can be helpful in developing project descriptions.

Individual study plans

The third planning document is the highly detailed plan of study for individual research studies, prepared by the principal researcher(s) in collaboration with other researchers and the project team leader. A study plan should include:

- a statement of the research problem, and justification of the study in relation to the project in which it fits;
- importance of the proposed work and previous work in the field;
- a clear statement of the specific research objectives;
- a detailed description of how the work is to be carried out (methodology), including methods of data collection and analysis;
- cost estimates, including personnel needed and their skills, materials and facilities required, duration of the project;
- proposed coordination and collaborative arrangements with other scientists, organizations, or individuals;
- scheduling of the research and planned outputs; and
- planned technology transfer activities, including planned publications, reports, conferences, etc.

An example of the format and instructions used by the Forest Research Institute of Malaysia for developing its study plans is given in box 5.2.1.

Box 5.2.1. Format for study plans used at FRIM, the Forest Research Institute of Malaysia (FRIM 1993).

A study plan shall document the rationale for undertaking a specific line of work in research, development, or application of technology (RD&A). The study plan shall be written by the Study Leader and coworkers, reviewed by scientists within and outside of FRIM, endorsed by the Project Leader and approved by the division director.

A study plan shall follow this general outline:

Title - shall be short (no more than ten words) and descriptive. It shall start with an action verb - to describe, to improve, to understand, to determine. Avoid terms such as to study, to learn, or to test. It shall be phrased in terms of the problem to be solved or the expected outcome. It shall not mention the methodology or approach.

Objective(s) - shall be achievable, verifiable and tangible. The objective(s) shall relate to a goal that is either socioeconomic, technologic or scientific. Ideally there shall be only one objective for a study. Separable objectives usually point to the need for separate studies. Occasionally economy of effort may justify working toward two or more objectives via a single study.

Justification - shall explain why FRIM should direct its limited resources at achieving the foregoing objective. Who wants what, and why? What is the situation or problem? What would be the technological, social, or economic impact of success in achieving the objective(s)? It shall identify the audience concerned about this study.

Review of literature or experience - shall provide a technological framework for the work that is proposed. Only key documents shall be cited. An exhaustive review of literature shall not be included. Relevant practical experience may be summarized.

Duration and plan of work - shall provide detailed sections on approach to solve the problem; method and procedures; and location and timing of work. The section on approach puts this study in context with others and as part of the overall RD&A process. The section on methods and procedures gives detailed information on: sequence of activities; equipment, land, or facilities to be used; experimental designs; collecting, handling, and analyzing data; statistical analysis; illustrations needed to document the study or for publication. The section on locations and timing tells where and when each phase or step of the work will be done.

Anticipated output and impact - shall outline the intermediate output from the RD&A process, identify audiences for the output, and suggest how achievement of expected objectives will affect socioeconomic, technical, or scientific situations.

Schedule of work and events - shall provide time schedules and charts in a chronology by which progress of the study may be evaluated. The work schedule or chart shall show each phase of work on a monthly calendar. The expected time line shall start with the month when work should commence and continue through termination of the study.

Staffing - shall show the commitments of people required to accomplish the objective(s). Involved scientists shall be named. The amount of time committed to the study during each calendar year by each scientist shall be estimated (to 0.1 scientist years). Any special work to be done by research supporting services, e.g., a new computer programme, shall be identified. Unusual need for work by people in other grades shall be estimated.

Financing - shall show any cost for transport and travel, equipment, supplies or other expenses. Costs for the study during each calendar year shall be estimated by management using average costs per scientist-year.

Cooperation and coordination - shall identify other investigators or organizations working on the same or related problems and expected interaction with them during the study.

Source: FRIM (1993).

Please read the situation description below and complete the activities that follow.

Activities

Situation Analysis

The Ghosa Division of Forestry Research is a successful forestry research organization that is currently investigating a number of topics relevant to the stability and sustainable use of forest resources in Ghosa.

Ghosa has been undergoing rapid change. The nation's pace of development is quickening, with the overall standard of living of many people increasing despite increasing populations and rural-to-urban migration of rural people in search of employment. Almost all the available agricultural land is already farmed using traditional methods, with associated high erosion rates and declining productivity. Forested areas protected by law are being encroached upon by landless farmers looking for a means to generate their own livelihood. Forests are under increasing pressures everywhere from the forest products industries, government-sponsored economic development and resettlement schemes, demand for agricultural land, and increasing human populations. On the other hand, forests are being increasingly viewed by top policy makers as resources deserving protection due to their vital contribution to the nation's economic and ecological health.

In response to these trends, and based upon surveys of key stakeholders of forests and natural resources, the division formulated a research program plan several years ago that attempted to meet the nation's needs. However, since the plan was written, many additional research projects have been undertaken. Thus, the rapid pace of change, the increasing complexity of the overall research agenda, and the growing size of the research organization have rendered the division's prior program plans increasingly obsolete. The research program lacks coherence, is difficult to manage, monitor, or evaluate. A list of current research activities (following) is available.

-
- a. *An investigation looking into the silvicultural aspects of producing Acacia auriculiformis in plantation and agroforestry configurations.*
 - b. *Research regarding the characteristics and marketing potential of oil made from the nut of a native palm.*
 - c. *Species/site matching investigations for Eucalyptus camaldulensis and Acacia mangium, and two native species.*
 - d. *Provenance trials of Calliandra calothyrsus.*
 - e. *Several investigations examining the differences between wood properties of several species of Dipterocarps grown in native, mixed forests or plantations.*
 - f. *A soil survey program to map major soil types in all forested public lands administered by the Department of Natural Resources.*
 - g. *A financial cost/benefit analysis comparing seedlings grown in rigid root trainer containers vs. those grown in polybags.*
 - h. *In-depth field studies examining the ecology, phenology, and seed characteristics of a number of important native tree species.*
 - i. *An examination of the reasons for Casuarina mortality 3 years after planting.*
 - j. *A series of studies examining the use and role of microsymbionts (mycorrhizae, Frankia, and Rhizobium) in the growth and post-planting survival of tree seedlings.*
 - k. *Silvicultural investigations examining the impacts of site preparation and plantation establishment techniques on the growth and yield of Eucalyptus camaldulensis.*
 - l. *A series of longitudinal studies examining the social and economic impacts of forestry extension and research on Ghosan society.*
 - m. *Ongoing longitudinal studies that examine the extent and decline of forest cover in Ghosa.*
 - n. *A socioeconomic research program attempting to identify small scale, low impact forest utilization industries that will help improve the standard of living of rural populations, while providing incentives to these people to protect their forest resources.*
 - o. *A research project funded by an external donor to test a number of tree species in a number of agroforestry configurations. Economic, soil conservation, and tree growth, site effects, and yield impacts are being examined.*
 - p. *Surveys to identify new species of plants or animals, and to develop measures of and baseline data for biodiversity.*
 - q. *Pharmaceutical surveys to identify new plant and animal derived compounds with potential commercial application.*
-

Please respond to the following activities.

STUDY UNIT ACTIVITIES

Activity 1



The research manager of Ghosa's Division of Forestry Research needs some assistance with organizing the division's current research agenda. Based on what you learned in this study unit regarding operational research planning levels, determine whether the above activities are research program areas, research projects, or individual studies. Then, identify the major program areas (we think there are five, one of which is resource assessment). For each program area, list the project associated with that program area. And next to each project, list the individual studies relevant to that project. We have included an example to help clarify the activity. Write your responses under the appropriate column headings below:

Major Program Areas	Projects	Individual Studies
1. Resource assessment	Forest assessment and status	m
2.		
3.		
4.		
5.		



One way the research agenda of the Ghosa Division of Forestry Research can be organized into an operational planning framework is as follows:

Comment 1

Major Program Areas	Projects	Individual Studies
1. Forest Products	Small-scale forest industries	n
	Nonwood products	b
	Wood products	e
	Pharmaceuticals	q
2. Silviculture	Silvics of individual species	a, c, d, k, o
3. Ecology/Biology	Forest soils	f
	Forest ecology	h, j, o
	Pathology/Entomology	i
	Biodiversity	p
4. Resource Assessment	Forest assessment and status	m
5. Socioeconomic Analysis	Baseline socioeconomic analysis	n
	Forestry program impact analysis	l
	cost/benefit analyses	g

This framework represents only one organizational viewpoint (ours!) regarding the various research activities presented, particularly at the program and project levels. You might have come up with different research program areas and projects. Don't worry if you did, as the point of this exercise is not for you to agree with us on how the division's agenda can be organized! We just wanted you to get some practice discerning the differences between program areas, projects, and studies, and to create a framework that provides the basis for operational planning.

Activity 2

In your own words, define the following terms:

Research Program Area:

Research Project:

Research Study:



Comment 2

Research Program Area: a broad subject area or topic for research that an organization is pursuing or plans to pursue. These often are defined along disciplinary lines, though using broad categories that cut across scientific disciplines may be more desirable for problems requiring interdisciplinary research.

Research Project: a self-contained area of investigation with specific goals and objectives which relate to a particular program area. Research programs often include one or more projects. Thus, projects are the building blocks of research programs.

Research Study: an individual research activity designed to generate specific information needed to fulfill the goals and objectives of the project. There may be one or more studies being implemented within a specific research project. Studies are the building blocks of research projects.

Activity 3

As the Ghosa Division of Forestry Research proceeds with the planning process, what items or topics should be included in the project plans? *Write your responses in the spaces provided below.*

1.

2.

3.

4.

5.

6.

7.

8.



Comment 3

Project plans should include:

1. A statement of the project's mission;
2. The justification of the project;
3. Identification of key problems to be addressed within the scope of the project and the approach to solving these problems;
4. Objectives and planned outputs;
5. A plan of work that defines responsibilities of project members;
6. Staffing, equipment, and other resource needs;
7. Anticipated sources of funding, and approximate levels required for the work planned; and
8. A reporting schedule that identifies indicators or milestones that reflect progress.

Activity 4

As the Ghosa's Division of Forestry Research continues with the planning process, what items or topics should be included in the individual study plans? Write your responses in the spaces provided below.

1.

2.

3.

4.

5.

6.



Comment 4

Study plans should include:

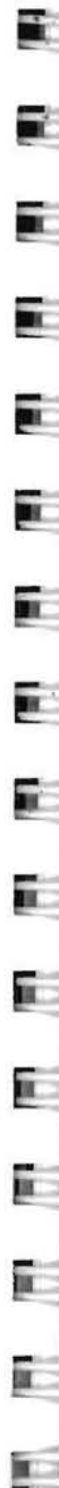
1. A statement of the research problem, and justification of the study in relation to the project in which it fits;
2. Importance of the work and previous work in the field;
3. A clear statement of the specific research objectives;
4. A detailed description of how the work is to be carried out (methodology), including methods of data collection and analysis;
5. Cost estimates, including personnel needed and their skills, facilities required, duration of the project;
6. Interorganizational linkages and collaboration required to implement the research;
7. Scheduling of the research and planned outputs (reporting etc.); and
8. Planned technology transfer activities.

Summary

Operational plans of forestry research organizations are medium-term plans of the activities the organization intends to implement in order to carry out its mission, and to achieve its strategic goals and objectives. Operational plans are closely linked to strategic plans, and detail in a practical way how the strategic plan will be implemented. The output of strategic research planning is a key input to operational planning; and the output of program planning is a key input to annual planning and budgeting.

By completing this study unit, you learned that operational planning can be structured into three distinct levels; research program areas, research projects, and individual studies, each with their own type of plan. By using the planning framework presented, we think you will be better equipped to guide your staff in its operational planning activities.

If you would like more information regarding operational planning, we encourage you to proceed to the next study unit which contains more detailed and practical information which can help you in your planning activities. We also suggest that you obtain and review the interesting articles identified in the literature cited and other references listed at the end of the module. Two key articles directly related to the topics covered in the module, and cited in the text, are reprinted for your use in the section on readings at the end of the module.



Links Between Strategic Planning and the Research Program

Objectives

When you have completed this study unit you should be better able to:

- describe the factors that are essential to consider when conducting program planning;
- explain how each of these factors are incorporated into the program planning process;
- state the importance of linking program planning to strategic planning; and
- describe the logical framework and its application to program planning.

Within the three planning levels discussed in Study Unit 5.2 (research program areas, research projects, and individual studies), research program planning can be improved by:

- linking program planning and strategic planning;
- evaluating both staffing requirements and availability;
- incorporating monitoring and evaluation into key planning documents;
- including both external and internal input into the planning process;
- blending researcher interests and organizational goals;
- involving stakeholders in program planning; and
- recognizing existing knowledge and information.

This study unit takes an in-depth look at each of these activities. You'll also learn about a useful tool for program planning—the Logical Framework. By mastering the concepts explored in this unit, you will be better able to improve the quality and utility of your organization's plans.

Linking Program Planning and Strategic Planning

If it is to be effective, research program planning should be designed to implement the strategies outlined in the strategic plan. This requires that plans for broad research program areas address specific strategic objectives and goals

developed in the strategic plan. In turn, plans for research projects within a program area should address the problem areas identified in the program area plan. How research program areas are defined is often strongly influenced by the mission and research capabilities of the organization. The research organization's mission and mandates may

prescribe certain types of forestry-related research, or deliberately exclude other types, and thus restrict the scope of problems it will address. Problem areas can be defined in many ways, often along organizational lines. For example, if the research organization has a research unit on the silviculture of natural forests, then a program plan may be developed for that subject area of research, and may serve as both a program area and research unit plan.

The size of the organization may influence the way in which research program areas are defined, and how program planning is done at other levels in the organization. For example, in a relatively small research organization, there may be only one program area plan for the entire organization, and no need for research work unit or research project plans. In contrast, for larger organizations there may be a need to develop some type of program planning at each organizational level, as illustrated in figure 5.2.2. Thus, there may be an overall strategic plan for the entire research organization, which sets the mission and broad overall goals for the organization, and develops a broad strategic framework within which its research program will be carried out. Within this framework there may be separate program plans developed for each research administrative area in the organization. Each of these program plans would identify and justify research problem areas, and set priorities for research and other activities of the unit for a given period of years, typically 3 to 5 years. The exact period to be covered may be flexible, or it may be spelled out by regulations. Each program plan would address the appropriate goals and objectives outlined in the organization's strategic plan and explain how those goals and objectives would be implemented during the next few years.

Within each program area, there may be several projects, each with its own mission, goals, and objectives spelled out in a research project description or plan. These project plans would be clearly linked to the research problem area identified in the program area plans, so that by reading the project plans one could see how the program area plan was to be implemented.

In turn, the research project plans are implemented by the individual studies that are carried out to address the specific problems identified. These individual study plans should clearly identify the specific problem being addressed, and relate this to the larger problem identified in the research work unit/project plan.

Regardless of the exact levels of program planning used within the organization, the program plans for the organization need to be clearly linked to the strategic plan. The strategic plan provides the framework within which program planning takes place. Program plans should indicate how the research activities planned for the

particular problem being addressed will ultimately help to achieve the goals and objectives outlined in the strategic plan.

Evaluating Staffing Requirements and Availability

Program planning and priority setting must be related to the availability of trained scientific and support personnel. Program plans should contain a section on staffing requirements that include scientific and support skills needed to conduct the proposed research, an appraisal of available skills, and an action program to overcome any apparent deficiencies. If there are deficiencies in the required skills, then the necessary skill levels must be obtained by hiring new personnel, training existing personnel, continuing education, work experience, or by some other means. If there appears to be no way to make up the deficiencies, then the proposed research program will have to be modified. In conducting this appraisal of staffing needs, it is important to recognize and allow for the time required to achieve the required skill level.

In most developing countries, the research resource that is in shortest supply is trained and experienced researchers. In a survey of forestry research institutions in developing countries, research managers identified the level of training of researchers as the most important factor influencing the research capacity of their institution (Bengston and Gregersen 1988). Constraints imposed by lack of trained researchers are compounded by the fact that researchers cannot simply be transferred to wherever they are most needed the way other resources may be transferred. A person trained as a silviculturalist cannot fill a position for a forest products technologist. Moreover, the training of a new scientist to fill a particular position takes a long time (see Study Unit 9.3). As many research managers are painfully aware, the availability of human resources imposes severe limitations on program planning. The availability of trained personnel is a key parameter in program planning.

Incorporating Monitoring and Evaluation into Program Planning

Monitoring and evaluation of research programs should be ongoing and built into all program, project, and study plans. Program plans, project descriptions, and study plans can be used to monitor progress and evaluate performance relative to the stated objectives, but only if research objectives and scheduling of activities are clearly stated in those documents. In many research organizations, research managers periodically review each research project approximately every two years. Such reviews

serve as an important input into program formulation, and include evaluation of research progress, staffing and training, program and budget development, support services, research facilities, and dissemination of research results (see Murphy 1985, Daniels 1987, McLean 1988a).

Monitoring and evaluation of research programs may include external review teams as they are needed (Ruttan 1978). Some of the most effective external reviews are participatory, and include senior research management personnel. They monitor progress, identify problems, and evaluate alternative solutions. Action plans for needed follow-up are developed and tracked until all items are completed (usually within one year after the review). External review teams can provide useful insights in evaluating an organization's broad goals, objectives, and strategies, and its capacity to effectively carry out its proposed program of research. Members of such external review teams are likely to be far more helpful to the research organization if they focus their review efforts on these broad strategic items, and resist the temptation to concentrate on operational details such as performance appraisals of individual scientists and reviews of research methodologies used in individual studies.

Monitoring and evaluation should be designed to go beyond checking on the successful completion of the planned research. It also should obtain information that could be used to judge how successfully the research results were disseminated to potential users, and were subsequently adopted and implemented. If enough time has elapsed, then monitoring and evaluation should also assess the potential societal, environmental, and other impacts resulting from adopting and implementing those research results.

Including Both Internal and External Input in the Planning Process

Research program planning includes planning for the research program areas, projects, and studies that are to be carried out by the organization. It also includes planning, whether formal or informal, for the research support areas that will be required to support the research programs of the organization. The development of a research program should reflect both internal and external input. Figure 5.3.1 identifies key internal and external influences on program planning.

Internally, the organization's strategic plan is perhaps one of the most important sources of input concerning the overall direction and nature of the research program. In addition, team leaders and researchers may propose research projects and studies for funding

consideration. These are reviewed by the appropriate program managers, who may rely upon advisory committees of researchers appointed by managers to review and evaluate such proposals. Conflicts among researchers and team leaders over the allocation of funds and other resources are likely to arise, especially if resources for research are severely limited, and favored studies or projects must be curtailed. Resolving such conflicts may test the leadership skills of research managers (see module 9). Involving those affected by resource allocation decisions early in the planning process, and attempting to reach a group consensus regarding an equitable distribution of resources, may go far towards reducing or avoiding such conflicts. An assessment of the existing capacity of the organization to conduct research provides important input into the planning process. The current capacity of the organization to initiate and carry out research may impose severe constraints on research programs in the short-run, and also in the longer-run, since building up research capacity is a slow process.

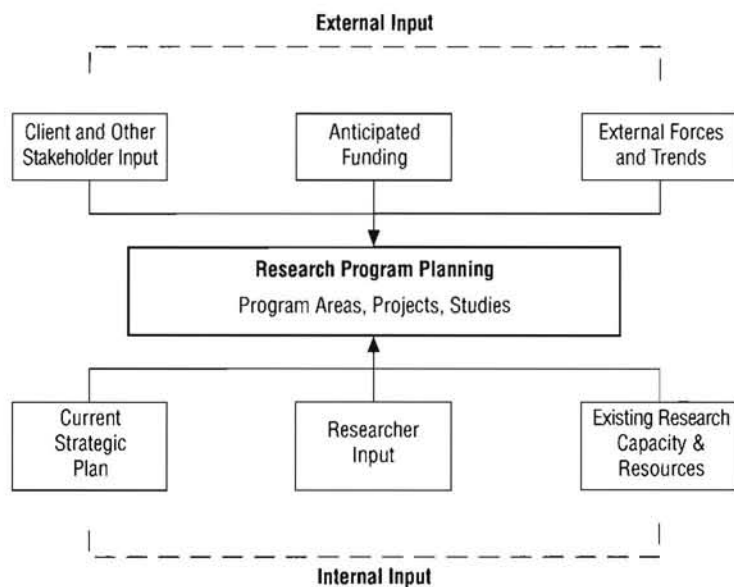


Figure 5.3.1. External and internal influences on research program planning.

External input on research priorities and the nature of the research program should be actively sought from clients and other stakeholder groups. An assessment of the level of funding and the capacity of the organization that can be anticipated throughout the program period must be obtained from higher administrative levels in the organization in order to set realistic constraints on the program.

Blending Researcher Interests and Organizational Goals

In planning research programs, a certain amount of tension exists between the interests of individual researchers and the need for publicly-supported forestry research organizations to be responsive to the most pressing needs of the forest-based sector and society. Researchers generally will have the highest morale and be most productive when they have a significant voice in selecting research studies to work on and projects to work within. Experienced researchers have invested a great deal of time and effort developing expertise in a particular area of research, and may be reluctant to work on projects outside of their area of specialization. At the same time, research activities must be geared to forestry and national development goals. Unless research is responsive to social goals, it will become increasingly difficult to mobilize the funds needed for research.

To reduce this tension, researchers should be partners with managers in planning and program formulation. Researchers have a particularly important role in planning how the research is to be implemented, and in carrying out this implementation plan once it is approved. As researchers are actively brought into the planning process, the likelihood of a good “fit” between researchers’ interests and organizational goals increases greatly. There are a number of advantages in having researchers participate in the planning process.

First, researchers can generate high quality proposals for research studies, projects, and programs. Without good project proposals available, the most sophisticated methods for research planning and priority setting will be of little use. The researcher’s own experience and research background suggest lines of research that are likely to be productive. Most experienced researchers can produce a number of research proposals that are relevant for their field of research, in which they have an interest and which they are qualified to do. They also are familiar with the practical capabilities of the available facilities, equipment, and staff. Scientists will be more interested and productive in pursuing research topics they have proposed. A certain amount of freedom in determining what to work on is an important internal reward for many scientists. Pelz and Andrews (1966) found that researchers are most productive when several people are involved in shaping research assignments, but the scientist retains significant input to the decision process. Pelz and Andrews also found that performance was low where the chief alone determined scientists’ assignments.

Managers, therefore, actively seek the input of researchers on what scientific investigations could be carried out to address various goals of the organization. But rarely will there be enough resources to carry out all proposals received, and rarely will all of the proposals be relevant to national and organizational goals. Many researchers are driven more by the research needs determined within their own professional discipline, than by the research needs of society. Responsibility for ensuring that the research program is relevant to the needs of society rests squarely with managers. Managers must develop criteria for selecting research proposals, and provide clear guidance to research scientists on priority areas for research.

Second, researchers—especially top researchers and team leaders—can contribute by formally reviewing and evaluating proposed subjects for research, both project and study proposals. Researchers are in the best position to identify constraints and opportunities relating to improved practices, and they should have a good idea of what is already known nationally or internationally on proposed topics within their area of expertise. Information that researchers possess on the results of related research, expected costs of proposed research, and the probability of success is likely to be the main source of data on these important questions. Managers should form committees of scientists and managers to review and evaluate research that is proposed.

Involving Stakeholders in Program Planning

Some of the preceding modules stressed the importance of identifying and analyzing key stakeholders of a forestry research organization, and including them in some phases of the strategic planning process. (Stakeholders are people, groups, or organizations that have a claim on the organization's attention, resources, or output, or are affected by that output.) Forestry research stakeholders might include public officials, governing bodies, public land managers, interest groups, small farmers, indigenous peoples, extension agents and organizations, industries and businesses based on forest products, the general public who use forest products, goods and services, other research organizations, educational institutions, and international donor and technical assistance agencies, among others.

It is equally important to involve representatives of key stakeholder groups in program planning. While strategic planning provides overall direction for a research organization, more detailed input is needed to work out a specific program of research. In some countries, certain stakeholder groups are organized into research advisory boards, councils, or committees that meet periodically to develop recommendations to forestry

research organizations on research priorities and programs. If a country has no forestry research council or similar advisory groups, it is important to actively seek input from key stakeholders and incorporate them into the decision-making process. Including key stakeholder groups in the program planning process and, to the extent possible, accommodating their interests, will enhance the ability of a forestry research organization to generate financial and political support. Their participation will ensure that the research program of the organization will be more user-focused.

Recognizing Existing Knowledge and Information

To avoid wasting scarce resources on nonessential research, it is important to be aware of what technology is already available that could be adapted to local conditions. One way to do this is to keep track of what research has been and is being conducted in other forestry and nonforestry national and international research organizations. Some of the research being conducted elsewhere may meet the needs of your own clients, with relatively little modification.

One source of useful technologies often overlooked is indigenous knowledge. This is knowledge about appropriate technologies that has evolved out of the accumulated experience of local people interacting with their environment. Although this may not be formal scientific knowledge, in the sense that it has not gone through a formal process of scientific verification, it often is knowledge that has been successfully applied for many years. However, such knowledge must be gathered and used with caution. Not all technologies being applied in practice are necessarily successful or useful to others. It is necessary to screen local indigenous knowledge for its actual effectiveness and potential for large-scale diffusion. Nevertheless, the research community often can rely upon indigenous knowledge for an initial screening of alternative technologies in practice. Such knowledge can provide a good starting point for more systematic scientific research.

The Logical Framework: A Useful Tool for Program Planning

The Logical Framework (LF), sometimes called the Logframe, is a useful tool for designing and planning projects and programs of all kinds, including research (Delp et al. 1977, McLean 1988b). It helps the planner and manager systematically identify the objectives for some activity, plan for required inputs and desired outputs, and define indicators that can be used to monitor and evaluate performance. The LF is appropriate for any level of planning other than strategic planning, from the development of

broad, long-term programs to individual research projects. It is often used by small groups of managers as a framework for planning and generating ideas.

The information required to plan and evaluate an activity using this technique can be summarized in a table such as figure 5.3.2 (figure 5.3.3 provides a generalized example of how LF can be applied to a research program).

The left-hand column in the table is a brief “narrative summary” of the stated goal of a research project or program, the purpose of the project/program, what outputs (results) it is expected to produce, and what inputs will be required to produce those outputs:

- **the goal** is the ultimate objective to which the research project or program contributes, e.g., a timber harvesting research program may help to achieve a national development goal such as self-sufficiency in wood products;
- **the purpose** of a research project or program is what it is expected to achieve upon completion, e.g., in the timber harvesting example, cited above, the purpose might be to increase the productivity of timber harvesting operations through the development and adoption of more efficient harvesting technology;
- **outputs** are the desired results of the research project or program derived directly from management of inputs, e.g., a timber harvesting research program would be expected to develop new harvesting systems with specific characteristics and within an estimated time frame; and
- **inputs** are the human, physical, and financial resources required to produce the desired outputs. The quantity and quality of inputs should be specified, e.g., the number of scientists and technicians and their level of training, etc.

These four factors are represented by the rows of the table and are referred to in the jargon of LF as the “vertical logic.” The idea is to systematically think through why the project or program is being undertaken, how it contributes to broader social goals, and the inputs needed to achieve the outputs, purpose, and goals.

One of the key assumptions of the LF method is that a direct cause and effect relationship exists between input, output, purpose, and goal (the items in the left-hand column of figure 5.3.2). It assumes that:

*If we provide the following inputs,
then we can produce the outputs.*

Project Design Summary—Logical Framework

Project Title: _____

Life of Project from: Fiscal Year _____ to Fiscal Year _____

Total Funding: _____ Date Prepared: _____

Narrative Summary	Verifiable Indicators	Means of Verification	Important Assumptions
<i>Goal: (the broader objective to which this project contributes):</i>	<i>Measures of goal achievement:</i>	<i>Sources of information, methods used:</i>	<i>Assumptions for achieving goal:</i>
<i>Project Purpose:</i>	<i>End of project status (conditions that will indicate purpose has been achieved):</i>	<i>Sources of information, methods used:</i>	<i>Assumptions for achieving purpose:</i>
<i>Outputs:</i>	<i>Magnitude of outputs, planned completion date:</i>	<i>Sources of information, methods used:</i>	<i>Assumptions for generating outputs:</i>
<i>Inputs:</i>	<i>Type, level, and cost of inputs, planned starting date:</i>	<i>Sources of information, methods used:</i>	<i>Assumptions for providing inputs, initial assumptions about the project:</i>

Source: Adapted from Delp et al. (1977) and McLean (1988).

Figure 5.3.2. The "Logical Framework."

Project Design Summary—Logical Framework

Project Title: Tree Improvement Research Project

Life of Project from: Fiscal Year 1994 to Fiscal Year 2004

Date Prepared: December 1993

Narrative Summary	Verifiable Indicators	Means of Verification	Important Assumptions
<p>Goal: Increase the availability to local farmers of genetically improved tree seedlings that will increase yields of forest products from their lands.</p>	<p>Measures of goal achievement: Genetically improved tree seedlings become available to local farmers.</p>	<p>Sources of information, methods used: A sample of local farmers will be surveyed one year after completion of the project to determine if genetically improved tree seedlings have become available to them, if they are aware of its availability and potential usefulness, and if they have obtained some of the stock for planting on their lands.</p>	<p>Assumptions for achieving goal: Seed from the seed orchard will be used to produce seedlings that will be made available to farmers. Farmers will: be informed that the improved seedlings are available; be aware of the potential gains from using the improved stock; obtain, plant, and care for the improved seedlings; and obtain improved yields of timber.</p>
<p>Project Purpose: Develop an improved variety of a local timber species that could be planted by farmers to yield a larger volume of timber and provide marketable products at an earlier age.</p>	<p>End of project status (conditions that will indicate purpose has been achieved): Establishment and survival of a seed orchard that is producing seed of the desired quality.</p>	<p>Sources of information, methods used: Direct observation and testing of seed in trial outplantings that compare growth and yield of improved and unimproved varieties.</p>	<p>Assumptions for achieving purpose: There is enough natural genetic variability among the available trees to obtain an improved variety of that species. Seedlings of the improved variety will be produced. The improved seedlings will be accepted and planted by farmers.</p>
<p>Outputs: Establishment of a seed orchard to supply seed for a high-yield variety of the desired species. Popular and scientific publications announcing research plans and reporting research results.</p>	<p>Magnitude of outputs, planned completion date: The seed orchard will be at least two hectares in extent. The project will be completed by the year 2004. At least one article about the project and its progress published in local news media annually. Three articles reporting research results published in technical or scientific publications.</p>	<p>Sources of information, methods used: Direct measurement of the extent of the seed orchard and date of establishment. Clippings or other records of news articles will be filed for future reference. Records will be kept of manuscript submissions to and acceptances by scientific or other journals.</p>	<p>Assumptions for generating outputs: Improved varieties of the desired species can be developed in time to establish the orchard and produce improved seed before the end of the project. News media would be willing to publish articles about the project. Time and personnel with the necessary communication skills will be available to produce the publications.</p>
<p>Inputs: Funding over a ten-year period. Half-time senior scientist year and three skilled field/laboratory assistants. Land for trial outplantings and the seed orchard. Supplies and equipment.</p>	<p>Type, level, and cost of inputs, planned starting date: Funding to cover planned budget to be secured from international funding agency by April 1994. Scientists and the required assistants available for the time period specified. Agreement with public land management agency to commit land for the seed orchard. Detailed list and costs of supplies and equipment needed over time to support the project.</p>	<p>Sources of information, methods used: Funding is available for use at planned starting date. Personnel are assigned to begin work at planned starting date. Agreement to commit land for seed orchard is approved and signed. Necessary supplies and equipment have been ordered.</p>	<p>Assumptions for providing inputs, initial assumptions about the project: Funding will be available to commit personnel, facilities, and other resources well enough in advance to start the project when scheduled. The land, supplies, equipment, and other resources will be available when needed.</p>

Figure 5.3.3. Simplified example of applying the “Logical Framework” to a fictitious tree improvement research project.

If we produce the outputs,
then the purpose will be achieved.

If the purpose is achieved,
then the goal may be realized.

As we move across the columns of figure 5.3.2, we see the “horizontal logic” of the LF, indicating how we could determine whether or not we actually have achieved the targets described in the left-hand column. It lists verifiable indicators, means of verification, and important assumptions:

- **verifiable indicators** are things that could be measured to demonstrate that the desired results are being accomplished;
- **means of verification** specify where that evidence can be found and how it can be measured; and
- **important assumptions** qualify the other entries by listing those factors which may not be controlled by research managers, but which influence the success of a project or program. The assumptions column should help to keep managers realistic in their expectations.

The recommended procedure for completing the logical framework is to begin by working through the vertical logic. For a proposed research program, managers must determine at each lower level the conditions which are necessary and sufficient to achieve the next upper level, i.e., the inputs that are listed should be necessary and sufficient to produce all of the outputs; the outputs should be necessary and sufficient to achieve the purposes, and so on. Next, the horizontal logic is completed by first identifying the indicators, then the means of verification, and finally the assumptions for each of the vertical logic levels (i.e., the rows of the table).

One advantage of the LF as a planning tool is its simplicity—it is easy to understand. The LF guides the planning process by providing a structure and ensuring that the manager thinks through the fundamental aspects of a project design (but it is not a substitute for the considerable effort that is required to plan effectively).

The framework also is a useful tool in monitoring and evaluating a project or program. Evaluation requires clear targets against which performance is measured. The Verifiable Indicators column should provide such targets. The Means of Verification column specifies the actual data to be monitored for each level. Assumptions concerning inputs, outputs, and purpose define what external factors necessary for project success should be monitored and evaluated. Finally, impact evaluations—which deal with the

contribution of research to national development goals—are concerned with the types of indicators specified at the goal level.

The Logical Framework, as presented here, also has some important limitations:

- it does not explicitly take external and secondary impacts of project activities into account;
- it does not take uncertainty into account;
- it does not consider potential alternative actions; and
- the IF-THEN relationships assumed among the various project components and elements in the environment are an oversimplification of the real world.

Despite these limitations, the Logical Framework can be a useful tool in planning, monitoring, and evaluating research. For more detail on this tool, see Delp et al. (1977), USAID (1980), and McLean (1988c).

Activities

STUDY UNIT ACTIVITIES

Activity 1



Simply organizing planning by using the tri-level framework examined in the previous Study Unit (5.2) will not guarantee the production of high quality program plans. There are other things managers of research can do to significantly improve the quality and utility of operational research plans. *List five of these activities below:*

1.

2.

3.

4.

5.

If you had trouble remembering these activities or actions, reread the introduction and text in this study unit; then complete the exercise.



Comment 1

Some of the activities or actions that managers of research can take to significantly improve operational research plans include:

1. Strengthen linkages between program planning and strategic planning;
2. Evaluate both staffing requirements and availability;
3. Incorporate monitoring and evaluation into the key planning documents;
4. Include both external and internal input into the planning process;
5. Blend researcher interest and organizational goals;
6. Involve stakeholders in program planning; and
7. Recognize and tap existing knowledge and information.

Please read the background information below and then complete the activities that follow:

Linking operational plans to strategic plans is essential for the efficient and effective operation of forestry research organizations. In an attempt to deal with the great changes that have occurred recently, Ghosa's Division of Forestry Research recently completed a strategic planning exercise which defined the organization's mission and goals. A brief summary of the main points of the division's Strategic Plan is presented here:

Mission Statement

The Ghosa Division of Forestry Research exists to provide the people of Ghosa with research results that address the needs of all forest users, and to discover ways to achieve sustainable use and development of forest resources that contribute to national economic development, for the benefit of current and future generations.

Organization Goals

1. *To better understand the biophysical processes active in Ghosa's ecosystems.*
2. *To develop new means for sustainable use and development of the forest.*
3. *To determine the current status of forest use, condition, and extent, and make future projections regarding these variables.*
4. *To discover new forest-derived products, particularly those that could provide for small-scale, low-impact use of the forest.*
5. *To document forest based knowledge of indigenous forest dwellers, and scientifically validate this information.*
6. *To expand our knowledge and refine our practices regarding reforestation and ecosystem restoration.*

STUDY UNIT ACTIVITIES

Activity 2



Please review the operational planning framework you created in Activity 1, Study Unit 5.2. How does the division's current research agenda address its stated mission and goals? For instance, what is not being addressed by the current research agenda, and what areas of research are currently receiving too much emphasis? Write your response in the space below.



Comment 2

Actually, the research agenda relates well to the strategic mission and goals of the organization, particularly regarding basic biology, reforestation/restoration, and socioeconomic studies.

However, the current research agenda does not include any activities intended to explore, validate, or test indigenous knowledge of forest biology or forest resource use, a glaring omission. And only one study is devoted to resource assessment, an important goal of the division. Further, there are a number of studies devoted to nurseries and reforestation, perhaps too much emphasis considering the many demands on the research organization.

There is also a sense that this research agenda is a hodgepodge of interests and study plans, with little cohesion or emphasis at the research program level. It almost seems that the research agenda was developed solely from the bottom-up, with independent, discrete studies having little relation to one another. Finally, the research agenda does not encourage interdisciplinary research and collaboration because of its fragmented nature.

STUDY UNIT ACTIVITIES**Activity 3**

If you were manager of this research organization what would you do to better link the organization's research program to its strategic plan? *Write your response in the space provided below.*

STUDY UNIT ACTIVITIES**Activity 4**

Again referring to the Situation Analysis in Study Unit 5.2, how can the Division ensure that the viewpoints of key stakeholders are included into the planning process? *Write your response in the space provided below.*

**Comment 3**

It is clear that the current research agenda needs to be updated to better match the organization's mission and goals. To better link the research program to the strategic plan, as manager you might decide to institute new research programs or studies to address deficiencies, or to reduce the emphasis on other research activities that are currently well funded, yet are not major goals of the organization. Probably the primary goal of the research manager in this case however, would be to completely reevaluate the entire division's programs, projects, and studies, and develop mid-range program plans that better address the organization's mission and goals. By conducting such an exercise, the mission and goals would be better met, resources would be more efficiently distributed, and interdisciplinary collaboration and research quality would be enhanced.

**Comment 4**

Remember, stakeholders of forestry research organizations might include public officials, governing bodies, public land managers, interest groups, small farmers, indigenous peoples, extension agents and organizations, other research organizations, educational institutions, and international donor and technical assistance agencies, among others.

To ensure that stakeholder viewpoints are included in the program planning process, stakeholders can be organized into research advisory boards, councils, committees that meet periodically review current research activities and make recommendations regarding research priorities and programs. Regardless of the means by which stakeholder input is solicited, it is imperative that their views be considered when conducting research program planning. By doing so, not only will the organization produce more useful, relevant research results, but will enhance its ability to generate financial and political support.

Summary

Research program planning can be improved by:

- linking program planning and strategic planning;
- evaluating both staffing requirements and availability;
- incorporating monitoring and evaluation into key planning documents;
- including both external and internal input into the planning process;
- blending researcher interests and organizational goals;
- involving stakeholders in program planning; and
- recognizing existing knowledge and information.

This study unit examined each of these activities in detail, providing you with proven, practical information that you can use to improve the quality and utility of your organization's research program planning. You also learned of a useful tool for program planning—The Logical Framework, which is an excellent structured approach for use in program, project or study unit planning activities.

If you would like more information regarding research program planning, we encourage you obtain and review the interesting articles identified in the literature cited and other references listed at the end of the module. Two key articles directly related to the topics covered in the module, and cited in the text, are reprinted for your use in the section on readings at the end of the module.

Skill & Knowledge Assessment

Module 5 - Developing the Research Program



Below are listed a number of skill and knowledge statements derived from the objectives of the study units in module 5. These are identical to those listed in the initial skill and knowledge assessment at the beginning of the module. Now that you have completed module 5, please read each statement carefully and indicate with a checkmark the level that best describes your current skill or knowledge, from 1 to 5, using the following descriptions:

- 1 I cannot perform this skill, or I have not been exposed to the information.
- 2 I cannot perform this skill, but have observed the skill or have been exposed to the information.
- 3 I can perform the skill or express the knowledge with assistance from others.
- 4 I can perform the skill or express the knowledge without assistance from others.
- 5 I can perform the skill or express the knowledge well enough to instruct others.

Skill or Knowledge Statement	Your Level of Skill or Knowledge				
	1	2	3	4	5
a) Identify and describe the various organizational models commonly used by public and private sector forestry research organizations.					
b) Identify three key desirable features of a forestry research organization's structure which enhance forestry research capacity, and explain how these three features contribute to improved efficiency and effectiveness of research implementation.					
c) Explain what research program planning is and why it is needed.					
d) Describe three program levels commonly encountered in a forestry research organization that play important roles in program planning.					
e) Describe five factors that are essential when conducting program planning, and describe how they can be incorporated into the program planning process.					
f) State the importance of linking program planning to strategic planning.					

LITERATURE CITED - MODULE 5

- Bengston, D. N., and H. M. Gregersen. 1988. What influences forestry research capacity in developed and less-developed countries? *Journal of Forestry* 86(2):41-43.
- Bengston, D. N., and H. F. Kaiser. 1988. Research planning and evaluation in the U.S. Forest Service: Current practice and options for improvement. *Evaluation Review* 12(3):276-90.
- Brunig, E. F. 1982. Summary report on the Asia-Pacific Regional Workshop for Forest Research Directors at the Environment and Policy Institute, East-West Center, Honolulu, 22-29 August 1982. 33 p.
- Dagg, M., and F. Haworth. 1988. *Program formulation in national agricultural research*. ISNAR Working Paper no. 17. The Hague, Netherlands: International Service for National Agricultural Research. 19p.
- Daniels, D., ed. 1987. *Evaluation in national agricultural research*. IDRC-254e. Ottawa, Ontario, Canada: International Development Research Centre. 162 p.
- Delp, P., A. Thesen, J. Motiwalla, and N. Seshadri. 1977. *System tools for project planning*. MUCIA, Program of Advanced Studies in Institution Building and Technical Assistance Methodology. 274 p.
- Elz, D., ed. 1984. *The planning and management of agricultural research*. Proceedings of a World Bank and ISNAR Symposium. Washington, D.C.: The World Bank. 141 p.
- FAO of the United Nations. 1984a. *Provisional forestry research compendium for Africa*. Paper FO:WERD/A/84/Inf.2 for the Technical Consultation on Wood Energy Research and Development in Africa, Addis Ababa, Ethiopia, 27-30 November, 1984. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1984b. *Survey of wood energy research and development capabilities in Africa*. Secretariat Note FO:WERD/A/84/9 for Technical Consultation on Wood Energy Research and Development in Africa. Addis Ababa, Ethiopia, 27-30 November, 1984. Rome: Food and Agriculture Organization of the United Nations (FAO).
- FAO of the United Nations. 1984c. *Cooperation in wood energy research and development*. Secretariat Note FO:WERD/A/84/10 for Technical Consultation on Wood Energy Research and Development in Africa. Addis Ababa, Ethiopia, 27-30 November, 1984. Rome: Food and Agriculture Organization of the United Nations (FAO). 22 pp.
- FRIM. 1993. Sistem Arahan Pengurusan Dan Pentadbiran FRIM, Part A: Organisation and Research Management. Kuala Lumpur, Malaysia: Forest Research Institute Malaysia.
- Hilmi, H. 1986. *World compendium of forestry and forest products research institutions*. FAO Forestry Paper 71. Rome: Food and Agriculture Organization (FAO) of the United Nations. 613p.
- ISNAR. 1987. *Medium-term plan 1988-1992*. The Hague, Netherlands: International Service for National Agricultural Research. 49 p.

- Iyamabo, D. E. 1975. Managing forest research in developing countries. In *Managing forestry research for results*, 57-66. Proceedings of the first meeting of Subject Group S6.06, Management of Forestry Research, Paris, France, Sept. 1975. IUFRO. 146 p.
- Iyamabo, D. E. 1976. Forestry research in developing countries. *Unasylya* 28(111):12-17.
- Jain, H. K. 1989. *Organization and structure in national agricultural research systems*. Working Paper no. 21. The Hague, Netherlands: International Service for National Agricultural Research. 49p.
- Lundgren, A. L., L. S. Hamilton, and N. T. Vergara. 1986. *Strategies for improving the effectiveness of Asia-Pacific forestry research for sustainable development*. Workshop Report. East-West Environment and Policy Institute, Honolulu, HI. 56 pp.
- McLean, D. 1988a. *Monitoring and evaluation in the management of agricultural research*. ISNAR Working Paper No. 14. The Hague, Netherlands: International Service for National Agricultural Research. 29 p.
- McLean, D. 1988b. *The logical framework in research planning and evaluation*. Working Paper no. 12, ISNAR. The Hague, Netherlands: International Service for National Agricultural Research. 11 p.
- Milne, G. R. 1987. *Planning and management at the Newfoundland Forestry Centre: A review and recommendation for change*. Newfoundland Forestry Centre, Forestry Canada, St. John's, Newfoundland. 57 p.
- Murira, K. K. 1993. Personal communication, December 1993.
- Murphy, J. 1985. *Using evaluations for planning and management: An introduction*. Working Paper no. 2, ISNAR. The Hague, Netherlands: International Service for National Agricultural Research. 27 p.
- Odeyinde, M. A., and J. E. Abu. 1992. Forestry research funding in Nigeria. In *Forest research management initiatives for the 1990s*, eds. J. A. Kininmonth and G. L. Tarlton, 86-96. FRI Bulletin 173. Rotorua, New Zealand: Forest Research Institute.
- O'Laughlin, C. L. 1993. Science reform in New Zealand and its impact on forestry research. In *Research management for the 1990s*, ed. A. D. Kiil, 5-8. Edmonton, Alberta: Forestry Canada, Northwest Region, Northern Forestry Centre.
- Pelz, D. C., and F. M. Andrews. 1966. *Scientists in organizations: Productive climates for research and development*. New York: John Wiley and Sons. 318 p.
- Putti, J. M. 1986. Problems in managing research institutions in the public sector. *Journal of the Society of Research Administrators* 17(4):39-41.
- Ruttan, V. W. 1978. Reviewing agricultural research programmes. *Agricultural Administration* 5:1-19.
- Ruttan, V. W. 1981. *The Asia Bureau agricultural research review*. Bulletin no. 81-2. Minneapolis, MN: Economic Development Center, Department of Economics, University of Minnesota. 19 p.
- Ruttan, V. W. 1982. *Agricultural research policy*. Minneapolis, MN: University of Minnesota Press. 369p.

SEARCA. 1982. *Asian cases on agricultural research management*. College, Laguna, Philippines: Southeast Asian Center for Graduate Study and Research in Agriculture. 348p.

Trigo, E. J. 1986. *Agricultural research organization in the developing world: Diversity and evolution*. ISNAR Working Paper no. 4. The Hague: International Service for National Agricultural Research. 44p.

USAID. 1980. *Design and evaluation of AID-assisted projects*. Washington, D.C.: Training and Development Division, U.S. Agency for International Development.

Wadsworth, F. H. 1968. *Public forestry research in Latin America, its status and needs*. Research Paper ITF-6. Rio Piedras, Puerto Rico: USDA Forest Service, Institute of Tropical Forestry. 12p.

Zambia Forest Department. 1987. *Forestry research in Zambia*. Joensuu, Finland: FINNIDA/VTT Technology. 15p.

ADDITIONAL SOURCES OF INFORMATION

Hobbs, S. H. 1990. *Problems and solutions for "decentralizing" national agricultural research systems*. Working Paper no. 36. The Hague: ISNAR. 22p.

Weil, E., and F. Cangemi. 1983. Linking long-range research to strategic planning. *Research Management* 26(3):32-39.

READINGS FOR MODULE 5

The following readings have been selected to provide you with additional information related to the material covered in Module 5. We hope you will find them of interest.

Jain, H. K. 1989. *Organization and structure in national agricultural research systems*. ISNAR Working Paper no. 21. The Hague: ISNAR. 49p.

Ng, F. S. P. 1992. How to organize forestry research with scarce resources. In *SADC forestry research, Report of the second regional workshop, 21-25 Sept. 1992, Gabrone, Botswana*, annex 5:40-47. Lilongwe: SADC Forestry Sector Technical Co-ordination Unit. 84p.

WORKING PAPER No. 21

**ORGANIZATION AND STRUCTURE
IN
NATIONAL AGRICULTURAL
RESEARCH SYSTEMS**

H.K. JAIN

May 1989

isnar

International Service for National Agricultural Research

TABLE OF CONTENTS

Defining National Agricultural Research Systems	1
Rationale for Reorganization of Research Systems	2
Basic Components of NARS	3
Governance Functions	4
Budget allocation and management	4
Resources and their management	4
Personnel policies	5
Centralization	5
Research Functions	6
Research policy and resource allocation	6
Program formulation	6
Program implementation, monitoring, and evaluation	6
Research coordination	7
Links with extension	7
Organization and Structure in NARS: The Four Entities	7
Organizational Types in NARS	9
The Agricultural Research Council (ARC)	9
Managing councils	10
Coordinating councils	10
Funding councils	11
National Research Institutes (NRI)	11
Structure of Research Councils and National Institutes	12
Structure of NARS in sub-Saharan Africa	16
Ministry of Agriculture Model	22
Organization of NARS in North Africa - West Asia	22
The University Faculties of Agriculture	23
Organization of Experiment Stations	26
Single-commodity stations	26
Multi-commodity stations	26
Pure disciplinary form	28
Systems-based stations	28
National Research Programs	28

Reorganization: The Next Phase	31
Continued evolution of NARS	31
Creation of planning capacity	32
Decentralization	33
Inter-institutional coordination	33
Commitment to development	34
Improvement in the board structure	35
Linkage with the private sector	36
Research foundations	38
The future direction of coordinating and funding councils	39
Harnessing the ministry of agriculture model	40
Transformation of the university-based research services	40
Rationalization of the research station network	41
National and regional research stations	41
Structure of experiment stations	42
Experiment station programs and linkages	46
Institutional mechanisms for transfer of technology	48

SUMMARY

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

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

Defining National Agricultural Research Systems

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

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

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

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

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

Rationale for Reorganization of Research Systems

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

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

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

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

Basic Components of NARS

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

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

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

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

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

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

Governance Functions

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

Budget allocation and management

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

Resources and their management

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

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

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

Personnel policies

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

Centralization

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

Research Functions

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

Research policy and resource allocation

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

Program formulation

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

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

Program implementation, monitoring, and evaluation:

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

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

Research coordination

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

Links with extension

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

Organization and Structure in NARS: The Four Entities

Social scientists¹⁾ define organizations as the instruments by which public policy is implemented. Two fundamental issues involved in every organization are accomplishing goals while utilizing resources efficiently and providing a climate that enhances the well-being of

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

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

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

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

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

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

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

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

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

Organizational Types in NARS

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

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

The Agricultural Research Council (ARC)

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

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

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

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

Managing councils

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

Coordinating councils

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

Funding councils

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

National Research Institutes (NRI)

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

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

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

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

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

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

Structure of Research Councils and National Institutes

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

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

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

* Law creating INIA is under discussion at the Uruguayan Congress level.

** Research activities went back to the central administrative system of the Ministry of Agriculture since 1979.

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

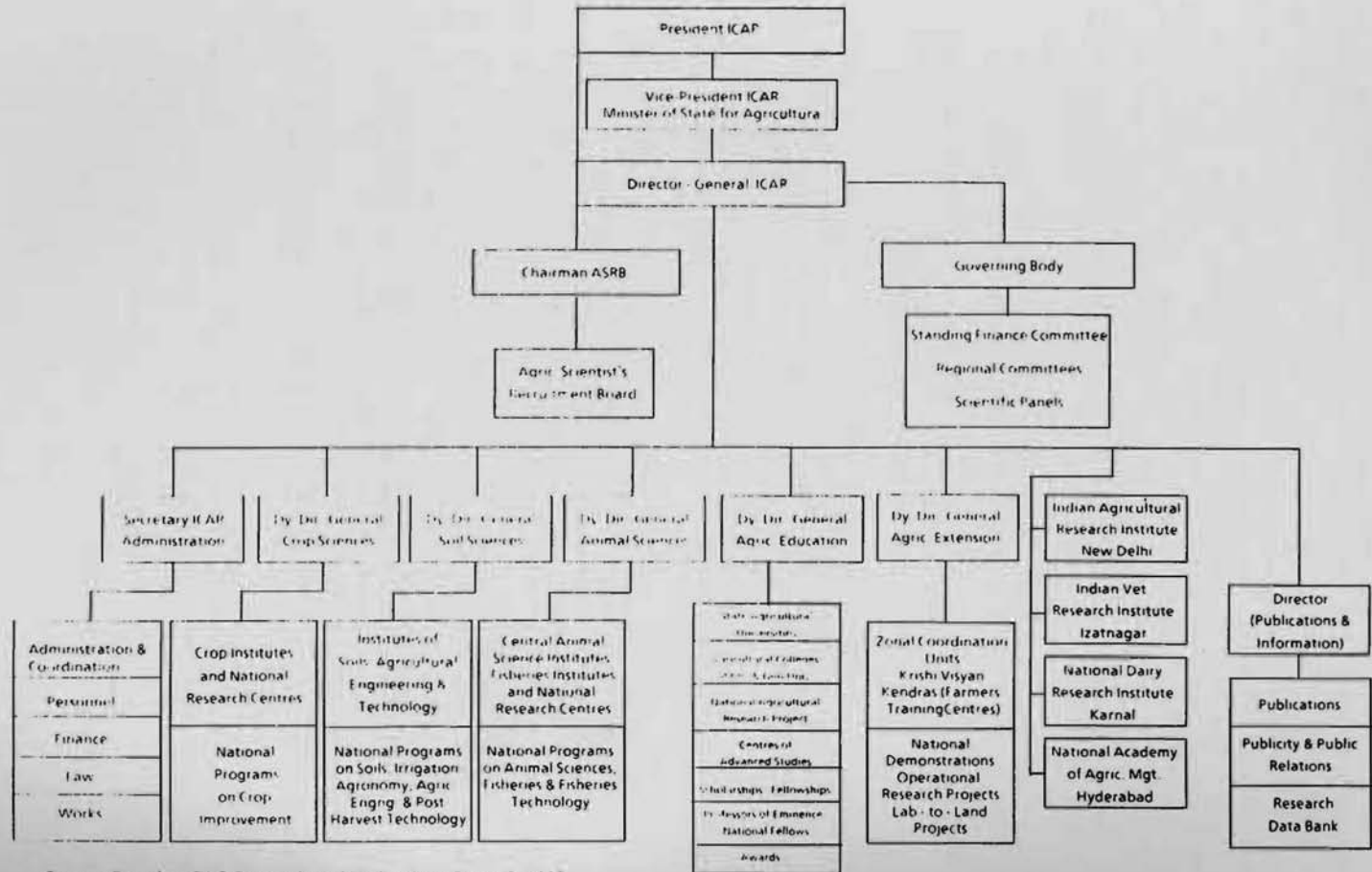
scientists employed in the state agricultural universities. Many of the latter, however, do both teaching and research -- some doing more teaching than research.

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

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

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

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



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

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

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

Structure of NARS in sub-Saharan Africa

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

Figure 2: Organizational structure of INTA (Argentina)
(Pre-decentralization period)

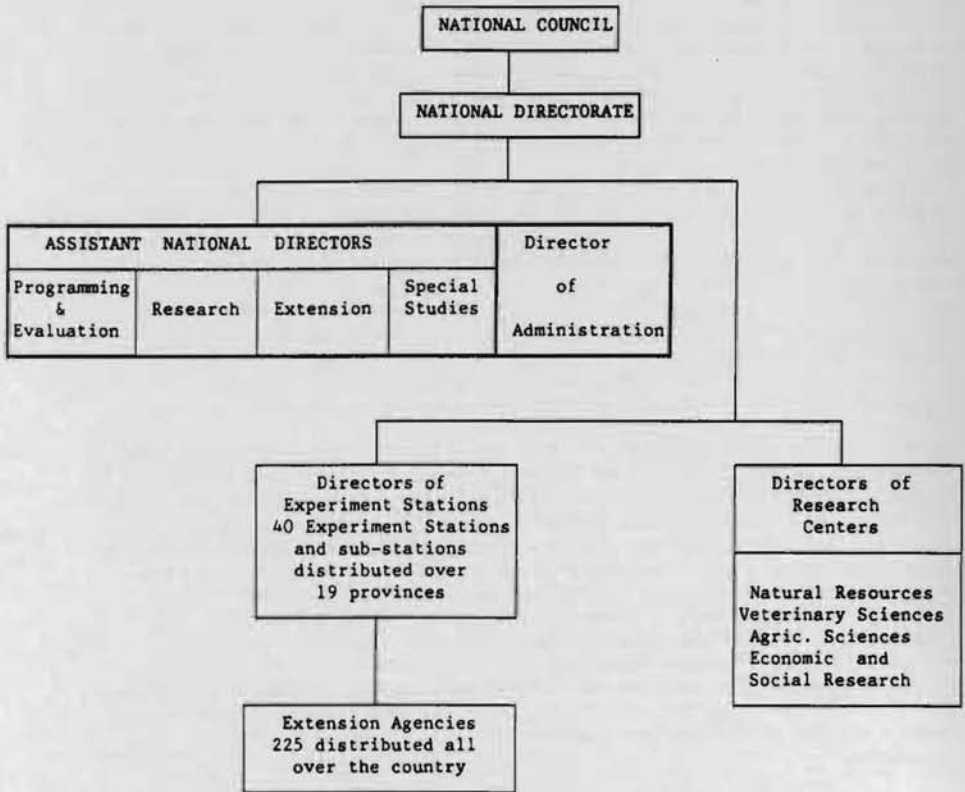


Figure 3: Organizational structure of INTA (Argentina)
(Post-decentralization)

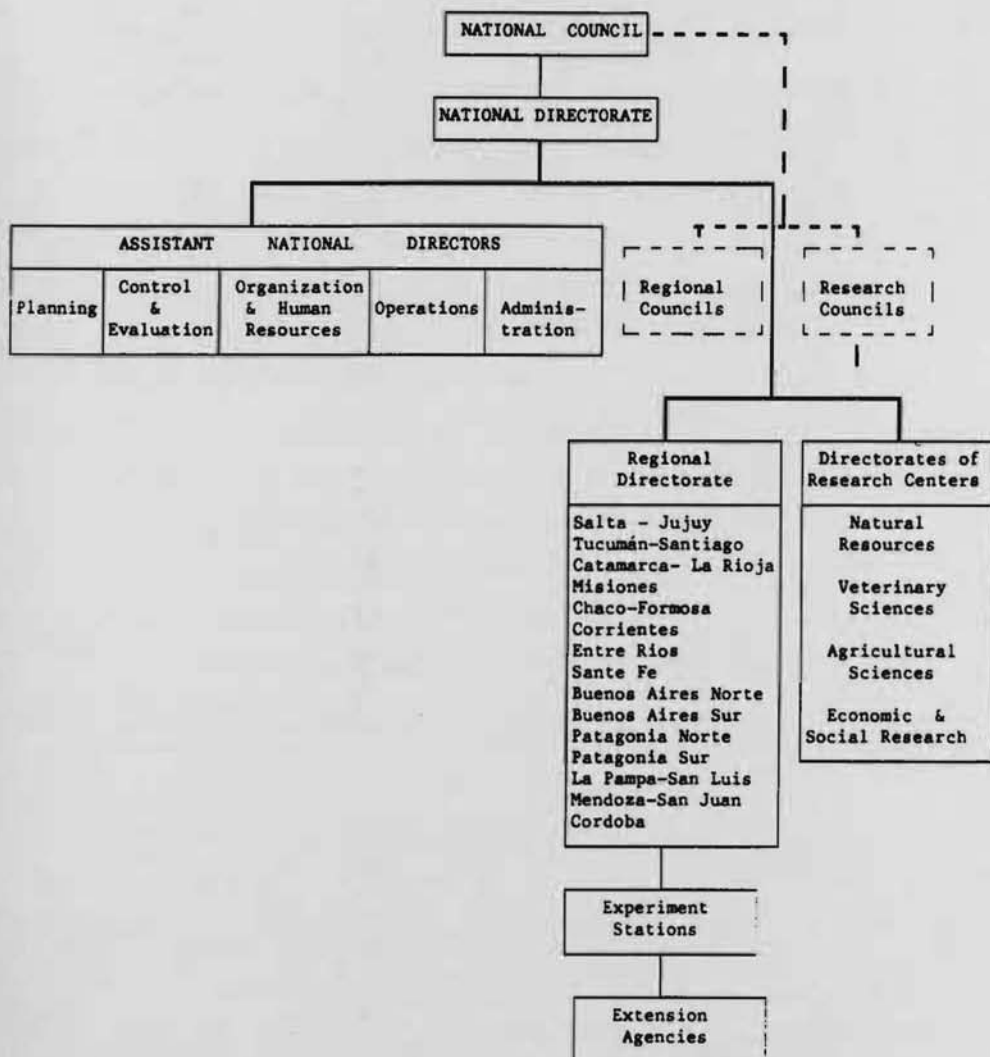


Table 2: Regional institutions for agricultural research in the sub-Saharan African countries during the colonial period

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

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

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

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

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

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

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

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

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

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

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

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

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

Ministry of Agriculture Model

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

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

Organization of NARS in North Africa - West Asia

The Arab NARS, according to Hariri¹⁾, can be recognized in five different types on the basis of their structural diversity. First, there is the pluralist model characterized by considerable fragmentation of the different institutions. These institutions in the different departments of government, and even in the same department, are fairly independent in the determination of their research programs, and there is not a great deal of interaction between them. The second group of NARS is those where the instrument of budgeting is used to bring about some degree of coordination between the institutions of the same ministry. The ministry decides upon a common science budget from which allocations are made to the different research institutions it manages. Even so, there is not a

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

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

The University Faculties of Agriculture

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

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

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

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

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

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

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

Organization of Experiment Stations

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

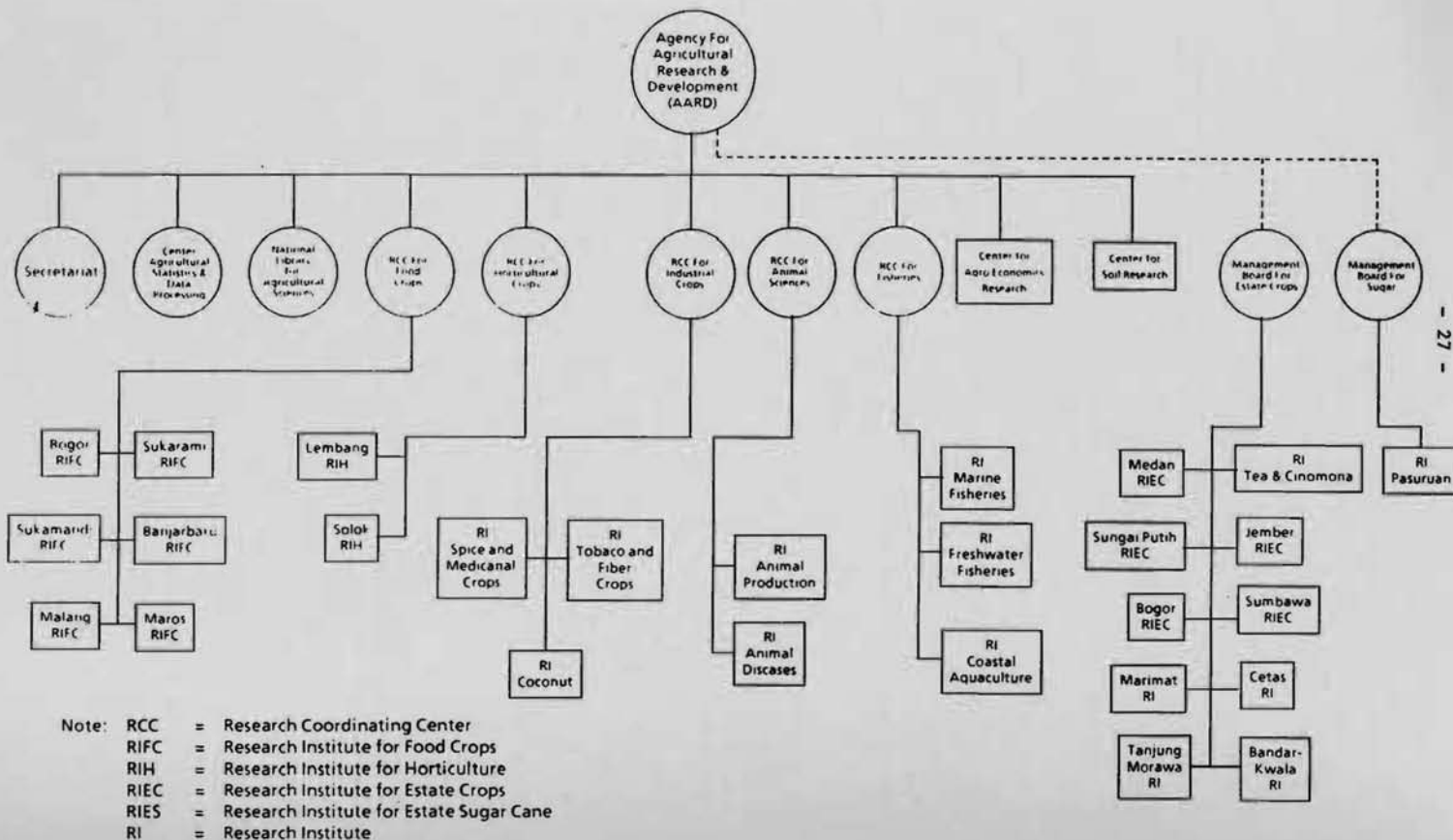
Single-commodity stations

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

Multi-commodity stations

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

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



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

Pure disciplinary form

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

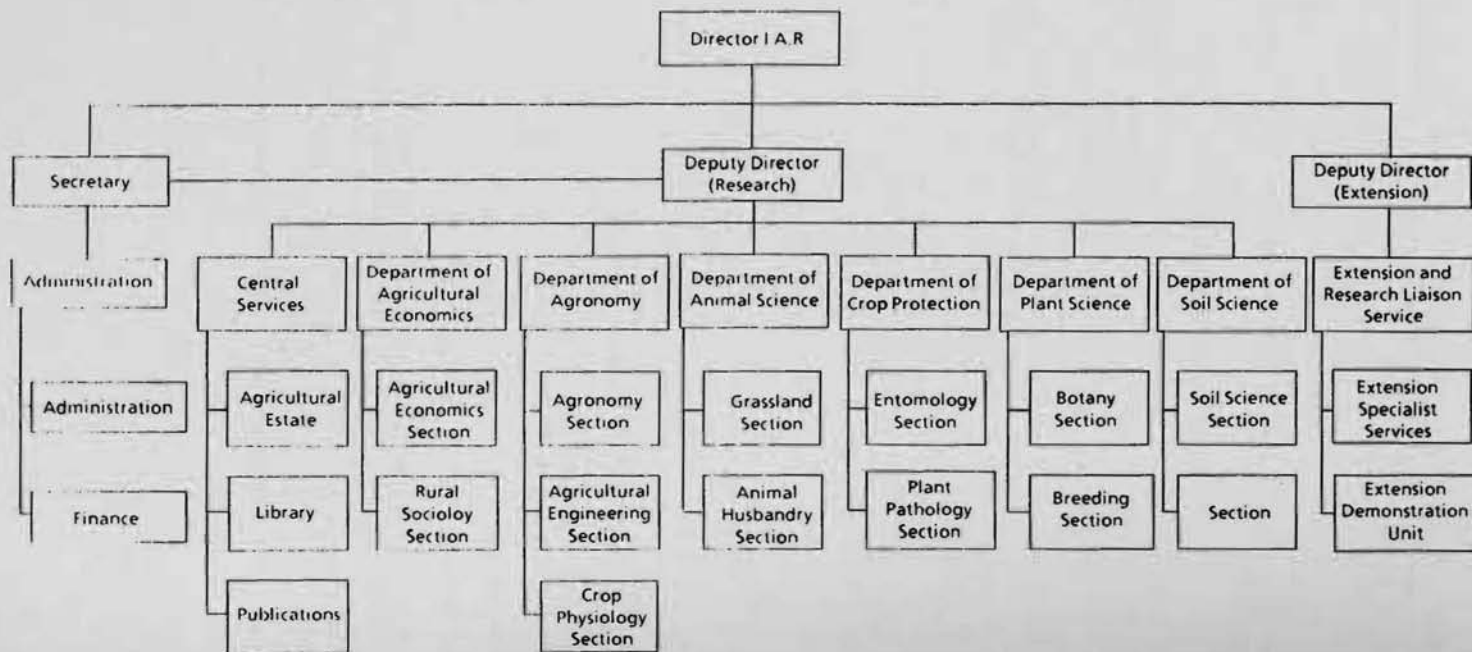
Systems-based stations

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

National Research Programs

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

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



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

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

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

- * help to define the objectives and technical content of the nationally coordinated program;
- * recommend allocation of resources to the different cooperating stations for the implementation of their part of the program;
- * monitor the progress of work at each center;
- * organize multi-location trials of improved varieties and other technologies emerging from the program and consolidate the findings from these trials for presentation, review, and recommendations;
- * organize annual workshop of all the participating scientists to review the past year's results and to plan the next year's work at each of the centers; the workshop would provide an opportunity for interaction with the senior staff of the extension service for identification of technologies to be recommended to farmers;

- * prepare and present annual progress report of the program to the national director;
- * liaise with the international agricultural research centers for introduction of new genetic materials and technologies for induction into the national program;
- * organize training of young scientists from the different cooperating centers.

Reorganization: The Next Phase

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

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

Continued evolution of NARS

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

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

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

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

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

Creation of planning capacity

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

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

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

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

Decentralization

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

Inter-institutional coordination

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

Commitment to development

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

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

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

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

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

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

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

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

Improvement in the Board structure

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

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

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

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

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

Linkage with the private sector

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

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

In the developed countries most of the adaptive research is carried out by the agribusiness companies as part of their promotion programs for the sale of seeds, fertilizers, pesticides, farm machines, and other modern farm inputs. This frees the public research services to concentrate their resources on strategic and applied research. It also helps to reduce the size of the research stations, leading to a more efficient management. In many developing countries, especially in Latin America, a similar trend is now beginning to emerge. Carl Pray and Ruben Echeverria¹⁾ have reviewed the role of private-sector agricultural research and technology transfer in the developing countries. The need now is to accelerate, through conscious policy decisions, these collaborative processes.

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

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

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

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

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

Research foundations

The NARS in Latin America, in general, have been more successful in developing links of this kind with the private sector. Apart from the joint ventures with individual companies, a major concept in some of these countries in the past ten years has been to create foundations that would extend funding support to institutions both in the private and public sectors. These foundations, encouraged with funding support from USAID and the private sector, are in different stages of evolution in the different countries. Margaret Sarles¹⁾, of Rutgers University, in a recent paper has analyzed the experience of USAID in helping to set up a number of such research foundations. The foundations were set up largely in response to the difficulties of various kinds which were found to be associated with the public-sector institutions. Thus, it was noted that in many cases these institutions suffered from administrative and leadership weakness, that they failed to give advice to the farmers and agribusiness groups who were their clients, and that their weak financial position was made worse by burdensome budgeting and fund dispersal mechanisms. The foundations were conceived to provide an institutional model which would be more flexible administratively and free from public-sector over-regulation, offering a technical rather than a political orientation, as developing formal leadership roles for farmers and agribusinesses, and as capable of developing linkages between the national agricultural research system and the technology transfer systems, international sources of technology, and new outside sources of funding.

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

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

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

The future direction of coordinating and funding councils

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

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

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

Harnessing the Ministry of Agriculture model

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

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

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

Transformation of the university-based research services

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

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

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

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

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

Rationalization of the Research Station Network

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

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

National and regional research stations

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

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

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

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

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

Structure of experiment stations

Finally, we come to the issue of the scientific structure of an experiment station. The different organizational models of experiment stations have been discussed by Paul Bennell¹⁾ of ISNAR. He has listed

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

Table 5: Organization of research station network

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

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

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

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

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

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

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

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

THE PURE DISCIPLINARY FORM

Advantages

Provides effective disciplinary "home for researchers

- * specialization -- particularly for basic, strategic, and applied research
- * critical mass for specific disciplinary areas
- * effective supervision and on-the-job training
- * well suited to component research where clients able to clearly articulate their needs
- * career development

Simple, straightforward management structure

- * unity of command

Advantages of agglomeration

Disadvantages

Not conducive to cross-disciplinary collaborative research (commodity and systems approaches)

- * exacerbates professional rivalries
- * complicates coordination process
- * excessive specialization and sophistication
- * difficulty in adopting a holistic approach to commodity and/or system improvement

Strong tendencies (although not intrinsic) towards:

- * individualized rather than team work - excessive researcher autonomy
- * proliferation of projects, with weak program focus, inefficiencies of excessive dispersion of research activities
- * remoteness from clientele / lack of understanding of farmer problems

Excessive centralization: disadvantages of agglomeration

THE PURE COMMODITY FORM

Advantages

Encourages focused and integrated research

- * holistic approach to commodity improvement
- * cross-disciplinary teamwork (especially during programming and evaluation processes)
- * enhances motivation - researchers identify strongly with the commodity
- * with clear objectives and coordinated activities, easier to monitor and evaluate
- * in certain situations, can effectively complement or be incorporated with systems research
- * locational factor: advantages of agglomeration

Disadvantages

- * researcher lacks benefits of disciplinary agglomeration (except in very large commodity organizations)
- * usually only feasible when relatively large number of experienced researchers
- * team-work imposes additional stresses and strains
- * excessive reliance inconsistent with systems' perspective and may lead to inadequate emphasis on non-commodity factor and environmental research problems
- * locational factors: diseconomies of agglomeration
- * in smaller NARS, only few commodities able to justify commodity teams, and may lead to rigidities and inflexibilities

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

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

Table 7: Research station organization by mandate

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

Experiment station programs and linkages

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

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

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

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

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

Institutional mechanisms for transfer of technology

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

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

- Mobilizing the available technologies from the different groups of scientists at the station and organizing them into an integrated package that can be recommended to farmers.
- Organizing verification trials on farmers' fields in collaboration with the extension service.
- Rendering scientific information in a form the extension staff and the farmers will understand. The extension service benefits little from the scientific papers published in academic journals. The research-extension liaison department helps the experiment station and the extension service to develop a publication program based on popular farm bulletins and production technology of different crops and livestock, and on management of resources.
- Laying down demonstrations of new varieties and techniques on the research station for visiting farmers, extension staff, and government officials; and assisting the extension service in laying similar demonstrations on farmers' fields.
- Receiving feedback and an assessment of their needs from the farmers and the extension service and helping to place this information on the research agenda of the different groups of scientists through participation in the deliberation of the program committee and other planning bodies.
- Organizing farmers' fairs and field days on the research station in collaboration with the scientists from different groups and disciplines.

- Organizing regular meetings and workshops for the extension staff to meet the scientists for a two-way exchange of information, ideas and knowledge.
- Organizing training programs for the farmers and extension workers in the field.

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

Acknowledgement: I am grateful to the members of the ISNAR Working Group on Organization and Structure - Carlos Valverde, Ajibola Taylor, Guy Rocheteau, Byron Mook, Ghazi Hariri, and Joseph Casas for their comments on the drafts of this paper and for valuable feedback.

HOW TO ORGANISE FORESTRY RESEARCH WITH SCARCE RESOURCES

By F.S.P. Ng
 Chief, Forest Research, Education and Training Branch
 FAO

Introduction

The success of R & D (research and development) depends on several factors, of which the following are particularly relevant:

- (a) money
- (b) manpower
- (c) time
- (d) strategy

If all other factors are equal, a well-funded enterprise may be expected to achieve more than a poorly-funded one. On the basis of funding, developing countries rank very low in the world list, so low that even the total national research budget of a country like India is dwarfed by the research budgets of big manufacturing companies like General Motors of USA and Hitachi of Japan (see Tables 1 and 2).

Table 1. Total country R & D expenditure (based on UNESCO, 1991)

COUNTRY	YEAR	CURRENCY	AMOUNT '000,000	US\$ EQUIV. '000,000 March 1991
USA	1988	US\$	139,255	139,255
Japan	1988	yen	10,627,572	78,723
France	1988	franc	130,631	24,835
UK	1986	pound	8,778	16,562
Canada	1989	dollar	8,685	7,529
Australia	1988	dollar	4,187	3,271
India	1988	rupee	34,718	1,929
Pakistan	1987	rupee	5,582	256
Singapore	1987	dollar	375	216
Thailand	1987	baht	2,664	107
Malaysia	1989	ringgit	97	36
Sri Lanka	1984	rupee	257	6

**Table 2. R & D expenditure of commercial corporations in 1990
(The top 20, based on Business Week, December 2, 1991)**

CORPORATION	EXPENDITURE IN US\$ '000.000
General Motors	5,342
IBM	4,941
Siemens	4,132
Ford Motor	3,558
Hitachi	3,011
AT&T	2,433
Matsushita Electric	2,423
Philips Electronics	2,411
Alcatel Alsthom	2,237
Fujitsu	2,097
Toshiba	1,864
Nippon Telegraph & Telephone	1,739
NEC	1,728
Bayer	1,699
Digital Equipment	1,614
General Electric	1,479
Du Pont	1,428
Hewlett-Packard	1,367
Eastman Kodak	1,329
Dow Chemical	1,136

The R & D expenditure of the business corporations is of course supported by income from their business, which means that each time we buy a car, a computer, a roll of film, or an agricultural chemical, we are paying for somebody's research. People who say "We cannot afford to support research" simply do not understand what they are taking about.

If all other factors are equal, the research enterprise with stronger manpower may be expected to achieve more than one with weaker manpower. The manpower factor consists of two components: the number, and the quality, of the researchers. If we consider the numbers, just for forestry research, the comparative figures for a selected number of countries is given in Table 3.

Table 3. Number of forest scientists in selected countries (based on the FAO/IUFRO Directory of Forestry Research Organisations, Draft, August 1992)

USA	2162
Japan	1005
India	385
Brazil	346
Malaysia	132
Austria	100
Tanzania	82
Malawi	11
Botswana	4
Lesotho	3

Quality is difficult to assess, but if we use the academic qualifications as a crude measure, the number of scientists with PhD makes up only a small percentage, usually less than 25%, of the scientists in developing countries.

The managers of research institutes in developing countries are left with two factors that they may be able to manipulate: time and strategy. However, time is also in very limited supply. If we keep a record

of how we spend our time, we usually find that we spend about 240 days a year at our official jobs. The working day is usually 8 hours, but in many developing countries it is 5 - 6 hours, so that people can leave in the early afternoon to supplement their incomes with a second job. Of the hours at work, deduct the time for meetings, correspondence, taking care of visitors, staff, and other matters, and one may be left with an average of 1 or 2 hours a day for research, or 240 - 480 hours a year. This is for a 'full time' scientist. What we can achieve in this time depends entirely on our research strategy.

For a senior scientist holding a managerial position, the research time may officially be zero. But there are so few scientists in developing countries that if the senior scientists do no research at all, there will only be junior scientists doing elementary research, and the sad thing about research in developing countries is that it seems to be permanently stuck in an elementary level. In my opinion, the senior scientists have to squeeze in some research time. Even a few hours a month will make a big difference to the overall quality and quantity of output of a research organisation.

Here are five strategic principles which I have personally found very useful in the management of research.

Keep research close at hand

The quicker you can get to your research, the better. If you need to travel half-a-day or more to get to your research, you will need to plan your visit at least a few days in advance, and you will need to allocate at least 3 days: 2 days for travelling and 1 day for work. As a result, you will be at the mercy of transportation, weather, other priorities fixed by your superiors, and any number of possible reasons for making a postponement. If your superiors schedule a meeting, even a short meeting falling within the 3 days of your planned trip, the trip may be cancelled. As a result your research will not get done efficiently, or not get done at all.

The cost also escalates. There is the nominal cost in terms of travel time, travel costs, and per diems. The true cost is a lot higher, because the time spent travelling represents opportunity wasted. If your research time is 240 hours a year, you cannot afford to spend a large part of it in travelling. If you are a senior scientist with managerial responsibilities, I would recommend that your laboratory or field research should never be more than a few minutes from your office, so that you can turn to it whenever you find some free time.

There is often a temptation to scatter one's research all over one's country. This is a mistake. It is better to stick to one location and get the research done well, than to cover a large area badly. When resources improve, stations can be established in other parts of the country, but only if such stations can be adequately staffed and maintained. Sometimes, there are political reasons for establishing a 'presence' all over the country. Under such circumstances, managers have to find a way to satisfy political needs without sacrificing scientific needs.

Use people-power

In horticulture and agriculture, many of the advances come from amateur efforts, driven by competitions at horticultural and agricultural shows in which panels of judges set the standards and award the prizes. In hybridisation work to develop new varieties, a prize-winning hybrid is the one in a million that contains the desired combination of characteristics. The task of raising a million plants to find the best one, is too much even for a well-funded research organisation. A thousand amateur plant breeders working in their home gardens, can cover a lot more ground than can any research organisation; and at no cost to the national treasury.

Once, I led a research team on pine improvement in Malaysia. We were hampered by the problem that the local pine plantations would not produce any seeds. We solved this problem by asking foresters all over the country to tell us where they had seen large pine cones. Soon we had reports from three localities: two in coastal locations and one on the crest of a hill. It immediately became apparent on visiting those areas that these were the places with breezes blowing day and night, which carry the

pollen. Elsewhere, the air was too still, and the pollen was not being transferred to the female cones. We were able to develop the plot on the hill crest into a seed stand. In contrast, an earlier project leader spent thousands of dollars planting a large 'seed stand' in the northern tip of the country, where according to his theory, the climate would be suitable for seed production. It did not work, and we spent thousands of dollars every year to maintain this useless plot.

In dealing with natural resources research, it is always worthwhile consider how to mobilise people-power. The local people often have interesting beliefs, observations or experiences. If you are receptive, they will share their ideas and experiences with you. Then you can check the more interesting ideas experimentally, and save a lot of time.

Use reliable tools

A scientist must be in complete control of the tools of research, not the other way round.

When I was a student, I knew a student whose PhD project involved analysing the data from a space satellite. He spent a whole year devising the analytical programme in anticipation of the launch of the satellite. At the last moment, the launch was aborted. The student was forced to write off a whole year's work.

This was not a good way to start a research career.

Since then, I have seen scientists waste months and years trying to get their phytotrons, their constant-humidity rooms, their seed storage cold rooms, etc. to work. Why do they choose to work on matters which require the use of equipment that they cannot fix or maintain? In a country with frequent failures in power supply, it is silly to attempt to do any research with equipment that need reliable power supplies. It is silly also to be dependent on equipment that can only be fixed by manufacturers in distant countries, who are in any case not interested to fix the equipment for you. At one time, it used to be a great event for a developing country to receive the gift of an electron microscope. Instant technology transfer! These machines would work for about two weeks and then they became museum pieces. They were so sensitive that each time a vehicle passed by outside, the components get shifted a little out of alignment.

Do multiple projects

It is a lot more cost-effective for a scientist to work on multiple projects than to work on a single narrowly-defined project. The cost-effectiveness comes through in several ways.

First, there is the cost of overheads. The time spent browsing through the literature in a library is an overhead cost. A scientist with multiple interests will get a lot more out of browsing than one with a narrow interest. Similarly, the one with multiple interests will get more out of field visits to farms and forests, more from overseas travel, more from conversations with other scientists, more from conferences, and so on.

It is necessary also to appreciate that the solution to a problem is not entirely dependent on the time, money, or manpower that one devotes to it. For example, in the examination of research programmes in forestry as well as in agriculture, one often come across honey-production as a priority project. Yet, to the best of my knowledge, no tropical country has ever succeeded in commercial honey production. This is apparently because in a tropical environment, there are many species of wild bees which collect pollen and nectar. The honey bee is no match for the wild bees. In a temperate climate, the winter culls the wild bees while the bee-keeper keeps the honey bees alive by feeding them with sugar. This combination of natural and human intervention gives the honey bees a competitive advantage. The lack of a winter in the tropics puts the honey bees at a great competitive disadvantage and until there is a breakthrough idea or observation, research on honey production in the tropics quickly reaches stagnation; it is therefore better for the scientists involved to work on various entomological projects in parallel so that they do not waste time. Putting a stagnant problem 'on the shelf' is a practical way of

dealing with such problems, until one can see a way forward. The worst situation is for a scientist to be kept strictly to a stagnant problem and being forced to make regular reports of 'progress'.

There are people who hop from one research to another without making progress in anything. The apparent inability of such people to solve problems poses a different kind of management challenge: tying such people down to one problem is unlikely to improve their problem-solving ability.

Keep it cheap

In research, the most important thing is to find the answers as quickly and as cheaply as possible. There are two approaches. One is to focus on the methodology, on the grounds that if you have the right methodologies, you will get the answers. The other is to focus on the answers, on the grounds that any method that produces the answers is the right method. I personally think we should focus on getting the answers.

There is a story in Malaysia that a team of scientists once tried to find out why it was so difficult to produce the common pond catfish by intensive aqua culture. The fish population would build up and then drop drastically. The scientists made a thorough plan of investigation. They monitored the chemical and physical condition of the water, the type and quantities of food, the growth and reproduction of the fish, and so on. All these efforts led nowhere. The answer came from an independent observer who found that there is a water snake which sooner or later finds the pond and settles in it. It waits outside the mudholes in which the baby catfish congregate and gobbles them up as they emerge.

I like to tell this story to young scientists who have just attended courses in experimental design and methodology, as an antidote to the stuff they have just been taught.

Here are some suggestions for keeping research cheap.

* Do a pilot experiment first.

I recently came across the following example of seed research from a country in Africa.

Project: Effect of heat on seeds of some indigenous species

Objective: To observe the effect of heat treatment in the germination of seeds of species which have low germination rates.

Materials and methods: Seeds of 3 species are placed in ovens at 60, 70, 80, and 100 degrees Celsius for 2, 4, 6, 8 and 10 hours. After this treatment, 150 seeds of each species are used for germination testing.

My comments:

- There are practically no living things that can survive 100 degrees Celsius for 2 or more hours. That means for sure, a waste of $150 \text{ (seeds)} \times 5 \text{ (treatment periods)} \times 3 \text{ (species)} = 2250 \text{ seeds}$.
- It is unlikely that seeds will survive at 70 and 80 degrees for 2 or more hours, so another $150 \text{ (seeds)} \times 2 \text{ (temperatures)} \times 5 \text{ (treatment periods)} \times 3 \text{ (species)} = 5000 \text{ seeds}$ are likely to be wasted.
- The experiment omits simple treatments like pouring boiling water over the seeds, or chipping off a bit of the seed coat. It also omits cutting tests to establish what percentage of seeds are viable to begin with.
- However, the real objection to the experiment as designed above is not that the experimenter is testing silly ideas (we all learn by making mistakes, and it is essential to allow scientists the freedom to test their ideas) but that the scientist is using up too much resources. A pilot experiment using 10 good

seeds per test (the scientist would first have to find a way to distinguish good from bad seeds) would have been more than enough to test these ideas. Then, there would be time and material saved, which could be used to test many more ideas, until a real understanding of the problem develops.

* Do multiple experiments. If your experiments are cheap, you can do lots of them, and thereby increase your chances of making worthwhile discoveries. You can terminate bad starts, change direction, and feel a greater sense of control. If you do 10 small experiments and make one hit, you are well on your way to becoming a successful scientist, while the person who is getting bogged down in one big experiment is well on the way to mediocrity. Your chances are better because you have more tries, you are covering more ground, and you are creating opportunities for faster learning.

* Collect minimum data. Data collection always involves a cost. First, make a list of all the possible data you could collect from an experiment. Then examine each kind critically to decide what can be left out. Distinguish between the main objective and subsidiary objectives. The more you simplify, the cheaper is the experiment, and the better the chances of attaining the main objective. This is to be weighed against the risk that you may later wish you had collected some additional data to answer subsidiary questions. You must make your own choice, but remember that if you get bogged down in a big data-collection exercise, it will be at the expense of your ability to do multiple experiments.

* Proceed from point to point. Most experimental designs emphasise that experiments to compare between different treatments should be carried out simultaneously so as to avoid differences due to time lag. Yet the fact remains that most human learning is by point to point experimentation, rather than simultaneous experimentation, for example a wine-taster can only taste one wine at a time.

In testing the strength of timbers, the machines can only test one piece of timber at the time, so the average strength, range, and standard deviations, are calculated from a series of tests.

When the Forest Research Institute Malaysia (FRIM) began to provide tests for fire-resistant doors, manufacturers submitted their doors one at a time since the testing room itself was a furnace that had to be rebuilt after each test. The manufacturers were present to observe the tests, and learnt what the design and material weaknesses were. We found that after two or three trials, every manufacturer was able to produce doors to pass the test. This emphasises an important principle about point-to-point experimentation: You learn at each point and stop as soon as you have learnt enough. There is minimum waste of effort.

* Avoid grey areas. If farmers are producing 1 tonne per hectare of a crop and your research indicates that you can get 1.2 tonnes, it may be better to forget it. You need fancy statistics to show that your 1.2 is a real (consistent) improvement, and even if real, the difference is likely to be reduced under field conditions because field conditions can never be managed like experimental plots. Aim to double the yield. If you do lots of trials (by keeping trials cheap and simple) you have a better chance of finding the big effects, and you can afford to discard small effects. Think big!

Scientific journals are nowadays filled with papers that announce pitifully small effects backed by analyses of variance and other justifications, as if their authors are struggling to salvage years of unconvincing work. It is a shame!

Sometimes, you can move out of grey-area research simply by clarifying the objectives. For example, if you are asked to rate 10 timbers by their natural durability, you will need to design a big comparison test because each timber has a range of durability, and the ranges between the different species will overlap. But if what your client really needs is a timber that will meet a certain minimum specification, then the research moves into a yes-or-no area, which is much easier to do. You can eliminate quickly all those timbers that are of doubtful durability and concentrate on those that have a good chance.

* Be aware of genetic variation. The ideal experiment is when everything is kept constant except what the experimenter deliberately wants to vary. But because plants and animals are genetically variable, they react variably to experimental treatments. For example, in testing the ability of a hormone to induce rooting in stem cuttings, there is the problem that different plants of the same species may react to

different degrees. This can be dealt with by working on cuttings from the same plant or clone, and to test one clone at a time.

However, if the aim is to find a hormonal treatment that is strong enough to override clonal differences, one would deliberately use a mixture of genotypes and quickly screen a range of treatments to see which treatment would pass the minimum standard.

In tissue culture, some species, especially palms, are very difficult to culture, and out of thousands of trials only a few may respond. In the early years of tissue culture, researchers seized upon the 'one-in-a-thousand' successful cultures to generate new plantlets, without thinking of the genetic consequences. What they were multiplying were actually plants that were special only in their enhanced ability to regenerate under tissue-culture conditions, i.e. plants that were not typical and had no other no proven practical advantages. In the case of oil palms, the early promise of tissue-culture turned into a multi-million dollar nightmare when the tissue-cultured plants produced deformed rather than high-yielding plants. The scientists had lost control of the work by allowing the process to dictate what type of plants were being produced. A better approach is to quickly eliminate all tissue culture formulations that fail to induce regeneration in the majority of the trials; i.e. to ensure that the method is a method of propagation and not a method of uncontrolled genetic elimination and distortion.

However, under other circumstances, genetic screening is a quick and effective tool. For example, in looking for disease-resistant plants, one would look for surviving individuals in a population that has been decimated by the disease. In this case, disease-resistance is itself the desired trait, especially if everything else depends on this trait. This is different from the oil palm situation described above where high oil-production was the desired trait, not ease of propagation by tissue-culture. The tissue-culturists were side-tracked by their own propaganda into a race to produce oil palms by tissue culture. The method became the aim and the original aim was forgotten.

*Test the whole before the parts. For example, before testing a chemical fraction for suspected physiological activity, first test a crude extract. If there is no effect from the crude extract, there is no point proceeding to the separation and testing of the parts.

*Test the main issue before the subsidiary issues. For example, before testing the germinability of batch of seeds, check whether the seeds are sound and mature (i.e. not worm-ridden, fungus-infested, soft and immature, empty, rotten).

*Use systematic elimination. When looking for the causes of a particular effect, eliminate the various alternatives systematically, beginning with the cheapest and simplest methods until left with a narrow field for the more complicated elimination.

*Survey the field. Scientists often get bogged down in a small and unimportant activity because they cannot see the whole field and have no basis for deciding how to allocate their time and effort. Between concentrating on a narrow area of work and making a broad survey, it is usually better to start with a broad survey. A broad survey provides the scientist with a commanding overview of the subject and is the best immunisation against small-thinking and pettiness.

*Work according to the appropriate order of magnitude. For every kind of measurement, there is an appropriate level of magnitude. In studying the height growth of plants, the nearest centimetre is enough. In studying the weight gain in cattle, the nearest kilo; in mice, the nearest gram.

*Be equipment-wise. You can lose a lot of sleep and time with equipment problems. If you have a limited range of equipment, do the kind of research for which your equipment is best suited. Avoid equipment that is likely to break down and cannot be fixed quickly and locally. If you have the opportunity to buy equipment, buy a model that is tried and tested in your country. Be suspicious of the promises of the salespeople.

Between buying one big unit of anything (environment chamber, oven, autoclave, etc.) and two or more smaller units, consider buying the smaller units. Then you have backups if one should break down. You

can have the option of running parallel or separate experiments instead of having to wait for the one unit to be free.

In seed research, consider building seed storage rooms underground so that they are cool even when the air-conditioner fails. Consider having several small rooms rather than one big one so that you do not have to cool a big room even when only a small part of it is being used.

Conclusion

Research can be as expensive or as cheap as you like. For example, if you have an electron microscope, you can do the research that electron microscopes allow you to do, but you must have the means to maintain the equipment. If you have only an ordinary light microscope, your costs are lower but you have to limit yourself to what a light microscope can do.

Financial resources therefore determine the type of research you can do. They do not determine the quality of research. The quality is up to you, the individual scientist.

Ernest Rutherford, the pioneer of nuclear physics, who discovered the structure of atoms, with a budget of just a few pounds (sterling) said, "We have no money, therefore we must think". This could be an appropriate motto for all scientists.

References

BUSINESS WEEK (1991). December 2. Research and development strategies. Pp. 68 - 84.

UNESCO (1991) October. Statistics on science and technology.