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Research Report

NUMBER 1

Partners in Agricultural Technology

Linking Research and Technology Transfer to Serve Farmers

Thomas Eponou

The mandate of the International Service for National Agricultural Research (ISNAR) is to assist developing countries in bringing about lasting improvements in the performance of their national agricultural research systems and organizations. It does this by promoting appropriate agricultural research policies, sustainable research institutions, and improved research management. ISNAR's services to national research are ultimately intended to benefit producers and consumers in developing countries and to safeguard the natural environment for future generations.

ISNAR offers developing countries three types of service, supported by research and training:

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ISNAR was established in 1979 by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force. It began operating at its headquarters in The Hague, The Netherlands, on September 1, 1980.

ISNAR is a nonprofit autonomous institute, international in character, and apolitical in its management, staffing, and operations. It is financially supported by a number of the members of the CGIAR, an informal group of donors that includes countries, development banks, international organizations, and foundations. Of the 18 centers in the CGIAR system of international centers, ISNAR is the only one that focuses specifically on institutional development within national agricultural research systems.

ISNAR's Research Report series presents the findings of research conducted by the institute and its partners in the areas of agricultural research policy, organization, and management.

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CONTENTS

ACKNOWLEDGMENTS vi

FOREWORD vii

ABSTRACT viii

ACRONYMS ix

EXECUTIVE SUMMARY x

1. INTRODUCTION 1

2. CONTEXT OF THE TECHNOLOGY SYSTEM 5
- 2.1 Policy 5
  - 2.1.1 An Enabling Environment 5
  - 2.1.2 Leadership 6
  - 2.1.3 Pressure 8
- 2.2 The Structure of Farming Systems 9
- 2.3 Donor Involvement 11
  - 2.3.1 Lack of Sustainability 11
  - 2.3.2 Discontinuity of Effort 12
  - 2.3.3 Coordination Problems 12
  - 2.3.4 Duplication of Effort 13
- 2.4 Recommendations 15

3. EFFECTS OF STRUCTURE AND ORGANIZATION ON LINKAGES 17
- 3.1 Basic Problems in Structure and Organization 18
  - 3.1.1 Missing Tasks 18
  - 3.1.2 Missing Linkage Mechanisms 20
  - 3.1.3 Duplication of Effort 20
  - 3.1.4 Lack of Cohesion 21
  - 3.1.5 Differences in Legal Status 21
- 3.2 Attempts to Solve Basic Problems 21
  - 3.2.1 Merging Research and Transfer 21
  - 3.2.2 Decentralization 24
  - 3.2.3 Special Units 24
- 3.3 Approaches to Technology Generation and Transfer 27
  - 3.3.1 The Chain-Link Model 27
  - 3.3.2 The Linear Model 27
  - 3.3.3 Participatory Technology Development 29
- 3.4 Recommendations 29

4. RESOURCE ISSUES FOR LINKAGES 31
4.1 Human Resources 31
4.1.1 Motivation and Rewards 31
4.1.2 Planning and Time Management 32
4.1.3 Managerial Capacity 33
4.1.4 Human Resource Mix 33
4.2 Financial Resources. 35
4.2.1 Availability 35
4.2.2 Management 36
4.2.3 Compatibility between System Financial Resources and Linkage Needs. 37
4.2.4 Balancing Resources among Institutions and Units 38
4.2.5 Contracts 38
4.3 Recommendations 39

5. MANAGING LINKAGE MECHANISMS 43
5.1 Typology of Linkage Mechanisms 43
5.2 Effectiveness of Selected Linkage Mechanisms 46
5.2.1 Function 1: Planning and Review 46
5.2.2 Function 2: Collaborative Activities 50
5.2.3 Function 3: Exchange of Resources 54
5.2.4 Function 4: Dissemination of Information 56
5.2.5 Function 5: Evaluation and Feedback 59
5.2.6 Function 6: Coordination. 61
5.3 Recommendations 62

6. CONCLUSION 65

REFERENCES 67
RTTL DOCUMENTS 71
PARTICIPANTS IN THE RTTL STUDY 76

ANNEX: GUIDELINES FOR MANAGERS 77
1. INTRODUCTION. 77
2. BASIC LINKAGE PROBLEMS 77
2.1 Missing Critical Tasks 77
2.2 Missing Linkages 77
2.3 Nonfunctional Linkage Mechanisms 78
2.4 Ineffective Linkage Mechanisms 78
2.5 Duplication of Effort 78
2.6 Fluctuations in the Operation of Linkage Mechanisms 78
3. ISSUES AND RECOMMENDATIONS 78
3.1 Issues at the System and Policy Level 78
3.2 Managerial Issues 79

TABLES

Table 1. Selected Subsystems and Technologies Covered by the Study 3
Table 2. Percentage of Surveyed Subsystems Exhibiting Problems Related to Shared Goals 7
Table 3. Distribution of Subsystems by Structure and Quality of Integration 23
Table 4. Linkage Mechanisms Used for Specific Functions and Interactions 44

BOXES

Box 1. Duplication of effort induced by donor involvement: the case of seed potato technology in the Philippines 14
Box 2. Conflicts and tensions in the technology system: the case of the Colombian Agricultural Institute 22
Box 3. The trouble with reorganization: the case of Costa Rica 25
Box 4. The linear model at work: the case of maize in Costa Rica 28
Box 5. Bridging the gap with donor funds: the case of the Dutch-supported agricultural project in Colombia's Nariño Province 37
Box 6. The benefits of financial agreements: the case of Côte d'Ivoire's cotton subsystem 39
Box 7. Representing the interests of stakeholders at different decision-making levels: the case of the Colombian coffee growers federation 50

FIGURES

Figure 1. Number of linkage mechanisms observed for each technology-system task 19
Figure 2. Number of mechanisms observed for each linkage function 45

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T.E.
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FOREWORD

Necessity, goes an old adage, is the motherhood of invention. An obvious lesson or interpretation for agricultural researchers is that the needs and conditions of farmers and consumers should form the template from which technological innovations are crafted.

However, making the twin products of research — knowledge and technology — relevant to farmers' and other users' needs is only half the battle. The other half is delivering the goods in suitable form. The most important intermediary and ally of research in both these tasks is the technology transfer community, mainly government extensionists, but also NGOs, specialized service agencies, and private agricultural input companies.

How well researchers and technology transfer agents communicate and cooperate has a strong influence on whether agricultural science succeeds or fails as a catalyst of national development and as a tool for eliminating poverty. This point underpinned one of the conclusions of an international meeting a few years ago in The Hague which brought together ISNAR staff and senior agricultural research managers from 30 countries. The report of that meeting states:

> "The linkage between research and extension and the transfer of technology [are] ... extremely important areas which are currently underemphasized in ISNAR's program....Two issues of importance are 1) defining the responsibility of the NARS in this linkage... and 2) defining the necessary institutional framework."

That was in late 1986. In 1987, ISNAR responded to the challenge by launching a major study of "research-technology transfer linkages" (RTTL). Funding was provided by the Governments of Italy and Germany and the Rockefeller Foundation. To date, the project has produced several dozen published and unpublished research papers. This final research report by the project leader pulls together and analyzes the findings on 20 technology subsystems in the seven countries covered by the study. We hope it will be a useful tool for those research and extension leaders called upon to manage linkages. The report is a companion volume to an earlier ISNAR publication on linkages titled *The Technology Triangle: Linking Farmers, Technology Transfer Agents, and Agricultural Researchers*.

Another important "research relevance" issue that national research systems need to understand better is their relationship with farmer organizations. ISNAR will now turn its attention to this complementary linkage topic. As with the RTTL project, studying the dynamics, advantages, and pitfalls of working with these grass roots groups will help ISNAR to complete one more dossier in its portfolio on the linkages between agricultural research and its surrounding environment.

Christian Bonte-Friedheim
Director General, ISNAR

ABSTRACT

The capacity of agricultural technology systems to establish and manage good linkages between researchers and technology transfer agents strongly influences the extent to which farmers end up gaining access to relevant and useful technologies. The International Service for National Agricultural Research conducted a study of the links between research and technology transfer in seven developing countries. The report synthesizes the findings and makes recommendations in four areas: the technology-system context (policy environment, donor policies, and the nature of existing farming systems) in which linkages operate; the effects of the system's organization and structure on linkage behavior; resources for linkages; and the management of linkage mechanisms. An annex gives general guidelines for dealing with most of the linkage problems identified in the main report.

ABREGE

L'accès effectif des paysans à des technologies pertinentes et utiles dépend en grande mesure de la capacité des systèmes de technologies agricoles à promouvoir des liaisons adéquates entre chercheurs et agents de transfert de technologies, et à gérer celles-ci. Le Service International pour la Recherche Agricole Nationale a mené une étude sur les liaisons entre la recherche et le transfert de technologies dans sept pays en développement. Ce rapport synthétise les résultats obtenus et fait des recommandations relatives aux quatre aspects suivants : l'environnement du système de technologies au sein duquel s'exercent les liaisons (les politiques nationales, celles des bailleurs de fonds et la nature des systèmes agricoles en place) ; les effets de l'organisation et de la structure du système sur le mode de fonctionnement des liaisons ; les ressources disponibles au maintien des liaisons ; la gestion des mécanismes de liaison. Une annexe présente des principes généraux pour traiter des principales difficultés en matière de liaisons soulevées dans le rapport.

RESUMEN

La capacidad de los sistemas de tecnología agrícola de establecer y manejar buenos vínculos entre investigadores y agentes de transferencia de tecnología influye considerablemente hasta que punto los agricultores adquieren acceso a tecnologías relevantes y útiles. El Servicio Internacional para la Investigación Agrícola Nacional condujo un estudio sobre los enlaces entre la investigación y la transferencia de tecnología en siete países en desarrollo. El informe sintetiza los hallaszgos y hace recomendaciones en cuatro áreas: el contexto sistema-tecnología (entorno de las políticas, políticas de los donantes, y la naturaleza de los sistemas agrícolas existentes) en el cual operan los vínculos; los efectos de la organización y estructura del sistema en el desenvolvimiento de los enlaces; recursos para los vínculos; y la dirección y el manejo de los mecanismos de los enlaces. Un anexo provee guías generales para tratar la mayoría de los problemas de enlaces identificados en el informe principal.

ACRONYMS

AERLS	Agricultural Extension-Research Liaison Service
AgGDP	agricultural gross domestic product
AKIS	agricultural knowledge and information systems
ARPT	Adaptive Research Planning Team (Zambia)
CGIAR	Consultative Group on International Agricultural Research
CIDT	Compagnie Ivoirienne de Development des Fibres Textiles
CIP	International Potato Center
COFRE	Committee for On-Farm Research and Extension (Zimbabwe)
FEDEARROZ	Federacíon de Arroceros de Colombia
FSR	farming systems research
IAR	Institut of Agricultural Research (Nigeria)
ICA	Instituto Colombiano Agropecuario
IDB	Inter-American Development Bank
IDESSA	Institut des Savanes (Côte d'Ivoire)
ISNAR	International Service for National Agricultural Research
NARS	national agricultural research system
OFCOR	on-farm client-oriented research
NGO	nongovernmental organization
OSP	Office des Semences et Plants (Côte d'Ivoire)
PACO	Projet Agricole du Centre-Ouest (Côte d'Ivoire)
PCARRD	Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development
R&D	Research and Development
RELO	research-extension liaison officer
RTTL	research-technology transfer linkages
T&V	training and visit
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

The impetus for the ISNAR study presented in this report was a growing awareness that technologies in developing countries were not reaching farmers, particularly resource-poor farmers. A principal reason for this was found to be poor linkages between research organizations and technology transfer agencies. It is the relationship between these two groups that largely determines whether farmers obtain new and relevant technologies.

In 1987 ISNAR was asked by donors and managers to investigate key factors influencing linkages. This report is a synthesis of the ISNAR case studies and research papers produced on the subject since that time. ISNAR hopes this report will help give the issue of linkages the high profile it deserves in agricultural technology systems.

The Research-Technology Transfer Linkages (RTTL) study was funded by the governments of Italy and Germany, as well as by the Rockefeller Foundation. In this report of the study findings, "research" refers to all public-sector institutes and organizations that carry out research in the broadly defined area of agriculture. These include research departments and units of ministries of agriculture, semi-autonomous agricultural research institutes, commodity boards and other agricultural parastatals with research aims, and university faculties of agriculture. The general term "technology transfer" refers to all public and private bodies that attempt to bring research results Ä in the form of new agricultural technologies and new information Ä to farmers. These include agricultural extension services, commodity boards, government and parastatal seed-production units, NGOs, and commercial firms.

The report focuses on four key areas of linkages between research and technology transfer. A summary of the findings and recommendations for each area are presented below.

Context of the Technology System

The context in which an agricultural technology system operates strongly influences the performance of links between research and technology transfer. Key forces in the outside environment are national agricultural-sector policies, donor behavior, and the existing farming systems targeted by research.

The ISNAR study found that many linkage problems can be traced to problems in the technology-system context. **It is crucial that policymakers recognize research and technology transfer as two components of the same system and that they deal with them from a systems perspective.** They must assume leadership by providing research and technology transfer with performance incentives; by promoting the complementarity of research, technology transfer, and the other development instruments of the system; by enforcing accountability; and by clearly defining mandates.

Farming systems in developing countries are diverse. They therefore require skilled transfer agents to communicate the complex needs of farmers to researchers. There is often a shortage of such skilled workers, but training and subject-matter specialists can help to improve skills. A receptive and open attitude on the part of researchers contributes to improving channels of communication.

Donor involvement, always necessary, can nevertheless be a source of problems. Lack of coordination between a donor and the national system can lead to projects summarily coming to a halt when donor funds cease. Lack of coordination also leads to conflicting pro-

cedures and goals, disagreement over resource allocations, and unnecessary competition. The results can be seen in projects that are not sustainable, discontinuity and duplication of effort, and fluctuations in the performance of linkages between research and technology transfer. **Coordination of donor input must rest with the national system to avoid conflicting goals and procedures, disagreements over resource allocations, and interdonor competition.**

Effects of Structure and Organization on Linkages

Major organizational problems identified by the study were missing tasks, missing linkages, and duplication of effort. Adaptation and packaging of technologies, reproduction of technologies (for example, seed multiplication), and evaluation after delivery to farmers were the most common missing tasks. The tasks most frequently associated with missing linkages were: problem diagnosis, research planning, technology release, and technology reproduction. Duplication was found to be a common linkage problem. Technology systems are sometimes organized in such a way that the same task is performed by two separate units. As mentioned above, duplication can also be introduced into the system by donor involvement. These problems often stem from the fact that system needs and capabilities were not assessed before the establishment of linkages.

Reorganization is often used in an attempt to eliminate these difficulties. **The RTTL study found, though, that reorganization — for example, merging research with technology transfer — does not necessarily improve the situation.** In fact, it can aggravate problems such as when an organization becomes too large to manage and conflicts between staff members arise.

There is no structural model valid for all technology systems. A basic finding was that whatever model is used, its chances of success are greater if the required linkages are in place; the required financial, human, and managerial resources are available; and the atmosphere is conducive to cooperation.

The way research is organized needs to be compatible with the way technology transfer services are organized; otherwise linkages may not work. For example, integration of the two groups can easily be hindered by a difference in their legal status. Logistical difficulties can arise when research is organized on a disciplinary or commodity basis, while technology transfer operates regionally.

Different models of technology transfer were studied. The commodity or "chain-link" model was found to be the most effective. Systems using this approach were observed to have good financial and human resources. However, their success was due to good management of appropriate linkages, leadership, accountability, and incentives in line with objectives.

An important finding was that different models may be needed for different technological situations, such as commercial innovation, low-external-input technologies, or technologies geared toward sustainability. The type of model used also has a bearing on the types of linkage mechanisms that should be used and where to place them.

Strategies to solve basic linkage problems include decentralization and the creation of special units. The success of decentralization is mixed. **There is no clear evidence that decentralization leads to better integration of research and technology transfer because it does not always address the real causes of linkage problems.** The creation of special units, such as farming systems research (FSR) groups, pre-extension and research-extension liaison services, and training units, is another strategy. FSR units encountered the

same problems as other research programs when dealing with technology transfer. Generally, the other types of linkage unit were fairly effective in bridging gaps between research and technology transfer.

Resources

Funding

In agricultural systems where financial resources are scarce, funding for linkages is often the first to be cut and groups find themselves competing for funds.

Successful management of resources for linkages is marked by the several characteristics: recognition of the importance of linkages by providing a budget for linkage mechanisms, a flexible attitude (for example, setting aside funds for contingencies), and timely release of funds.

For the less-developed countries, the average expenditure on agricultural research for the period 1981-85 was only 0.94% of agricultural gross domestic product (AgGDP). System budgets are also a problem for linkages: salaries often account for 90% of the total budget, leaving little for operational expenses.

Financial resources are often inadequate for the linkage requirements of a system. And they are not always evenly distributed to the research and transfer components. A simple lack of money often leads to one component being unable to perform a linkage task.

Personnel

In the area of human resources, key factors for the performance of linkages are motivation and rewards, time management, managerial skill, human resource mix, and meeting system requirements with appropriate personnel.

Reward systems currently in use are not generally compatible with the goals of technology systems. Managers should design new systems that reward technology generation and transfer, rather than scientific publication. Sabbaticals, training, and promotion should be based on the relevance and field success of the technologies developed, adapted, or packaged. Given the financial constraints faced by many systems, donors could help to change the reward system by modifying their own criteria for granting fellowships and scholarships.

The mix of human resources is important. Managers should analyze their systems and identify the types and numbers of employees needed for effective generation and transfer of technology and for linking the two functions. They should also have more freedom in human resource management than is currently the case.

Problems resulting from differences in the status of researchers and technology transfer staff cannot be totally overcome because they are normally part and parcel of the institutional structure. They can be minimized, however, by changing the reward system. Some form of competition is necessary but this should be kept to a minimum by improving the resource-allocation process and making the incentive and reward systems more equitable. Managers at all levels of the system must be aware that technology generation and technology transfer are two elements of one mission: making relevant technologies available to farmers.

Educational differences between research and technology transfer personnel can sometimes be so wide that cooperation between the two groups is severely handicapped.

Communication and direct collaboration may be difficult because either one or both groups are incapable of dealing with the other. Managers must be aware that the special units needed in such cases require additional resources. The success of such units also greatly depends on the quality of their staff.

Exchange and secondment of personnel are good mechanisms for improving linkages but are rarely used. Formal financial agreements between research and technology transfer can be an effective linkage mechanism as they allow for technology transfer's input into the research agenda.

Managing Linkage Mechanisms

Management has the most to contribute to solving linkage problems. One major task is to select appropriate linkages and linkage mechanisms according to the strengths and weaknesses of the technology system. **The types and quality of resources required vary for each linkage function and even for mechanisms used for the same function.** Some require well-trained people, while others demand substantial funding. Research managers must assess their own resources as well as those of their counterparts in the system.

Managers must also attempt to predict the behavior and attitudes of their counterparts in other organizations involved in the technology system before choosing specific mechanisms. Behavior and attitudes are not static. They are reinforced by results as well as by changes in the external environment, including the policy context. Though managers have little control over such environmental factors, they are able to deal with some system constraints such as organizational problems. Managers can improve joint planning and review; enhance performance of collaborative tasks; strengthen linkages by establishing contract-client relationships with technology transfer and providing proper working conditions and motivation for staff rotation and secondment; improve the flow of information and knowledge between research and technology transfer; encourage feedback; and improve coordination.

Most systems rely heavily on communication mechanisms to link research with technology transfer. This reflects the traditional view of the sequential nature of the roles of the two groups. These mechanisms, used alone, are not sufficient to ensure integration; their effectiveness is enhanced by using other mechanisms in the system.

Linkage mechanisms cost time and money. Managers should regularly evaluate them and take corrective action when necessary.

1. INTRODUCTION

Despite large investments in both agricultural research and technology transfer over the last three decades, parts of Africa, Asia, and South America are still afflicted by poverty and hunger. Millions of farmers still use primitive technologies in an era when biotechnology and other areas of scientific innovation offer attractive new possibilities. The need for improved technologies is particularly acute in cases where farming resources have deteriorated due to poor management or to environmental damage caused by overpopulation, overgrazing, and overexploitation of forests.

When it comes to technology, resource-poor farmers in developing countries are in a difficult position. First, their farming systems are usually complex and diverse, yet the span of technologies available to them is narrow. Second, they lack the capacity to test and adapt technologies themselves. Third, they have little or no power to exert pressure on policymakers in order to widen the spectrum of technologies relevant to their needs.

The continuing poor living conditions of large portions of the world's population can be traced to many factors, among them ineffective national development strategies and policies, unfavorable international economic relations, and high rates of population growth (Eicher and Staatz 1982; Mellor and Ahmed 1988). Policies and strategies have focused separately on agricultural research groups and technology transfer. However, it is the interaction of these two groups that largely determines whether resource-poor farmers gain access to technology, and whether that technology is relevant. Good linkages between the two are essential. Unfortunately, for many years the significance of linkages was overlooked because of the overriding influence of other issues (pricing, for example) on the performance of the agricultural sector. In fact, the agricultural technology systems of many developing countries suffer from weak linkages. And in some countries, they do not even exist.

Investigation has shown that the following factors are essential for good services to small farmers and require strong linkages (Merrill-Sands and Kaimowitz 1991):

- Research must focus on real problems and constraints faced by farmers.
- Agroecological and socioeconomic aspects of farming systems should be taken into account in technology development and consolidation.
- Technology transfer groups should be aware of technologies available to farmers.
- Feedback regarding transferred technologies should be provided to research so that necessary adjustments can be made to future technologies.

The absence of linkages has resulted in completely untenable situations in some technology systems: technologies are irrelevant to the true needs of farmers, or technology transfer groups are unaware of the existence of certain relevant technologies. In the meantime, technology-hungry farmers strive to produce as much as possible from their meager resources using outmoded means.

Returns to donor and national public investment in agricultural research and technology transfer could be significantly higher if innovations were to reach more farmers. Unfortunately, the situation has simply not improved in some countries where the World Bank and other donors have invested heavily in research and technology transfer. In some cases, such as the Sahel region of Africa, the situation has not only failed to improve, it has actually worsened due to environmental deterioration over the past two decades.

Though much was expected from Farming Systems Research (FSR) and other approaches based on direct linkages between research and farmers, results have been disap-

pointing (Byrne 1989). In many cases, successes were negligible in proportion to the resources invested. It has become evident to proponents of these approaches that they are inadequate substitutes for strong linkages between research and technology transfer.

ISNAR was requested by donors and research managers to assist national agricultural research systems (NARS) in strengthening linkages. ISNAR had already identified linkages within the research/transfer/farmer triangle as being one of the dozen or so critical factors affecting the performance of research systems. In 1987, ISNAR launched a research project with the following objectives:

- to identify key factors influencing the performance of linkages between research and technology transfer;
- to analyze major weaknesses in these linkages;
- to draw lessons from the project to serve as guidelines to research managers.

It was recognized from the beginning that a review of the existing literature would provide clues but, by itself, would not be enough to fulfill these objectives. The problems plaguing linkages are diverse, ranging from complete ignorance of the need for linkages to lack of resources for their establishment. The complex nature of linkage issues thus demanded a multidisciplinary approach. Issues had to be examined from the standpoints of economics, political science, organization theory, sociology, social psychology, and psychology.

Research conducted by a multidisciplinary group of acknowledged experts produced six theoretical papers from which the analytical framework and the project's guidelines were developed. The guidelines were then tested in a pilot case study in Colombia. There followed an in-depth comparative analysis of seven countries.

Twenty technology subsystems — also referred to as agricultural knowledge and information systems (AKIS) — in seven countries were studied. A subsystem was defined as a set of institutions involved in the development and transfer of technologies for a specific domain. A domain could be a region, a specific group of farmers, a commodity, or a specific problem. The countries studied were Côte d'Ivoire, Nigeria, Tanzania, Costa Rica, the Dominican Republic, Colombia, and the Philippines. In most of the countries, three or four subsystems were studied (table 1). In the case of the Dominican Republic, only one subsystem was examined.

Using a systems approach, the researchers did their analysis at two levels: subsystem and technology.

At the subsystem level they studied organizational factors and assessed institutional performance covering a period of about 30 years. Key variables for assessing the latter were:

- level of functional integration of research and technology transfer, that is, the complementarity achieved among the various participants in working toward subsystem goals;
- the capacity to make develop and deliver relevant and responsive technologies, that is, products that are technically, socioeconomically, and environmentally sound solutions to the needs and problems of producers;
- sustainability, namely the ability to maintain performance over an extended period.

Table 1. *Selected Subsystems and Technologies Covered by the Study*

Countries	**Subsystem**	**Technologies**
Colombia	1. Rice 2. Bean 3. Coffee 4. Pasto area	Imported rice variety Blight-resistant high-yielding variety Fertilizer Reducing pesticide consumption Fertilizer Nima and Calima beans varieties Rust-resistant variety Fumigation pump Pasture improvement Guinea pig
Costa Rica	5. Strawberry 6. Macadamia 7. Corn	Black-plastic weed control Early planting dates Nursery Plant population Los Diamantes 8043 variety
Côte d'Ivoire	8. Cotton 9. Rice and Maize 10. Tilapia	Bouaké 189 rice variety New cotton variety IDSA 6 rice variety CJB maize rust-resistant variety Growing tilapia
Dominican Republic	11. Rice in Bonao	Juma 57 rice variety Two-crop-cycle planting dates Water weed control
Nigeria	12. Cassava 13. Maize 14. Cowpea	CBB-resistant variety Mechanical processing TZB-SR fertilizer package Spraying for plant protection
Philippines	15. Corn 16. Seed potato 17. Leyte soil improve-ment & conservation	Mildew-resistant yellow corn DMR2 white corn Ridomil seed dressing Diffused light storage Rapid multiplication technique Contour hedgerow Kudzu cover cropping
Tanzania	18. Coastal coconut 19. Mbeya cattle 20. Mpwapwa cattle	Rhinoceros beetle control by hook Fertilizer Coconut and citrus intercrop spacing Hybrid Mawa Rhodes grass for pasture improvement Mpwapwa breed

At the technology level, the case study researchers studied the presence and functioning of various linkage mechanisms. They traced the evolution of specific technologies, from diagnosis of farming problems and their inclusion in the research agenda, right through to their final evaluation after adoption by farmers. At each phase, the researchers identified and analyzed the nature and purpose of specific linkage mechanisms such as joint trials, training, and joint visits.

The researchers conducting the case studies — 13 men and four women in all — were, for the most part, from the national agricultural technology systems of the seven countries. For comparison purposes, they were asked to follow the same data collection and analysis methodology.

The present report summarizes the principal linkage issues, draws lessons from the project, and presents recommendations. It is important to stress that it does not provide a simple, mechanical solution to linkage problems; there is no single remedy for all such problems. Each problem and solution are system-specific and people-specific, and they will always be in some measure unique. This is a major lesson learned from the study. For example, for many years reorganization was perceived as the only solution to linkage problems. Research and history have shown that such a solution was often far too drastic.

This report should be useful to managers as a tool of analysis, though it does not attempt to answer specific questions. It is aimed at both senior managers and those at the operational levels. Since systems are structured and organized in different ways, the level for which each element of the synthesis is relevant will vary from one system to another. There has been no attempt to systematically separate the elements according to different managerial levels.

The next chapter discusses the “task environment” of the technology system. The third deals with structure and organization. Resource issues are discussed in chapter 4, and chapter 5 looks at issues in the management of linkages. An annex presents linkage issues in summary form and provides guidelines for managing linkages.

2. CONTEXT OF THE TECHNOLOGY SYSTEM

The overall effectiveness of a technology system is conditioned by its "task environment". This can be defined as the specific forces that influence decision-making processes and the transformation of organizations within a particular system (Kast and Rosenzweig 1985). In an agricultural technology system, the key elements of the task environment that affect the linkages between research and transfer are policy, the structure of farming systems, and donor involvement.

Shortcomings in these areas are beyond the control of system managers but they affect the functioning of mechanisms at the operational level. One of the most important findings of the ISNAR study is that many linkage problems encountered in the agricultural technology systems of developing countries originate in the three areas of the task environment mentioned above.

2.1 Policy

Three key activities at the policy level condition the extent to which the work of research and transfer can be integrated in a technology system: creation of an enabling environment, assumption of leadership, and application of pressure.

A prerequisite to these activities is that the contributions of both research and technology transfer in achieving agricultural development be valued. The ISNAR study showed, however, that policymakers often did not acknowledge their worth. And even when they did, the absence of a real constituency for research and technology transfer, due to lack of pressure from farmers, created a policy environment not conducive to the generation and transfer of technology. At the same time, the level of resources was scarcely in line with the mission of the technology system.

2.1.1 An Enabling Environment

An enabling environment is one in which research policies provide for performance incentives. At the system level, these policies should promote proper functioning of organizations in line with regulations. Financial, human, and physical resources must conform to mandates. Salaries, career development plans, and rules for promotion should be compatible with individual expectations. Moreover, incentives should be at least as attractive as those in other sectors of the economy.

Research and technology transfer, as instruments of development, can function effectively only if complemented by other instruments such as pricing policies, public investment, and agricultural credit. In many of the case studies, it seemed that the need for complementarity was not perceived. Far from complementing one another, various instruments were at times actually in conflict.

It may be useful to view linkages between research and technology transfer as analogous to the interplay of supply and demand in the marketplace. Research is the supplier and the farmer represents demand. Linkages between farmers, technology transfer, and research are an outcome of available supply and demand; that is, linkages constitute the market, as it were, where two components — research and the farmer — should dynamically interact via technology transfer.

However, where demand for technology is low, linkages (the market) will obviously be weak. Demand can be low, for example, when farmers have limited access to inputs, credits, and customers for their products. It can also be low due to logistical problems or a weak infrastructure — as when transfer agents are unable to reach farmers. Thus, the public sector proves to be inadequate when it comes to ensuring the minimum conditions needed for proper functioning of the agricultural sector.

Evidence from the case studies showed that in many instances the absence of linkages was a by-product of an overall malfunctioning of the technology system. In such circumstances, working on linkages alone is unlikely to improve the performance of the system. A holistic approach is probably needed.

In general, mandates are so broadly defined that organizations are free to interpret and implement them. For example, research may understand its mandate to be generation of knowledge rather than conversion of knowledge into useable technologies for farmers. Technology transfer may perceive its role as facilitating innovation at the farm level by improving farmers' access to inputs, credit, and markets. It may not consider technology to be a form of input. Or it may consider that inducing research to produced relevant results is not part of its mandate.

The end result is a no-man's land of responsibility — where certain tasks are not clearly assigned to one group or another, and disagreements over jurisdiction erupt into open conflict. This partially explains why most systems are characterized by the nonperformance of certain tasks, duplication of effort, and missing linkages.

2.1.2 Leadership

The chaotic situation described above is often reinforced by the absence of leadership at the policy level. As with other areas of the public sector in many developing countries, it seems that nobody is responsible for ensuring performance of the agricultural technology system. In other words, poor linkages reflect the failure of the overall administrative system of the country. The key missing element is leadership, or "the human element factor that binds a group together and motivates it toward goals," as Davis defined it (1977).

In systems lacking good leadership, accountability and shared goals are often unknown. There are neither clear norms nor stated goals against which to assess performance. None of the 20 technology systems studied had an explicit monitoring and evaluation system for organizations or even for the system as a whole. Röling and Seegers (1991) pinpoint the situation found in many cases:

> "Actors carried out their part of the total task, sometimes very effectively. But no-one was responsible for reaching the end objective. The extent to which it was reached was not even measured. If it was, there was no one to report to. There was no joint management, no shared ideology about development. No-one seemed to care."

Table 2 gives an indication of the extent to which the subsystems in the study suffered from difficulties related to a lack of shared goals.

Lack of shared goals sometimes stems from the failure of research leaders to recognize and properly apply a systems perspective. It is important that policymakers always perceive research and technology transfer as components of one system regardless of the particular organization and structure in place and their administrative locations. Even when a systems

perspective is adopted, policymakers may make the mistake of assuming that research and technology transfer will automatically cooperate. Or they may assume that linkages can be established or imposed simply through administrative rules. In general, the use of a systems perspective is not given sufficient consideration.

Table 2. *Percentage of Surveyed Subsystems Exhibiting Problems Related to Shared Goals*

Type of problem	**Percentage**
Lack of explicit mission for system as a whole	85
Incongruence between missions of research and technology transfer components	65
Confusion in mission of research component	35
Difficulties in sustaining consensus on strategic goals because of poor managerial decisions	75
Lack of continuity in pursuing stated goals for financial reasons	70
Lack of monitoring of participating organizations to ensure they share common strategic goals	80

Source: RTTL case study data.

With important commodities such as export crops, leadership is sometimes indirectly exercised through monitoring the performance of either agro-industrial companies, such as the cotton development agency in Côte d'Ivoire, or farmers' organizations, as in the case of coffee in Colombia. Leadership means responsive policy decisions. These in turn can create a system environment that responds effectively to changes. The induced-innovation model as described by Ruttan and Hayami (1971) works only in such systems.

Leadership may be exercised when the agricultural technology system has to solve a problem that could seriously affect the national economy. Consider the case of rice in Côte d'Ivoire. Self-sufficiency becomes a national priority when the price is high on international markets. Consequently, additional resources are made available for domestic rice production. In some instances, special organizations with well-defined mandates have been set up. But leadership and additional resources disappear as soon as rice imports are no longer perceived as a threat to the national economy. Since 1974 there have been two such periods of strong leadership in Côte d'Ivoire (Eponou 1990).

Leadership can also appear when a donor takes an interest in the technology system. Suddenly the system is an object of great attention by policymakers. But, as in the rice production example, support is neither long-lasting nor steady, and the system's performance fluctuates.

If leadership is not provided at the policy level, it is unlikely that linkages between research and technology transfer will improve. It remains to be seen how leadership can arise when the system's importance is not even recognized at the policy level. This leads to the often-asked question: Is the public sector, in its current state, the most appropriate location for the agricultural technology system?

2.1.3 Pressure

According to many technology system analysts, leadership from policymakers may not be sufficient to ensure integration of research and technology transfer. Policymakers, farmers, and donors must also exert pressure on the system to achieve that end (Kaimowitz 1991; Sims and Leonard 1989). Sims and Leonard assert that, in the absence of pressure or when "default incentives" exist in the system, researchers pursue their own interests and address issues unlikely to be relevant to the needs of farmers, particularly resource-poor farmers. This can only result in poor integration of research and technology transfer.

Kaimowitz (1991) identifies specific mechanisms that can be used to exert pressure. Policymakers can clearly define goals for institutions. By setting up joint campaigns and programs, eliminating constraints and gaps, and providing a system of sanctions, they can force institutions to work together. He cites the case of the Masagana 99 rice production program launched by President Marcos in the Philippines in the early 1970s. The program was both an attempt to reduce political instabilities and a response to the need for large rice imports caused by several crop failures. The program was successful and three years later the Philippines became self-sufficient because of strong integration of research and technology transfer. Kaimowitz also points to the example of rice in the Dominican Republic. After years of pressure, the yield of rice more than doubled.

Political pressure has often been exerted by authoritarian regimes or when a serious crisis arose (for example, Senegal's cowpea crisis in 1985). It should be noted that such tactics have several shortcomings. Results may not be cost-effective; secondary effects may be overlooked; and emphasis may be placed on short-term problems or symptoms rather than on basic causes.

Donor agencies can also exert pressure because they provide an important share of resources. The mechanisms at their disposal include the provision of operating funds for specific activities, substantial individual incentives, and constant monitoring and evaluation. In many cases — for example, the Ghana grain development project (Annor-Frempong 1988), the Dutch technology project (Engel 1989), the Philippine farming system development project for Eastern Visayas (Bernardo 1989), and the coconut project in Tanzania (Lupanga 1990) — integration has improved because donor agencies applied these mechanisms. Monitoring and evaluation, as well as making future funding conditional on the success of on-going activities, have served as powerful ways of exerting pressure on the donor projects encountered in the case studies. Unfortunately, pressure is not usually sustained once the projects end (Kaimowitz 1991).

Funding of research or technology transfer, participation in decision-making bodies, and protest and unrest can be used as pressure mechanisms by farmers. The Colombian Rice Growers Federation (FEDEARROZ) is a good illustration. It has been successful in defining constraints and seeking out solutions by attempting to bring together all the organizations working on rice. Farmer pressure has also been recognized as an important factor in the performance of agricultural technology institutions in Japan, Taiwan, and the Netherlands (Sims and Leonard 1989; Röling 1989).

According to Kaimowitz (1991), farmer pressure is stronger when farmers are affluent, politically influential, few in number, educated, and motivated to invest, and when they are already users of research-generated technologies. Unfortunately, the case studies showed that only large commercial farmers fall into this category. In many cases, pressure must be exerted by policymakers.

Technology system analysts believe that, given the current state of systems in many developing countries, farmer pressure must be created in cases where it does not exist. Röling and Seegers (1991) advocate inducing small farmers to apply pressure: they should have some control over research, technology transfer, public organizations in the technology system, and technology budgets.

The private sector can exert pressure through financing and contractual arrangements. Private companies can conduct their own research and thus provide pressure in the form of competition with government research.

It is important to note that applying pressure does not necessarily lead to better performance. Managers may resist pressure when they perceive it as interference. Resources, in line with the system's mandate, must be available before pressure can yield positive results.

2.2 The Structure of Farming Systems

One problem affecting linkages relates to the very nature of the farming systems served by technology systems. Most farming systems in developing countries are diverse and agroecologically and socioeconomically complex. Serving their technological needs poses difficult problems when it comes to the quantity, quality, and diversity of human resources required. It also requires more financial resources than for commercial agriculture. Unfortunately, most agricultural technology systems lack the required funds and skilled people.

Researchers cannot always use a systems perspective to identify farmers' problems because of their background training and the complexity of the systems. And even when they can, resources are usually not available.

Gathering information and providing feedback in a complex, heterogeneous environment requires well-trained and experienced technology transfer agents. Such people are rare in the technology systems of many developing countries. The village-level agents in a large number of the systems studied had no high school diploma. The main tasks assigned to them were distributing agricultural inputs and teaching basic farming practices. Most of them were unable to translate situations and problems observed in the field into material useful to research. Their reports were often anecdotal. In fact, many technology transfer agents had received no training to perform the tasks mentioned above and they lacked the most fundamental skills.

In India, the need for skilled transfer agents has been recognized and a scientific class of extension workers has been set up to act as a bridge between research and technology transfer. Testing and assessing technologies within the socioeconomic environment of farmers is part of their mandate (Prasad and Reddy 1991).

The same problem with skills arises when technology transfer agents are used as partners in collaborative tasks. In many cases, their only contribution is labor rather than knowledge, judgment, or insight; their contribution to making research protocols relevant is thus limited.

The wide educational gap between researchers and technology transfer agents often calls for special training units staffed by subject-matter specialists. In technology systems where the educational level of transfer agents is low, these units can substantially enhance system performance. Regular meetings can effectively upgrade the knowledge base of the agents.

The usefulness of these units in improving linkages at the research-technology transfer level has been acknowledged and documented (Swanson and Peterson 1991; Zaffaroni 1991). However, there are also problems associated with them. First, individuals with the required skills are not numerous in many of the systems studied. Second, these units increase the cost of human resources and consequently reduce the financial resources available for operations. Third, such units increase the risk of intergroup conflicts, particularly when individuals in these units perceive themselves as different or superior to those in existing groups. Finally, they increase the number of linkages to be financed and managed.

Farming systems research (FSR) units or on-farm research units may be used to enhance and target technologies for farmers. They obtain feedback that technology transfer agents are sometimes unable to elicit from farmers. The performance of these units depends to a great extent on the abilities of the individuals running them. An effective on-farm research unit needs experienced researchers to apply a systems perspective, deal with the complexities of field research, and ensure feedback. It also requires strong scientific leadership (Merrill-Sands and McAllister 1988). Many systems lack experienced researchers, and even when they are available they are often reluctant to do on-farm work because of the lack of rewards and status. Scientific leadership is a scarce resource in technology systems.

Strong linkages are needed to ensure precise targeting and continuous feedback. The use of special units for bridging gaps between functions calls for supplementary financial resources and effective operation of linkages. It is important to note that special units are not substitutes for traditional mechanisms used by commercial farmers, but they can strengthen or supplement these mechanisms. The real issue is that many technology systems cannot bear the costs of these units on a sustainable basis. This is shown by the fluctuations in the performance of the mechanisms over time. Periods of success often coincide with donor involvement in the system.

Evidence from the case studies shows that the financial costs incurred by special units can scarcely be borne by the national budget apportioned to technology systems. All the special units observed in the study were either initiated as donor projects or with donor assistance. The Nigerian agricultural extension-research liaison service (AERLS), the on-farm research unit in the Nariño Highlands of Colombia, and the use of subject-matter specialists in Sri Lanka were made possible by donor funds. These units were disbanded or ceased to function properly when donor funds ran out. The vast majority of FSR and on-farm research units in Africa have been financed by outside donors.

Almost all of the technology transfer systems financed by the World Bank in Africa and other parts of the world use the training and visit (T&V) approach. In Africa there is already concern about the incremental costs to ministries of agriculture and the long-term recurrent costs of transfer services (Howell 1988). It is unlikely that technology systems can afford the costs of travel to meetings, when they can hardly pay workers' salaries at the end of the month. Given the deteriorating economic situation in many developing countries, most agricultural research systems, if left to themselves, will be unable to finance research. The T&V approach may be good for strengthening linkages between research and technology transfer, but it is of little use to technology systems with a small resource endowment. Resource and other problems relating to the use of T&V in Africa have been well documented (Howell 1988; Gentil 1989; Morris 1991).

Even normal operations of technology systems can be problematic. In the Nigerian maize subsystem, for example, projects initiated in a given year had to be cancelled or suspended for lack of adequate financial backup. Funding for services, operations, salaries, and work incentives in technology transfer was inadequate (Ekpere and Idowu 1990).

The difficulties encountered in making these systems operational on a continuous basis are often reinforced by the absence of the following:

- basic infrastructures for input delivery;
- product storage and processing capacity;
- marketing and credit schemes.

Even when farmers are accessible by road, the overall cost of vehicles and maintenance is very high because of the poor state of the roads. Such constraints on an effective agricultural system have made policymakers reluctant to finance the additional efforts needed to establish and manage appropriate mechanisms and units. In some cases, the cost-effectiveness of these efforts may be questionable because of inaccessibility to inputs, credit, and markets. It seems that, in general, policymakers use national funds as bait for donor funds, but this results in ad hoc efforts with limited impact on farmers. This approach in itself a constraint on building strong linkages between research and technology transfer, because policymakers may only pay attention to those components most likely to be financed by a donor.

2.3 Donor Involvement

The most important issues with regard to donor involvement are:

- lack of sustainability;
- discontinuity of effort;
- coordination problems;
- duplication of effort.

It should be noted, though, that problems related to donor involvement are not always created by the donor. They sometimes result from existing weaknesses in the system.

2.3.1 Lack of Sustainability

Some technology systems become highly integrated over time because of external resources. This is the case when resources are specifically available for linkages and the project focuses on consolidation and transfer of technologies. Ideally, activities initiated by external funds are maintained by resources from the national budget once the project ends. The burden of these expenses is usually phased in gradually, as the project nears its scheduled completion.

In practice, however, projects are often designed without a prior assessment of the national technology system's capacity to ensure post-project continuity. The national budgets of many countries simply cannot support the added expenditures, particularly in the case of multiple projects. Linkage initiatives are thus lost and, in many cases, the level of integration achieved is not sustainable.

At least two other factors can undermine gains made in integrating research and transfer activities. One is the disappearance of leadership and accountability at all levels in those cases where staff morale falls due to changes in the incentive system. The other is the fact that projects often operate in isolation from the national system.

Luna (1989) gives the example of a national project in the Dominican Republic. In 1978, a T&V extension program was set up with funding from the World Bank and the government. By the time the program reached its zenith, 403 transfer agents had been hired,

trained, and assigned. In 1982, a decision was taken to discontinue the T&V approach when external financial assistance came to an end. Since that time, the national technology transfer service has been in a state of crisis because of insufficient resources to respond to farmer needs. It is a clear instance of the inability of a national government to assume the financial burden of project activities.

Palmieri (1989) and Coles (1990) discussed the effects of a large project funded in 1984 by the Inter-American Development Bank (IDB). Its goal was to increase agricultural productivity in Costa Rica by strengthening research and transfer within the Ministry of Agriculture and Livestock. Part of the project design was to increase the number of employees involved in research and transfer. The national government contributed the necessary personnel. The loan funds were designated for infrastructure, equipment, and some operating costs. The budget allocation process was by region and service (research and transfer budgets were separate).

Palmieri noted that, since the project ended, operating funds have been almost nonexistent, with 80% to 90% of the budget for the Directorate of Research and Extension spent on salaries. The field-level workers involved in research and transfer thus have no resources for fuel, vehicle maintenance, or living expenses, and it is common to see them use their own money to carry out their work. The result has been minimal execution of field-level operations. Any positive results of the externally funded project have been negated by the long-term implications of having added additional staff at the time of project implementation.

2.3.2 Discontinuity of Effort

Research often takes 10 years or more to produce useful results. Such a long-term enterprise normally requires continuous and stable funding. The ebb and flow of external funds, especially for projects with national scope, affects the continuity of technology output. Periods of resource shortages can interrupt the development and delivery of technology. In national systems dependent on external funds, time gaps between projects may correspond to periods of operational inactivity. These spawn other time losses because, when resources are again available, linkage mechanisms require a start-up period. In some instances the linkages must be totally redesigned because each new donor has its own perception of what is needed.

Luna (1989) discusses such a situation in the Dominican Republic. The Department of Agricultural Extension and Training, under the Subsecretariat of Research, Extension, and Training had five clearly differentiated periods (1962-67, 1968-73, 1973-78, 1978-82 and 1982 to the present) during which resources were relatively abundant at the beginning of each period but scarce at the end. Each period began with a program to strengthen technology transfer based largely on funds from external sources. In each period, the national budget was unable to assume the financial burden of the initiatives, and the transfer service was unable to maintain a steady flow of technology to farmers.

2.3.3 Coordination Problems

Coordination problems have a heavy bearing on the linkages between research and transfer. The linkage investigations carried out in the case-study countries highlight several coordination problems involving resources. They are relevant to agricultural technology systems across a variety of countries.

The first and possibly most important problem is the coordination of foreign donor technical assistance activity and financial contributions to national agricultural technology operations. Donors' procedures and goals sometimes conflict with national coordination needs. Indeed, foreign agencies sometimes even bypass national coordination controls and plans. National managers and administrators within research and transfer institutions have no authority over the objectives, programs, and allocations of such agencies. In each case, the relationship must be negotiated. At the same time, foreign agencies have no compelling reason to be guided by the coordinating bodies of national systems if negotiation and planning links are weak. They may prefer to organize funded activities in accord with their own programs and goals.

Unless there is control over financial allocations, the coordination role of national core bodies (e.g., PCARRD, the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development) is purely advisory. Such bodies can attempt to coordinate programs, but they cannot in any realistic sense ensure that the operations of national institutions conform with national program needs unless they have the authority to approve or reject foreign-funded research projects.

Even when control over allocation is in the hands of national managers, they may disregard coordination efforts if the interests of their institution are not in accord with coordination directives.

2.3.4 Duplication of Effort

The final problem encountered with donor resources is duplication of effort and competition over domains of competence. These problems stem from poor definition of mandates and from the absence of coordination and leadership at the policy level. Under these circumstances, organizations tend to define their mandate and scope of activities according to the opportunities to secure financial resources.

An example of duplication of effort can be found in the Philippine Potato Program. In 1977 both a national and international potato program were set up. The International Potato Center (CIP) became involved in the national Philippine Potato Program, while the Federal Republic of Germany funded the international Philippine-German Seed Potato Program. Unfortunately, efforts by the responsible national body, PCARRD, to coordinate the two projects failed. Box 1 describes this case of duplicated efforts and the reasons for it.

Despite the problems associated with donor involvement, donors can enhance integration by providing resources. They have been very effective in facilitating integration through training of both research and technology transfer personnel. Externally funded training can improve skills in generating or transferring technology and in the capacity to cooperate by reducing educational differences. Such indirect involvement was instrumental in the high level of performance seen in the maize subsystem of the Philippines (Bernardo 1990) and the fishery subsector of Côte d'Ivoire. In the latter case, both technology transfer agents and researchers received training in aquiculture. This helped them to develop the same approach and vision on the main issues (Eponou 1990).

Box 1. Duplication of effort induced by donor involvement: the case of seed potato technology in the Philippines

In 1976, the Philippine Council for Agriculture and Resources Research and Development (PCARRD) sponsored an interagency round table discussion on potato. This was stimulated by a seed potato shortage in the Philippines at a time when imports of seed were restricted to conserve foreign exchange.

The discussion underscored the importance of coordination of research efforts due to limited financial resources for potato. It resulted in a proposal to the Ministry of Agriculture for the formation of a National Potato Program.

The Philippine Government established the Philippine-German Seed Potato Program in 1977. The 10-year program was managed by the Bureau of Plant Industry of the Department of Agriculture. The German government provided financial resources and some technical expertise.

The national-level program, the Philippine Potato Program, was also created in 1977 to form a network of agencies involved in the development and transfer of potato technology. Coordination linkage functions were undertaken by PCARRD, through its round table discussions on potato. Among the other agencies involved in the program were the International Potato Center (CIP), the Northern Philippine Root Crop Center, and the Bureau of Agricultural Extension.

In the same year, CIP opened a regional headquarters in the Philippines and signed a Memorandum of Agreement with PCARRD in which CIP scientists were provided with facilities and human resources by the Philippine government in exchange for genetic material, technology, and training assistance. A jointly funded project (CIP-PCARRD) was also begun which stipulated the participation of the Root Crop Center, the Bureau of Plant Industry, the Institute of Plant Breeding, and CIP.

Nevertheless, coordination of research efforts between the two projects and the Bureau of Plant Industry did not occur. Both projects concentrated on rapid multiplication techniques and diffused-light storage for potatoes. One reason for this costly duplication of research was that the German Seed Potato Project insisted on collaborating with only the Bureau of Plant Industry and did not cooperate with other agencies in the Philippine Potato Program. While the precise reasons for this decision were not explained, it is clear that control over allocation of the project's financial resources by Germany resulted in by-passing the coordination efforts of PCARRD. As a result, the Bureau of Plant Industry, using the German funds, carried out research and transfer efforts which duplicated those of other national agencies and CIP.

Another salient point is that the Philippine Potato Program failed in its efforts to remove the seed supply constraint to potato production — not because it did not produce new technology but because the new technology was not adopted by farmers. Although the duplication of research effort, with its attendant loss of scarce financial resources, was undoubtedly a contributing factor, the primary reason for failure may have been lack of farmer interest in good-quality seed. This indicates faulty linkages with farmers in the identification phase of both externally funded projects.

2.4 Recommendations

The mandate and goals of all organizations in the technology system must be precisely defined at the policy-making level. It should be clearly stated that the overriding mission is to make relevant technologies available to farmers. Experience has shown, however, that strategic goals are not enough. Policymakers need to be active in defining organizational goals and even operational goals. Fundamental to this is the recognition by policymakers that the technology system is important a country's overall agricultural development strategy. This recognition should result in the following:

- Provision of resources to all organizations in the system in a balanced way and in line with the overriding mission.
- Leadership by policymakers in coordinating the whole technology system. Policymakers must provide mechanisms to ensure accountability as well as to ease tensions and avoid conflicts. Integration is made easier if policymakers perceive and treat research and technology transfer as two components of a single system. Policymakers must know that linkages cannot be administratively imposed. They should be established by consensus among the participants through managerial action.
- Criteria for rewarding personnel in accordance with the mandate and mission assigned to the technology system. For example, scientific publication cannot be the basic criterion for promotion if technology generation and transfer are the foremost mission of the system.
- An enabling environment. This can be created by exploiting the complementarity of research, technology transfer, and other development instruments such as pricing policy, public investment, and agricultural credit. In some cases, this can only be achieved by improving linkages with other ministries such as finance and planning.

Managers of research and technology transfer institutions need to be aware that strong linkages between research and technology transfer cannot be forged or maintained if either one or both have weak linkages with policy. Ensuring strong linkages with policy must therefore be a critical managerial objective.

Under certain circumstances, leadership alone is not sufficient. Pressure from policymakers, donors, and farmers is also needed for the system to achieve its goals. Policymakers must facilitate the emergence of this pressure by helping to create a constituency for research and technology transfer.

Given the diversity of resources needed to operate most agricultural systems in developing countries, donor resources are required if these systems are to be successful. Experience has shown that donor resources can improve linkages but often create additional problems. Sustainability and continuity can be built into systems: donor projects must have a longer life span and the recipient country must have the necessary resources to take over the project when donor funding ends. This should be addressed at the project planning phase.

Duplication of effort can be avoided by reinforcing coordination among donors and improving linkages within the different administrative units of the recipient country.

Donors must also ensure that all the institutions involved in their projects have the resources needed to establish effective links with the institutions being financed. Linkages between their projects and the national system must be strong enough to allow smooth integration of donor-supported work into the system. In some cases donors must assess

more carefully the capacity of the national system to ensure post-project continuity before choosing linkage mechanisms.

3. EFFECTS OF STRUCTURE AND ORGANIZATION ON LINKAGES

Weak links between research and technology transfer are often blamed on the structure and organization of the agricultural research system. Right or wrong, this perception has led many countries to overhaul their technology systems, in some cases more than once.

Structure generally refers to the formal institutional building blocks and administrative arrangements in place for generating and transferring technology, and how they relate to one another. The structure of an agricultural technology system, then, is basically the set of institutes, services, and agencies that plan and carry out the work, along with their division into a number of departments, units, teams, or projects of varying sizes and levels of authority.

Organization refers principally to the way the content of work is divided up within the formal structure. For example, the work may be organized along disciplinary lines, by commodity, or by agroecological zone. For the sake of simplicity and clarity, we use the term **reorganization** in this analysis to refer to major changes in a technology system's structure, organization, or both.

The numerous reorganizations that have taken place over the years in Latin American countries have been well documented by Nogueira (1989). African systems have also undergone major reorganizations. One trend has been to create special ministries of science and technology as a way to boost technology generation and use. Some Asian countries too have resorted to reorganizations of their technology systems. For example, the system in Indonesia has been reorganized three times since 1974.

There are various ways to divide tasks between research and technology transfer. Some will be assigned to research; some will be the job of technology transfer; still others will be carried out jointly by the two parties, with varying input from each group, depending on the nature of the task. But no matter which group performs them, some degree of cooperation will be necessary. As a minimum, communication between the two parties will be required, whether to seek advice or merely to keep each other informed of progress.

Generally speaking, linkage mechanisms are used to coordinate various tasks or, in the case of joint tasks, to perform them. The following linkage-related problems are prevalent in developing countries:

- **Missing tasks.** Certain tasks required of any agricultural technology system are not performed — for example, identifying farmers' technical problems or multiplying seeds of improved plant varieties.
- **Missing linkage mechanisms.** Certain linkage mechanisms that should be in place, such as joint review committees or research-extension liaison officer positions, have never been created.
- **Duplication of effort.** Research and technology transfer are each performing the same task separately — something that would be better handled either jointly or by just one party.
- **Non-operational linkage mechanisms.** Mechanisms exist but do not function. For example, a joint committee for monitoring and evaluating research results has been formally created but meets either rarely or not at all.

- **Ineffective linkage mechanisms.** Mechanisms are operational but results are not forthcoming. A joint review committee meets regularly, for example, but its recommendations are ignored.

The first three problems listed often relate to the technology system's structure and organization. It should be noted, however, that additional factors, such as the type and style of management in place, the availability of resources, and the context in which the technology system operates, may underlie these weaknesses.

This chapter analyzes the main structural and organizational factors and problems related to linkages. It also examines three specific strategies often used to deal with linkage problems: merging research and technology, decentralization, and the creation of special work units.

3.1 Basic Problems in Structure and Organization

3.1.1 Missing Tasks

To be effective, agricultural technology systems need to perform a variety of tasks in a roughly sequential manner:

- diagnose farmers' problems;
- design a research program
- generate technologies;
- consolidate technologies;
- disseminate information and knowledge;
- approve and release technologies;
- multiply improved genetic material and duplicate technology packages (reproduction);
- deliver technologies;
- evaluate technologies.

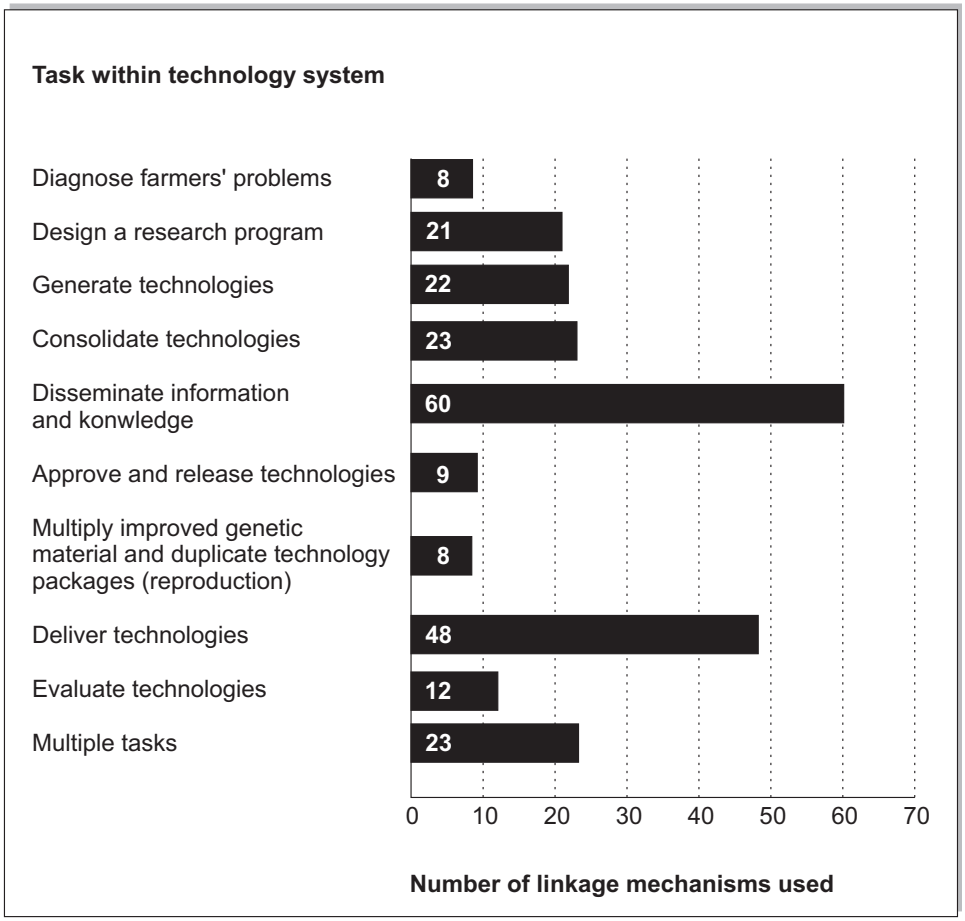
Figure 1 shows the number of linkage mechanisms identified for each of these tasks across the 20 subsystems studied.

The ISNAR linkages study found, however, that in a number of instances there were no linkage mechanisms in place simply because the task for which linkages were needed was not even being performed. The most common missing tasks were technology consolidation, reproduction (particularly seed multiplication), and evaluation.

Consolidation includes adaptation and packaging of technologies for use by farmers. Often, research is terminated too quickly, or the technology transfer work starts too late in the process. This may even occur in agricultural technology systems that have a farming systems research (FSR) unit. This was a problem in the tilapia subsystem of Côte d'Ivoire until a special project was established to consolidate and transfer tilapia technologies (Eponou 1990).

Once the technology packages or new germ plasm have been developed, they must be reproduced in large numbers for farmers. Often this does not happen, particularly when the work is assigned to public-sector agencies. Problems related to seed reproduction were reported in the case studies from Côte d'Ivoire (Eponou 1990), Nigeria (Ekpere and Idowu 1990), the Philippines (Azucena 1989), and Tanzania (Lupanga 1990).

Figure 1. *Number of linkage mechanisms observed for each technology-system task*



Note: The total number of linkage mechanisms identified by the cast study researchers was 234. The "multiple task" bar refers to mechanisms used for more than one technology system task.

Technologies need to be evaluated once farmers have received and begun using them. The ISNAR study found that efforts to provide feedback to research were weak in most of the systems examined (Eponou and Wuyts 1991).

How does the problem of missing tasks arise? It some instances, basic tasks are not assigned to any one organization; in others, they may be assigned to a unit lacking the capacity or capability to perform them. For example, in Côte d'Ivoire in the early 1980s a public organization was established to increase grain production by supplying farmers throughout the country with free seeds. Given the variety of agroecological zones, the demands of farmers were diverse. The Office des Semences et Plantes (OSP) simply did not have the resources — people, money, land, and information — to respond to farmers' needs. Seed production became a constraint on the technology system. Both research and technology

transfer had to produce the badly needed seeds. OSP was also in charge of seed certification, but was equally ill-equipped to perform that task (Eponou 1990).

Structural problems may also arise from a deliberate managerial decision not to perform certain tasks. For example, newly appointed research managers often cancel joint program planning (established by their predecessors) with technology transfer, because they undervalue its usefulness. Seed multiplication and evaluation of technology are typically not assigned to a specific unit.

When the task of releasing technologies is not formally assigned to a group or unit, there is often disagreement over when a specific technology is "ready to go". Delivery can also be delayed because researchers are generally reluctant to release a technology before publishing their results. Presumably, formal assignment of responsibility for technology release would eliminate this problem.

3.1.2 Missing Linkage Mechanisms

Critical tasks, such as technology consolidation and reproduction, cannot be integrated if specific linkage mechanisms are missing between the units performing these tasks. Linkages may be missing at both the decision-making and operational levels. Their absence undermines the technology system's performance by preventing groups from carrying out subsequent tasks. Damage varies with both the task to be performed and the level of development of the technology system. Problem diagnosis, research planning, technology release, and technology reproduction are the tasks most frequently associated with missing linkages (Eponou and Wuyts 1991).

Technology systems commonly have linkage mechanisms located within senior management. Linkages may take the form of occasional meetings between top-level managers without any precise direction or mechanisms at the operational level. Linkages may also be limited to the distribution of annual reports and research publications to the managers of technology transfer, without any venue for exploiting the information at the operational level.

When mechanisms do exist at the operational level, they usually do not last long because of a persistent lack of support from top management.

Sometimes there is too great a reliance on one specific linkage function — for example, dissemination of information. In some systems, the only linkage mechanisms are publications and occasional workshops or seminars organized by research; there are none for problem identification, planning of research, consolidation of technologies, or evaluation (feedback) — key tasks for ensuring the relevance of technologies and particularly important in systems serving resource-poor farmers.

3.1.3 Duplication of Effort

Inefficiency is built right into the technology system when the same task is performed by two separate units. This may happen even though their respective mandates call for their contributions to technology development and transfer to be sequential. Duplication of effort occurs most frequently at two stages: problem identification and technology consolidation. What often seems to happen is that farming systems research (FSR) or on-farm research is introduced, even though the national technology system already has its own farming systems projects operating in the same area.

Efforts are often duplicated when donors become involved. This was the case for the potato system of the Philippines, as discussed in chapter 2. Duplication can also stem from poor coordination or mutual lack of confidence in the competence of the various organizations or units in the system. In Costa Rica, for example, technology transfer agents started their own adaptive research because they considered the recommendations from research to be irrelevant. But research continued its trials (Palmieri 1990).

3.1.4 Lack of Cohesion

Consensus on priorities and respective responsibilities is difficult to achieve when research is organized by discipline or commodity and technology transfer by region. Even when both are organized regionally, research is often defined in an agroecological context while technology transfer is defined in an administrative one. This situation requires strong linkage mechanisms such as a coordination committee. Evidence from the study shows that these committees are more effective at the regional level than at the national level. Subject-matter specialists or liaison officers may also be needed. However, in some cases specialized units such as on-farm trial units, research-extension liaison units or pre-extension units may be needed to bridge a wide gap. An underlying problem is that these units create their own linkage problems and may be expensive to operate.

3.1.5 Differences in Legal Status

Differences in the administrative and legal status of research and technology transfer can also be problematic. Frustrations and disenchantment may arise because one organization is unable to meet the expectations of the other due to lack of control over resources or decision-making. This often happens when research is an autonomous organization but technology transfer is part of a ministerial department. While research's status allows it to react quickly, technology transfer may have to seek authorization from policymakers even for straightforward activities. Differences in the legal status of the organizations are often reflected in the professional status of personnel (as seen in salaries and other incentives). This can be a source of tension or conflict, especially when personnel in both groups have the same level of education.

3.2 Attempts to Solve Basic Problems

3.2.1 Merging Research and Transfer

It is widely believed that a good way to solve linkage problems is to merge research and technology transfer into a single institution. Physical proximity, operating under the same management, sharing an institutional culture, and direct supervision are perceived as ways to foster linkages between the two functions (Bourgeois 1990). Many reorganizations of technology systems have been based on these factors, which are thought to promote improved communication and mutual understanding between researchers and technology transfer agents.

The evidence shows, however, that a merger does not always lead to better integration. Even when research and technology transfer are brought together, effective linkage mechanisms need to be established and managed, and a favorable environment created to prevent

intergroup tensions and conflicts. Examples from Colombia (Kaimowitz 1989) and Costa Rica (Palmieri 1991) illustrate this point. In Colombia, researchers' low opinion of transfer agents persisted even when both groups were placed in the same organization in 1968. Tensions intensified as a result of disagreements over resource allocation. (See box 2.) And in Costa Rica in 1985, putting research and technology transfer under the same directorate did not improve integration. Duplication of effort, lack of faith in transfer personnel, and conflicts over the financing of different research programs persisted.

If potential sources of interpersonal and intergroup conflict are not first removed, then indifference or avoidance may turn into open hostility when research and transfer are merged. Furthermore, the ISNAR study encountered many cases where research and technology transfer were not within the same organization or even within the same ministry, and yet a strong level of integration was achieved. The cotton subsector of Côte d'Ivoire

Box 2. Conflicts and tensions in the technology system: the case of the Colombian Agricultural Institute

Relationships between researchers and transfer workers in Colombia's public agricultural technology system have generally been alienating. Even before the formation of the Colombian Agricultural Institute (ICA) in the 1950s, individuals in each group had negative perceptions about the other's role. Extension workers regarded researchers as patronizing, working in ivory towers and not giving due recognition to their contribution. Researchers regarded extension's involvement in adaptive research with disdain.

The two groups had to jointly conduct regional demonstration trials. However, the interaction was reduced to researchers issuing ready-made packages of inputs together with protocols detailing trial designs, sequence, and number of repetitions for transfer workers to implement. Afterwards, they would appropriate the data, analyze it, and publish the results and/or present them on field days. Over the years transfer workers grew resentful of being taken for granted by researchers and adopted a bureaucratic attitude towards joint adaptive research activities. Accuracy in recording slackened, leading to inconclusive results and frequent experiment failures.

When ICA became an independent public institution in 1962, it had three functions: first and foremost, research; second, postgraduate training; and third, technology transfer, which was considered the least important. In 1968, ICA's transfer section was expanded by the incorporation of the extension service from the ministry of agriculture. Relationships between researchers and transfer workers worsened, with researchers rejecting transfer workers as colleagues and regarding them as inferior.

In 1970, ICA set up rural development projects modeled after the Mexican Puebla projects. Under these projects, researchers and project professionals had to collaborate in adaptive research. However, researchers continued to regard project professionals as data collectors even though they both had a comparable level of education. Project professionals complained about researchers' unwillingness to leave their stations and their disregard for socioeconomic variables. They went on to set up their own trials — a move which provoked protest from researchers that it was not the project professionals' mandate or area of competence. For a time they forced the projects to refer to the trials as "technological adjustments" and not research. Disagreements between the two groups led to some projects being left unfinished.

Throughout the brief history of ICA, researchers tended to assume a dominant role vis-à-vis transfer workers whom they did not regard as counterparts, but as subordinates. This was not due to a genuine difference in the attributes of the two groups, but to the prevailing view of research and transfer tasks as sequential or competitive rather than complementary. The strained relationship between the two groups disrupted projects.

(Eponou 1990), where research was conducted in the Ministry of Scientific Research while the transfer agency was located in the Ministry of Agriculture, is a case in point. A high level of integration was also achieved in the maize subsystem of the Philippines, despite the great number of organizations involved and the variation in their administrative affiliation.

Table 3 underscores these observations. It correlates the structural relationship (e.g., merger, proximity of groups, or complete separation) between research and technology transfer with the level of integration between the two groups. What is especially interesting here is that integration of research and transfer was rated as fair to good in only one of the five subsystems in which the two groups had been merged.

Table 3. *Distribution of Subsystems by Structure and Quality of Integration*

Structure	**Fair to good integration**	**Unstable situation**	**Serious linkage problem**
Research and technology transfer in the same organization	**1**	**1**	**2**
Research and technology transfer in the same ministry	**1**	**3**	**2**
Research and technology transfer in different ministries	**3**	**3**	**3**

Source: RTTL case study data

Several factors appear to be far more important in ensuring the integration of research and technology transfer activities than whether the two groups are organizationally merged or separated. These include the overall level of goodwill and cooperation within the technology system, the types of mechanisms used, and how they are managed. Two basic linkage mechanisms, each suited to its context, were used in the cases mentioned above. In Côte d'Ivoire, a contractual agreement was made; and in the Philippines, a coordination committee was set up. All other mechanisms that were to be used, as well as the rules and procedures governing their use, were defined and agreed upon within this framework.

When research and technology transfer are placed in one organization, the system is sometimes too large for effective management. System coordination becomes an issue if proper decentralization measures are not adopted. The Colombian Agricultural Institute (ICA), whose mandate goes beyond purely agricultural activities to include other aspects of rural development, began to suffer size-related problems when research and technology transfer were put in the same organization in 1968. It has become complex, bureaucratic, and difficult to manage. The management needs of research and those of other development activities, such as sanitation campaigns and provision of credit to farmers, cannot be satisfied because they are too different. Furthermore, the geographic divisions based on administrative boundaries, while they may suit the needs of technology transfer, are not appropriate for research (Kaimowitz 1989).

3.2.2 Decentralization

A variety of reasons for decentralization are presented by different authors writing about the organization of agricultural research (Schultz 1971; Ramakrishnan 1985; Wekwete 1990; Rondinelli 1984; Hobbs 1990, etc.). But they all agree that decentralization:

- better serves the local requirements of farmers;
- reduces central administrative overload;
- results in faster response to problems at the operational level;
- improves integration.

Adverse effects of decentralization have included the following:

- poor coordination of research;
- lack of control over research direction;
- deviation from national development goals;
- added administrative tasks and linkage requirements.

Reviews of the subject (Conyers 1984; Rondinelli 1984) have concluded that the results of decentralization are mixed. There is no clear evidence that decentralization has been successful, although Rondinelli (1984) observed improvements in resource distribution, local participation, extension of services to local populations, and project identification and implementation. He qualified his observations by suggesting that decentralization is best attempted on a small scale. Analysis of the ISNAR case material leads to the same conclusion. There is no clear evidence that decentralization leads to better integration. Many decentralized systems lack good vertical linkages, and often face problems of resource management that are caused by centralized decision-making.

The crux of the problem is that the higher levels of government administration and management are reluctant to relinquish control over financial resources. But efficient decentralization requires some degree of autonomy over allocation decisions and processes (Hobbs 1990; Wekwete 1990). Decentralization of personnel to local and regional levels without a parallel shift in authority over resources results neither in improvements in resource timeliness and flexibility, nor in the ability to respond to local needs. Although decentralization can establish information feedback links from the local to the central level and alleviate the central ministry managerial load, this does not ensure that central offices will respond to local needs. Decision-making processes, including the way resources are allocated, may remain the same, thus causing the same delays and conflicts that existed before decentralization.

In some cases, linkage problems at the center have simply been transferred to the regional level because the real causes of problems have not been identified. For example, decentralization cannot by itself improve integration of research and technology transfer, if the source of the problem is poor intergroup dynamics, or lack of sufficient resources. In the latter case, it may even worsen the situation because of the additional resource requirements imposed by decentralization itself. Box 3 provides an example from Costa Rica.

3.2.3 Special Units

Special units have often been used by technology systems to facilitate integration of research and technology transfer. These units include FSR, pre-extension and research-extension liaison services, and training units. Many managers view special units as the solu-

Box 3. The trouble with reorganization: the case of Costa Rica

In 1985 an executive decree from the Costa Rican Ministry of Agriculture and Livestock announced a major reorganization of research and extension. Regional Agricultural Centers were upgraded to Regional Directorates, in effect increasing their authority and autonomy. The intention was to make researchers more responsive to users' needs by having them work more closely with local extension.

Regional Research Teams were formed in 1987 and became responsible for adaptive research on the principal crops of their respective regions. However, the reorganization was not successful. Research topics and objectives remained the same and linkages between research and extension did not improve.

In theory, the formulation of annual research plans was to be a bottom-up process. Regional plans would be sent from the Regional Directorates and Research Teams to a ministry Planning Directorate which would screen them and prepare a coordinated national-level Annual Plan of Operations responsive to regional needs. In fact, the national annual plan was negotiated at a single national meeting between the directors of research and extension. Because the decision making and allocation processes remained centralized, the focus of research efforts at the regional level did not shift to themes more responsive to farmer conditions. Rather, it remained fixed on maximizing yields.

An attempt was made to solve this problem by replacing the integrated national plan with individual operational plans for each region. A Planning Directorate was established to coordinate these. A planning meeting was designed to solicit extension agents' input regarding farmer needs. However, even this approach has not worked. In fact, in 1987-88 the researchers compiled their list of trials before the meeting occurred and extension's participation was limited to negotiating the number of trials.

tion to structural and organizational problems. But the performance of these units has been mixed.

Farming systems units that operate at the technology-consolidation level and perform tasks collaboratively have become the most widespread of such units. Despite their commitment to developing relevant technologies for farmers, FSR teams have encountered the same problems as other research programs when dealing with technology transfer. Effective participation of technology transfer in joint activities is not assured. Disagreements over the sharing of responsibilities and intergroup conflicts exist in many FSR teams. For example, in Guatemala, researchers' low esteem for extension agents, the lack of clear sharing of responsibilities, considerable status differences between research and technology transfer personnel, and research's domination of joint activities hindered linkages between the two groups in the 1970s. The system became effective only after these flaws were eliminated (Ortiz et al. 1991).

Establishing an FSR team cannot, by itself, improve linkages between research and technology transfer. In fact, FSR teams can be the root of other linkage problems that affect overall system performance. For example, linkages may deteriorate because of interference in technology transfer by FSR teams. At the same time, linkage problems can arise within research itself because of the need to share resources and power between on-station research and FSR. Factors underlying linkage problems between FSR and on-station research have been analyzed as part of ISNAR'S on-farm client-oriented research (OFCOR) project

(Merrill-Sands et al. 1991; Merrill-Sands and McAllister 1988). Linkage problems typically occur when the FSR program is funded by donors, but on-station research and technology transfer are without operating resources. The tendency is for the FSR team to expand its mandate and become a "state within a state".

Appropriate linkage mechanisms, such as liaison positions and planning and review committees, are still needed to strengthen linkages between FSR teams and technology transfer. Zambia provides a good example. Linkages between the Adaptive Research Planning Team (ARPT) and technology transfer improved considerably due to the creation of research-extension liaison officer positions and to the involvement of subject-matter specialists and district agricultural officers in ARPT's committee (Sutherland 1988).

The conflict between FSR teams and technology transfer can intensify when the former attempt to bypass the latter. Before it became evident that FSR teams could not replace technology transfer organizations, some research organizations tried to use on-farm research as a substitute for weak extension services (Ewell 1989). This had a negative impact at the farm level and on linkages between research and technology transfer.

The location of FSR units within the agricultural technology system has a bearing on their effectiveness. These units are most likely to succeed if they are part of the core program. The risk of failure is high when they are operated by ad hoc teams or are undervalued by management.

Training, pre-extension, and liaison units have been used in many cases to bridge the gap between research and technology transfer. These units, in spite of their additional linkage requirements, have in general been effective. However, most have been characterized by lack of continuity because of financial constraints. Often they are set up with donor funds but cease to function effectively when the project is over. The agricultural extension-research liaison service set up in Nigeria (Ekpere and Idowu 1991) effectively bridged the gap between research and technology transfer. Both the subject-matter specialist and audio-visual units translated research results into an acceptable form for technology transfer agents. However, because of financial problems, it could not always function properly.

A pre-extension unit has been operating successfully in Burundi in recent years. Its mandate is essentially to produce leaflets for technology transfer agents from research results, to train agents, and to provide feedback to research on the performance of the technologies (Contant and Bourgeois 1989). The unit is effective in spite of its small size — it consists of one social scientist and one agronomist.

Before opting for a "special unit" strategy, managers must assess the availability of local resources. Finding the right people is especially important since the effectiveness of a special unit largely depends on the ability and competence of its staff.

It has also been noted that, unless these units have a clearly defined mandate and authority, they have a tendency to broaden the scope of their activities to the point of losing sight of their original purpose. They can also create their own barriers in terms of language and procedures. Size and scope of the units should be kept to a manageable level. The effectiveness of the above-mentioned agricultural extension-research liaison service in Nigeria dropped drastically when it was given a national mandate. It became overstaffed, underfunded, and poorly linked to research.

3.3 Approaches to Technology Generation and Transfer

So far we have discussed the pros and cons of various means of achieving a high level of integration between research and technology transfer. However, in certain instances such integration may not be needed for the technology system to succeed. Different recommendation domains (for example, commercial farmers versus resource-poor farmers in a given country) require different approaches to innovation, each calling for a different level of integration between research and transfer. For instance, varieties for commercial farmers may be successfully developed and transferred using an approach in which there is a minimum of research/transfer linkages.

Three broad models of innovation can be identified: the "chain-link" model, the linear model, and the participatory technology development model. We turn now to a discussion of the these models and how research and technology transfer interact within them.

3.3.1 The Chain-Link Model

In the "chain-link" model of commercial innovation, as described by Röling and Seegers (1992), perceived potential markets are captured through innovation, testing, redesign, distribution, production, and marketing. Linkages take the form of feedback loops, especially between distribution and marketing on the one hand and units performing other tasks on the other hand. In this model, the systems perspective is fully recognized and is well managed.

This model is often used by commodity subsystems which, owing to a cess on sales of the commodity, generally can afford complex linkages. The cotton subsystem in Côte d'Ivoire (Eponou 1990) and the coffee subsystem in Colombia (Kaimowitz 1989) are the best examples in the case studies. Strong leadership is provided by one of the key actors in the system; it makes no difference whether it is provided by the public sector, a parastatal (Côte d'Ivoire), or a farmer organization (Colombia).

3.3.2 The Linear Model

This model was in operation in a large percentage of national research and transfer systems covered by the study. These systems were set up and functioned according to the principles of the linear model as described by Röling and Seegers (1992):

- Research, as representative of the scientific method, considers itself to be the sole source of technology.
- Knowledge generation, transfer, and use are sequential, but without any interaction or feedback loops.
- There is a science-practice continuum. The sequence is basic research, applied research, adaptive research, action by subject-matter specialists, extension, and application by farmers. The institutions of the system are organized accordingly. There is no need for synergy and there is a clear division of labor: research generates technology; technology transfer delivers technology to farmers; and farmers use technology.
- There is no collective responsibility for the outcome of joint effort, and research does not necessarily see the generation of practical technologies as the required output of its efforts.

Under this model of innovation, then, there is really no partnership between research and technology transfer. Linkages amount to little more than brief communication at the

time research delivers its results to technology transfer. Transfer agents, and to an even greater extent farmers, are excluded from the technology generation process. (See box 4.) The limited use of linkages means that there are few or no feedback loops in the system to ensure that technologies are relevant. However, this is not necessarily a bad thing, for in some cases a highly integrated approach is not needed.

Analysis of the cases shows that the standard linear model has achieved some important results in the case of commercial farmers or when dealing with crop varieties and agrochemicals. However, it has not been successful with all types of technologies, particularly those needed by resource-poor farmers and those that promote sustainability.

Box 4. The linear model at work: the case of maize in Costa Rica

The perception among Costa Rican researchers that cob rot was a major problem for farmers led to the development in 1980 of the LD 8043 maize variety, based on CIMMYT maize population 43. Intended for the humid tropics of Costa Rica, it was developed at the country's Los Diamantes experiment station.

At the time of the ISNAR case study, there had been no specific campaigns or other efforts to disseminate LD 8043 to extension workers or to farmers in the Atlantic Zone. Any extension workers familiar with the variety had heard about it through informal contacts with researchers or seed distribution agents. The seed distribution agency did set up demonstration plots from time to time, but none of the extension workers questioned as part of the ISNAR study had heard about LD 8043 that way.

Less than 6% of farmers in the region used LD 8043 as their major variety in 1988-89, and only 3% as the second. Even those who used it did not adopt the complete technical package recommended for the variety, which meant that LD 8043 could not demonstrate the qualities for which it had been bred.

The costs of the complete package were much higher than farmers were ready to spend and higher than they could get credit for. The price of maize was too low to use the inputs as required. The quality of the seed available through the seed company was considered very low by the farmers. What the farmers wanted was a version of their local Maicema (which can be easily shelled and has a husk which covers the cob) with higher yield and improved resistance to layering.

Researchers blamed extension workers for not having promoted LD 8043 properly. They alleged that extension workers had too many other things occupying them (their work covered all crops grown in the area). Extension, for its part, blamed research for not having carried out any profitability tests on the variety. It is true that no such tests were carried out, let alone in farmers' conditions. One small experiment in 1987, using only three components of the package, showed that farmers' local maize was more profitable, but was blamed on bad management of the extension-run variety plots.

With respect to seed quality, the seed company did not agree with farmers about the criteria to be used for judging quality. The seed company only considered germination, but farmers, who use only the large grains in the centre of the cob as seeds, were also concerned with vigour. An unknown factor was the time period between the production of the seed and its use by farmers. The quality of seed from the seed company was guaranteed for six months and sales agents were supposed to sell their stock within six weeks. But there was no control (Palmieri 1990).

3.3.3 Participatory Technology Development

Participatory technology development emerged as a response to the needs of resource-poor farmers who cannot be effectively served by either the chain-link model or the linear model. It has the following characteristics among others (Röling and Seegers 1992):

- Control over technology development lies with the farmers.
- Heavy emphasis is placed on local or indigenous knowledge and experimentation, with little use of off-the-shelf solutions.
- Catalysts, process managers, or activists play important roles.

In the participatory approach, it is usually adaptive research that is carried out and farmers often have a real influence on the institutions involved in both technology generation and transfer (Eponou and Röling 1992). Linkages between researchers, farmers, and technology transfer are built into the model because all tasks are done collaboratively. However, their effectiveness depends on the quality of the human resources involved.

3.4 Recommendations

No perfect structural or organizational model exists for all situations. Because the context, resource endowment, and the nature of the technologies to be developed and disseminated all affect the system's performance, these factors should be among the criteria for choosing a specific innovation model. But whatever model is chosen, there will always be a need for effective linkage mechanisms, however small their role.

For managers, the challenge lies in selecting a model whose structure, organization, and linkage mechanisms are most apt to ensure an efficient two-way flow of information and knowledge. Restructuring and reorganizing do not necessarily lead to better integration.

One single approach to innovation may not be suitable for responding to all the technological needs of farmers. The widely used linear model, for example, is not appropriate in all circumstances. The chain-link model and the participatory technology development approach should also be considered. Whatever approach is followed, different sets of linkages will be required for different technological needs. The choice of innovation model will depend on the types of problems to be solved, the resources available, and the manager's own capacity to initiate change.

Despite all the claims that the process of technology generation and transfer is synergistic and recursive, managers still perceive it to be fundamentally sequential. They must attempt to change this profoundly rooted perception.

Managers should be selective in establishing or strengthening linkages. They should identify gaps in information and knowledge flow. Tasks to be performed in the generation and transfer process may vary over time and according to the nature of the technology in question.

Objectives, contents, procedures, and timing of linkage events should be explicit for all participants and, in some cases, agreed upon beforehand. Such events could be joint trials, visits, surveys or committee work. It is important that participants perceive each other as equal partners and avoid falling into "master-disciple" relationships, even when the flow of information and knowledge is in one direction, i.e., not reciprocal.

Internal linkages are required within research itself before linkages can be established with technology transfer. Flaws in this respect are often found between FSR teams and on-station research.

Special units may be useful for bridging the gap between research and technology transfer. However, without additional resources and good management, they can actually exacerbate linkage problems or create new ones. The proper functioning of these units demands they be staffed with qualified personnel. Size and scope of activities must also be clearly defined. Donor encouragement over the years to create special units should not lead us to view these units as a guaranty of integration. In some cases, they can be replaced by simple linkage mechanisms, provided that managers change the structure or organization of the system.

Alternatives should always be sought when it becomes apparent that one or more units, for whatever reasons, are unable to perform assigned tasks. The tasks can be divided in various ways among participants. All participants must be well-informed about system activities and agree on the processes needed to perform their tasks effectively.

Decentralization of operations can enhance integration. However, it is important that such a move be accompanied by decentralization of resource allocation and management. Strong linkages should also be established between the central and regional offices to ensure coordination of effort at all levels. The authority and responsibility given to various managers at the regional level must be clearly and consistently defined.

4. RESOURCE ISSUES FOR LINKAGES

Various aspects of human, financial, and physical resources influence the level of integration between research and technology transfer. Evidence from the ISNAR study shows that the quantity, quality, and management of resources are sometimes the source of linkage problems, particularly non-operational linkage mechanisms and ineffective linkage mechanisms (see chapter 3). Although resources such as equipment and information are important, this chapter deals with the most fundamental resources in a system: people and money.

4.1 Human Resources

Four important issues are analyzed in this section:

- motivation and rewards;
- management of time allocated to linkages;
- managerial capacity;
- human resource mix.

4.1.1 Motivation and Rewards

A striking phenomenon in most of the technology systems studied is the flagrant incompatibility between professional reward systems and organizational goals. While the raison d'être of most of the publicly-funded research systems is to generate relevant technologies for farmers, their employee reward systems do not reflect this. In some cases, researchers who devote their efforts to technology development or to establishing linkages with technology transfer may even be penalized.

Promotion and peer recognition are perceived by researchers as the most important professional rewards. What criteria are used to assess and reward researchers?

In many of the technology systems studied, promotion is officially based largely or solely on the number of scientific articles published. Practical pamphlets and bulletins aimed at technology transfer agents and farmers are given little attention by managers. Moreover, no specific mechanisms exist to encourage researchers to produce this type of information. For example, in a few countries in French-speaking Africa the promotion system for publicly-funded researchers is modeled on that of universities. Indeed, university professors are often called on to evaluate researchers.

Peer recognition is based on a researcher's scientific publishing record, as well as on participation in scientific seminars, conferences, and networks. Researchers gain little or no peer recognition from working effectively with technology transfer. None of the systems studied has awards or events to mark high achievement in technology development or good collaboration with extension.

Even though researchers acknowledge the importance of linkages (Ekpere 1991), they do not always perceive them as their responsibility. The linkage activities that they are most likely to engage in are those that further their personal aims. Workshops and training of transfer personnel, for example, may be preferred because they help to give researchers a scientific profile.

In some systems the situation is aggravated by financial problems. Salaries, low to begin with, have been eroded by high inflation. The monthly pay envelope is not only insufficient to cover basic needs, it is also too often late. The morale of both researchers and technology transfer workers in such circumstances is low and they may have to resort to alternative sources of income. Researchers for example, sometimes drive taxis or operate their own farms. Low salaries obviously make the option of producing scientific publications more attractive because a good publishing track record is needed to leave the system for a better job.

Low morale among personnel leads to high turnover. This hinders the formation of informal linkages, often instrumental to integration when formal mechanisms are nonexistent or do not function well (Eponou 1990).

In Côte d'Ivoire for example, the coordinator of the R&D program of a regional project and the head of the field trials unit of the research institute in the same region had established an informal but effective working relationship. Technologies were successfully tested and transferred to farmers despite the fact that contractual arrangements between the institutions had been nullified. The subsystem achieved a high degree of integration at the operational level and made relevant technologies available to farmers. But both the level of integration and the performance of the subsystem dropped sharply when one of the two individuals involved was replaced (Eponou 1990).

4.1.2 Planning and Time Management

For linkages to work effectively, the time devoted to them should be carefully planned to avoid improvisation and lack of continuity. Moreover, linkage mechanisms that inherently optimize the use of time should be chosen.

Lack of continuity and the need to improvise may be due to the following:

- Participants in the system are insufficiently prepared for linkage work.
- The financial and/or human resources needed for the selected linkage mechanisms or events are not available.
- The mechanisms chosen may not be perceived as appropriate by others. Full participation is more likely if all partners agree, in advance, on the mechanisms to be used as well as the timing of events.

Some of the basic requirements of horizontal cooperation are identification of objectives, understanding of tasks to be carried out, awareness of one's role and that of the other participants, and adoption by consensus of compatible approaches (Gastal 1987).

Evidence from the study shows that, in general, planning of linkage activities is common. But the need to improvise and lack of continuity still plague many systems because of erratic funding, uncertainty as to the timing of release of funds, and problems related to donor involvement.

The ISNAR study found that there was no relationship between the number of linkage mechanisms in the system and the level of integration of research and technology transfer. It seems that in some cases, time was wasted because the mechanisms could not be properly used or were inappropriate. Integration between the two groups is not enhanced, for example, when researchers set up meetings to brief transfer personnel on research proposals, but without requesting their input as to the relevance of the proposals. Technology transfer is bound to question the usefulness of such meetings. Farming systems research (FSR), on-farm research, and, more recently, participatory action research have been advocated and

prescribed by donors. These may not be appropriate for all types of technologies or farmers (Bernardo 1991). There have also been debates over the effectiveness of the conventional training and visit (T&V) extension system which calls for special linkage mechanisms, particularly in complex and diverse farming systems such as those of the rain-fed agricultural areas of Africa (Gentil 1987; Russell 1987; Howell 1988). In addition to the financial requirements of T&V, the administrative effort of arranging meetings throughout the country on a regular basis has been questioned (Howell 1988). Using T&V as a way of strengthening linkages in some systems may be a waste of time because of the conspicuous lack of qualified manpower and financial resources.

4.1.3 Managerial Capacity

As underlined by Nickel (1989), many technology systems are forced to fill vacant management posts with research scientists who have little or no management experience. Because of poor management training programs, many managers lack the essential skills for running a research organization, including those for managing linkages. They are unable to provide leadership, to build a team, to communicate effectively, or to deal with conflicts (Bennell and Zuidema 1988). Matching the interests of researchers with those of the organization and reconciling divergent scientific views are a real challenge for many managers.

Individual personality problems have been reported as a source of poor linkages (Akinbode 1974). Personality clashes were not directly addressed in the study, but in one case difficulties arose because of the authoritarian management style of certain individuals. This alienated members of the research organization who refused to obey directives, including those related to linkages. The same people, however, cooperated with the technology transfer organization if they were approached informally.

4.1.4 Human Resource Mix

Technology generation and transfer are a social process involving actors with different personal attributes, attitudes, behaviors, motivations, interests, and goals. Individuals have different professions and positions with varying levels of prestige and incentives. They also belong to groups or organizations that do not necessarily have the same status, authority, and resources. Personal attributes, as well as professional and organizational differences, have been identified as factors contributing to poor linkages between research and technology transfer (Bennell 1989; Seegers and Kaimowitz 1989; Wuyts 1992).

If the mix of human resources in a technology system is not right, people may be unwilling or unable to cooperate. Group competence, in particular, is an important factor in carrying out linkage activities (Bennell 1989). Basic tasks such as gathering information on farmer problems or providing feedback to research on transferred technologies may not be properly performed because technology transfer agents are poorly trained in reporting procedures. Researchers may not be able to make information understandable to technology transfer agents because they have never been trained to communicate scientific results to nonscientists.

Differences in educational level are often mentioned as a source of linkage problems. The assumption is that the education gap between research and transfer personnel prevents the two groups from working together effectively; tensions thus arise or members of the two groups avoid each other. It is also assumed that technology transfer agents are not suffi-

ciently well educated to serve as partners in joint trials or surveys and that researchers are unable to communicate properly with them.

Contrary to these assumptions, there was no evidence from the case studies to suggest that conflicts or tensions are generated specifically by educational gaps. In fact, the cases show that conflicts and tensions exist even between researchers and technology transfer agents with similar educational backgrounds. Dandhan (1984) reports a case from Thailand where tensions increased when the educational gap was narrowed. In Colombia (Kaimowitz 1988) and Costa Rica (Palmieri 1990), both groups were reported to have the same level of training, but relationships were characterized by tension and open conflicts. By way of contrast, in Côte d'Ivoire no tensions existed in two different situations where there was a marked educational gap (Eponou 1990).

In most technology systems, researchers have more status than technology transfer agents. There is often a "pecking order" of occupations, reinforced by the general perception that researchers are the "white collar" workers who alone are capable of identifying, analyzing, and solving farmer problems. Technology transfer agents are perceived as the "blue collar" workers who mechanically deliver the product of research to farmers.

Colombia and Costa Rica provide two examples. In 1970 the Colombian Agricultural Institute (ICA) set up rural development projects where researchers and transfer agents were to collaborate on adaptive research. Because of disagreements between the two groups, the transfer agents set up their own trials. The researchers protested and forced the transfer agents, for a time, to refer to the trials as "technological adjustments" rather than research (Wuyts 1992). In Costa Rica, prior to 1985, an annual operational plan for research and technology transfer was prepared collaboratively by researchers and transfer agents for the basic commodities and regions of the country. As an input to the plan, technology transfer submitted lists of problems in each region. Researchers claimed that they had been compiled without a scientific methodology and refused to use them (Palmieri 1990).

Status differences are reflected in incentives. Researchers having the same level of education as transfer agents often have a higher salary and more opportunities for additional training and sabbaticals. In many cases, credit for the system's achievements accrues to research only. For example, technology transfer may not have the means to disseminate technological information on its own. It may also feel pressure from policymakers to deal with specific production problems and may find itself powerless to influence the orientation of research programs because the overall national agricultural system does not provide mechanisms for such input. This obviously frustrates technology transfer agents. The most common expression of their dissatisfaction is to question the competence and motivation of researchers and the relevance of their results.

For their part, researchers are sometimes outraged by a bias in resource allocation in favor of extension. Their resentment is expressed by questioning the competence and usefulness of technology transfer.

The ISNAR study found that tensions and conflicts originate at the policy level and should therefore be addressed at that level. They result from the distribution of power, authority, and resources and from perceptions of prestige and status (Wuyts 1991) among the organizations in the technology system.

Most technology systems have a limited number of qualified scientists and transfer agents. It is usually the best of these who are assigned coordination and other linkage tasks. This tends to overload them and may interfere with technology generation work.

The threat of overburdening the technology system has become more serious with the multiplication of networks and the involvement of participants, such as nongovernmental

organizations (NGOs). There is a risk in some cases of overemphasizing linkages **within** research at the expense of linkages **between** research and technology transfer.

4.2 Financial Resources

There are five major financial issues related to linkages:

- availability of funds;
- management of funds;
- compatibility between system financial resources and linkage requirements;
- balancing resources among institutions and units of the technology system;
- contractual arrangements.

4.2.1 Availability

Access to resources is one of the most critical factors determining institutional strength. National governments and donors are the major sources of funding. Contributions from the public sector, the most conventional way of financing technology development and transfer in developing countries, are determined by the level of economic development of, and support given to, the agricultural sector within the overall national economy. Donor contributions, by contrast, are more a function of linkages between donors, the public sector, and the institutions of the technology system.

In general, a high level of financial resources has a positive effect on linkage mechanisms because it allows for more than one mechanism to perform the same function, thus increasing the chances of achieving integration. The best illustration of this from the ISNAR study is the built-in redundancy mechanisms in the coffee subsystem of Colombia. The provision of back-up mechanisms may not be an efficient use of resources, but it seems to be effective and is a "respected administrative technique for ensuring against administrative breakdown in the process" (McDermott 1987).

Evidence from the case studies shows that in subsystems where operating funds are scarce, funds for linkages are among the first to be cut. For example, in the cowpea and cassava subsystems of Nigeria, the operating budget of the Agricultural Extension-Research Liaison Service (AERLS) was cut when the subsystems were under severe financial constraints (Ekpere and Idowu 1990). The subject-matter specialist positions in Sri Lanka and Colombia were eliminated when external funds were no longer available (Seegers 1990; Engels 1989). Carrillo and Groot (1990) listed scarcity of resources as one of the major factors contributing to poor linkages between research and extension in the Atlantic Coast region of Costa Rica. As a result, trials were not always finished, or results were published too late.

Competition for resources is likely to occur when there are serious resource limitations. Competition for donor funds is also likely to occur when resources are limited and institutional mandates are poorly defined. In order to operate under these conditions, institutions are forced to adopt an opportunistic management approach, redefining their mandates and programs according to donor priorities. This leads to duplication of effort and gaps since all organizations are willing to undertake activities for which financial resources are easily obtained. In short, domain consensus and correspondence are more difficult to achieve when resources are limited.

Limited resources may lead to competition and even to open conflict between research and transfer, whether they are in the same or separate institutions. This was observed in the case of the ICA subsystem of Colombia (Kaimowitz 1988). The budget allocation process normally underlies such difficulties (Eponou 1991).

It is important to stress that under certain conditions availability of resources may hinder recognition of interdependence and willingness to follow through on agreements. In the potato system of the Philippines, for example, the availability of separate donor resources to two national institutions created conditions conducive to unnecessary competition and duplication of effort (Francisco 1990).

4.2.2 Management

Linkages require good management of financial resources. Managers must:

- recognize the importance of linkages;
- budget for linkage mechanisms;
- be flexible in using resources;
- make resources available in a timely manner.

Technology systems characterized by these managerial practices were found to be more integrated than others. Commodity-based or special-project systems typically have these characteristics.

Poor management of linkages can arise when decision-making is not concentrated in one unit or when attitudes toward financial resources are inflexible. The poor interinstitutional linkages that characterize developing-country bureaucracies often cause delays in delivering financial and physical resources. Flexibility is essential in decentralized systems where financial resource management remains at central headquarters.

The flexibility found in highly integrated subsystems gives room for maneuvering to deal with contingencies. These systems not only set aside funds to deal with emergencies, but are also flexible enough in their resource management to take on whatever tasks or investments are required to develop and transfer technology to farmers.

Lack of flexibility in resource management is sometimes reflected in the timing of the release of funds. Institutions or units may not have access to resources when they are most needed because of overly bureaucratic administrative regulations. Linkage activities would have been suspended in the Nariño subsystem of Colombia, for example, had it not been for a Dutch-funded project stepping in to finance travel expenses of specialists, printing of extension materials, and production of audiovisual material (Engel 1989). (See box 5.)

Overly bureaucratic financial management regulations seriously hinder effectiveness either by damaging motivation or delaying actions. In many French-speaking countries of Africa, per diems are paid only after an assignment is completed, and payment often takes several months. This makes researchers reluctant to travel. When they are willing to travel, it can take many days before their travel authorization is signed. In some cases, the paperwork is ready only after the event has taken place. These problems were mentioned by researchers from some of the subsystems in Côte d'Ivoire as serious constraints to effective linkages with technology transfer.

Resources are sometimes theoretically available but, in reality, not accessible for operational purposes. Finances may be allocated purely as a token gesture. Salaries may be delayed causing personnel to engage in outside activities which leave little time for linkage-related work.

Box 5. Bridging the gap with donor funds: the case of the Dutch-supported agricultural project in Colombia's Nariño Province

During the 1970s, the Colombian government launched an integrated rural development project in Nariño Highlands Province. At one point, in the early 1980s, the research component of the project began to suffer financial difficulties. Fortunately, the Government of the Netherlands was able to provide contingency funds to cover some of the operational costs of research-extension linkage activities, as well other components such as credit and agricultural inputs for farmers.

In the case of linkage activities, the funds were used to cover, among other things, the production of audiovisual aids and printed extension materials, as well as travel expenses for subject-matter specialists. The provision of these funds at exactly the right moment contributed greatly to the positive impact of the project on the farmers.

An in-depth analysis of the situation reveals three important factors contributing to linkage-funding problems: a) the total allocation to technology systems; b) the structure of the budget; and c) the choice of linkage mechanisms.

a) This is well documented. Few developing countries allocate more than 1% of their agricultural gross domestic product (AgGDP) to research (Pardey and Roseboom 1990).
b) Evidence from the case studies shows that in systems where linkage mechanisms are not budgeted as separate items, the costs related to linkages are the first to be cut when financial resources become scarce. As a result, these systems are characterized by fluctuations in the effectiveness of their linkage mechanisms. The structure of budgets is often such that salaries account for 90% of the total budget leaving very little for operational expenses. Under these conditions, either total financial resources must be increased or the scope of activities must be drastically reduced for the system to be able to finance its linkages. Both are difficult decisions faced by managers. It seems that in many cases managers prefer not to finance linkages at all. They may not be aware that, by doing so, they reduce the effectiveness of the system.
c) Technology systems often choose linkage mechanisms that are beyond their financial means and therefore not sustainable. This results in fluctuations in the performance of linkage mechanisms.

4.2.3 Compatibility between System Financial Resources and Linkage Needs

Linkage mechanisms are often set up without an assessment of the financial capabilities of the system's component organizations. Very often the mechanisms are established with donor resources. When these are no longer available, linkages cease to function properly. In some cases, it has to do with the complexity of the linkages set up in the system. In other cases, the system simply cannot support any mechanism on a steady basis. For example, in most of the case studies ordinary costs such as transportation, per diems, publications, joint trials, and seminars and workshops related to linkages were paid by donors. One basic question not addressed by the ISNAR study is how research and technology transfer can link effectively in a context of very limited financial resources.

4.2.4 Balancing Resources among Institutions and Units

Technology development and transfer are not always perceived as components of a single system with a common goal. When it comes to financing, they are perceived as two separate systems, independent of each other or acting as substitutes for each other. One may be well financed while the other receives insufficient resources to cover even operating costs.

There is no rule for allocating resources between research and technology transfer. Top-level managers may be able to improve the balance by making the amounts allocated to research and technology transfer interdependent. This could be done by having a single, medium-term plan for both components. Making resource decisions based on such a plan could be one way to integrate the two functions and ease competition for resources.

Many of the case studies revealed situations where the system could not operate effectively because one component, either research or technology transfer, lacked adequate resources for its proper functioning. This situation was even more common among donor-funded projects. When planning projects or research programs, managers rarely assess the ability of their counterparts to respond effectively, given resource constraints on them.

An important phenomenon noticed in the case studies is what Ekpere (1991) refers to as the fluctuating situation in assuming responsibility for linkages. No one institution in the system is specifically charged with establishing and managing linkages. In the cassava subsystem of Nigeria, for example, each institution took on a linkage function when it happened to be convenient. The situation could improve if senior management were to assume responsibility for financing basic mechanisms unlikely to be covered by any of the institutions.

4.2.5 Contracts

Contracts and other financial agreements are ways of dealing with imbalances in resource allocations. There are few formal mechanisms for allocating resources between research and technology transfer, but financial agreements are the most common and seem to be effective. They have several advantages:

- They allow research and technology transfer to establish a contractor-client relationship, giving the latter a greater say in the research agenda.
- They clearly define the mechanisms to be used and the program for their use.
- The contractor often provides the leadership needed to ensure linkages in the technology system.
- Accountability and security for funding are built into the system.

The cotton subsystem of Côte d'Ivoire provides a good example of a successful contractual arrangement that has built and maintained strong linkages for more than 30 years. (See box 6.)

However, financial agreements can have shortcomings. They may bias the research agenda in favor of special groups, especially commercial farmers. They may create dependency between institutions, thus hindering creativity in approaches to research. Finally, they are more likely to be viable for executing R&D on marketed products, and thus may be of little benefit to resource-poor farmers.

Box 6. The benefits of financial agreements: the case of Côte d'Ivoire's cotton subsystem

The Compagnie Ivoirienne de Developpement Textile (CIDT), the Ivorian cotton development agency, has signed a financial agreement with the industrial crops department of the Institut des Savanes (IDESSA), the regional research institute. Through that agreement, IDESSA provides CIDT with technological backup. The two institutions work closely — from research planning to technology release. Planning meetings, technical committees, joint trials and field visits, and liaison positions, all defined under the agreement, are used as linkage mechanisms.

All IDESSA's operating costs for technology development and linkages are covered by CIDT through a cess on cotton revenues. The interesting element of the agreement is that the funds annually made available to IDESSA for cotton-related research are tied to cotton revenues. The more effective IDESSA is in meeting CIDT's technological needs, the greater the financial resources it gets for research on cotton.

Owing to this agreement, cotton is the subsector that has experienced the most noticeable success as far as small producers are concerned. Cotton yield has more than tripled over the last 30 years in the savannah zones of Cote d'Ivoire (Eponou, 1990).

4.3 Recommendations

Reward systems currently in use are not compatible with the mission and goals of technology systems. If performance of these systems is to be improved, top management should redefine the mission and goals, and design new reward systems that focus on technology generation and transfer. Linkages with technology transfer must be an explicit component in the job description of researchers. Part of the solution must come from policymakers.

Sabbaticals, training, and promotion must be based on the relevance and effective use of technologies, rather than on the number of scientific publications. National prizes for high achievement in both effective technology generation and transfer could be offered to boost the interest of researchers. Given the financial constraints faced by many systems, donors could contribute by changing their own criteria for selecting fellowships and awarding scholarships.

Managers at the operational levels must keep work focused on the stated goals of their organization and identify factors that could divert participants away from them.

The mix of human resources is important. Managers should analyze their systems and identify the types and numbers of employees needed for effective generation and transfer of technology. This means managers need to be given a freer hand in human resource management than they currently have.

Status differences cannot be totally overcome, but they can be minimized by changing the reward system. Some form of competition is inevitable but this should be kept to a minimum by improving the resource allocation process. Managers at all levels of the system must be aware that technology generation and technology transfer are two elements of the same mission, that is, making relevant technologies available to users. Such a mission is only feasible if both elements function cooperatively. At the system level, managers can ease tension by encouraging joint activities and giving credit to both research and technology transfer for the system's achievements.

Differences in the educational background of research and transfer professionals can sometimes be so wide that cooperation between the two cannot be managed using isolated linkage mechanisms. Communication and direct collaboration are difficult because either one or both groups are incapable of dealing with the other. Managers must be aware that the special units needed in such cases require additional resources. The success of such units also greatly depends on the quality of the human resources.

Exchange and secondment of personnel are good mechanisms for improving linkages but are rarely used. Formal financial agreements can be an effective linkage mechanism between research and technology transfer. They allow for technology transfer's input to the research agenda. Unfortunately, they cannot be used for all commodities.

Responsibility for financing linkages is not always clearly defined. Joint planning and budgeting of research and technology transfer may improve the situation. In some cases, senior managers must ensure a minimum level of integration by directly managing the resources needed for basic mechanisms. This can lessen the competition for resources that often results in poor linkages.

Linkage activities must be carefully planned and managed so as to ensure the most efficient and effective use of the financial and human resources allocated to them. These resources should be used with flexibility. It is important for managers to identify potential problems and choose mechanisms that are likely to avoid them. The choice must also take into account the resource endowments of the participating groups. For, if the cost is too great for any of the parties, the mechanisms may not work.

There is no one formula that can be used everywhere to solve linkage problems. Managers may end up using their financial resources unwisely if they adopt mechanisms and approaches without first assessing their relevance and the capacity of their system (and not just one organization in the system) to use them.

Many donor projects have failed because the factors noted above have not been taken into consideration. Often, one component has been financed with no assessment made of the goals, capacity, and available resources of the other component. Donors have often prescribed the use of FSR teams and the T&V approach to transfer, for example, without first checking their relevance and usefulness, as well as the capacity of the systems to bear the costs once donor funds and human resources are no longer available. It is in the interest of both donors and managers of the technology systems to properly assess these issues before any strategy is chosen.

Research and technology transfer are not always perceived as two components sharing a common goal — that of making relevant technologies available to farmers. This leads to an imbalance in financing.

The financing of linkages is often given low priority due to budgetary problems or to a lack of awareness of the role of linkages in a system. Sometimes the elimination of funding for linkages is simply the easiest solution. Limiting the scope of research activities is a better alternative than eliminating funding for linkages.

Funds need to be earmarked for linkages, with specific activities identified in the budget. Some flexibility should also be given to managing these funds in order to deal with contingencies.

The technology systems serving poor farmers require more linkages and more resources for linkages than those serving commercial farmers. The human skills needed to make these linkages work are also greater. Because most systems cannot meet these requirements, they have been ineffective in serving poor farmers. The problem does not lie in the linkage mechanisms themselves, but in their proper application.

Donor-funded projects have shown that whenever resources are available, the performance of these technology systems is enhanced. If relevant technologies are to reach poor farmers, donors should make greater commitments to increasing knowledge of their diverse production systems and to creating a greater technology span for them. It is unlikely that technology systems serving poor farmers can use their own financial, managerial, and human resources to establish and operate the kind of linkages needed to induce beneficial change in developing-country agriculture.

5. MANAGING LINKAGE MECHANISMS

The more knowledge and understanding managers have of linkage mechanisms, the better their chances of establishing and sustaining the appropriate mechanisms for their particular system. This chapter analyzes frequently used linkage mechanisms. We first present a typology of mechanisms based on their function. We then discuss the effectiveness of selected mechanisms using illustrations from the case studies.

5.1 Typology of Linkage Mechanisms

In the context of this study, a linkage mechanism is defined as **any structural or managerial device or procedure used to enhance the complementarity of technology generation and transfer processes.**

Linkage mechanisms can be grouped in various ways: by form (e.g., media), by task (e.g., seed multiplication), by degree of formality (e.g., ad hoc versus formal committee), by managerial level (e.g., field trial team), or by function (e.g., collaborative task). A typology by function is presented here because it is more relevant for managers who must regularly assess the performance of linkage mechanisms and take corrective action if necessary. A similar typology was developed by Merrill-Sands and Kaimowitz (1991).

Research and technology transfer institutions, managers, units, or personnel may link with each other for six broadly defined functions:

- planning and review;
- collaborative activities;
- exchange of resources;
- dissemination of knowledge and information;
- evaluation and feedback;
- coordination.

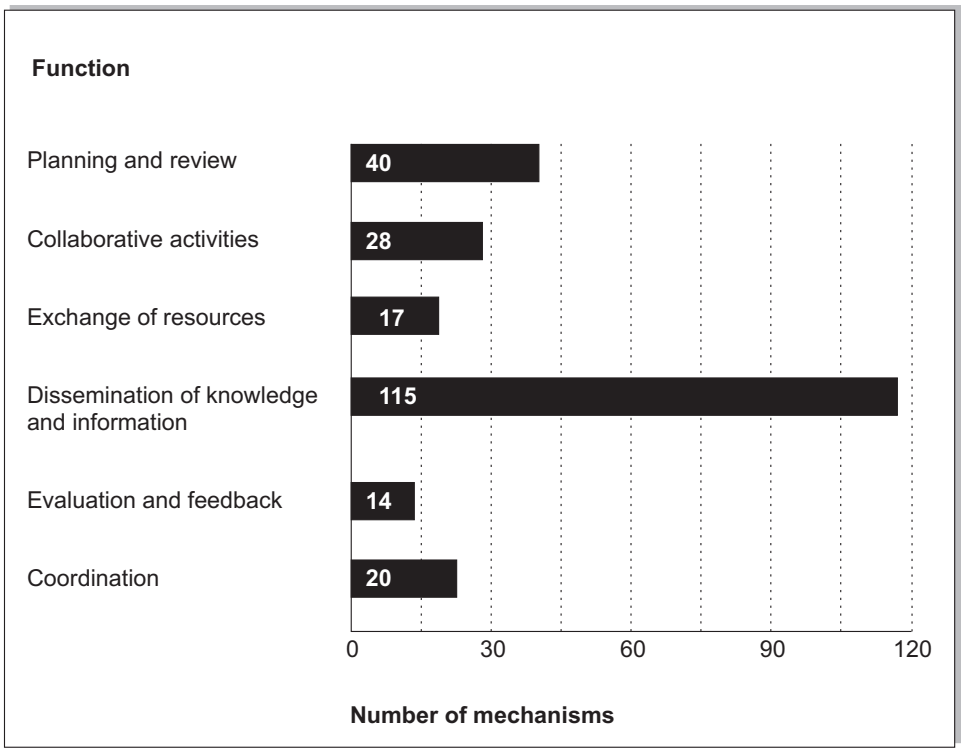
There is a certain amount of overlap between these categories, but the typology is useful in describing the main functions of linkage mechanisms. Specific mechanisms may be used for each function as shown in table 4. Some mechanisms can be used for more than one function. This is the case for committees, meetings, and surveys.

Figure 2 shows the breakdown of linkage mechanisms by function (i.e., their purpose) for the 20 subsystems covered by the ISNAR study. The subsystem, as defined earlier, is a set of agricultural research and technology transfer institutions involved in the development and transfer of technologies for a particular “domain”. A domain can be a commodity, a region, a specific group of farmers, or a research topic (Eponou and Wuyts 1991). The percentages were estimated using the profiles of linkage mechanisms submitted by the national researchers. The purpose of the mechanisms was one of the variables describing them. Dissemination of knowledge and information seems to be the most important purpose for linkages between research and technology transfer in the case studies, given the dominant role of publications as a mechanism (Eponou and Wuyts 1991). Feedback is the least frequent function, while resource allocation and coordination combined have the same weight as planning and review.

Table 4. *Linkage Mechanisms Used for Specific Functions and Interactions*

FUNCTION	INTERACTIONS	MECHANISMS
Planning and review	• input from both research and transfer to problem identification • program formulation and evaluation • agreement on the priority domains and a consensus on responsibility sharing	• joint problem identification • joint priority setting and planning committees or meetings • joint programming and review committees or meetings • joint technology release committees or meetings
Collaborative professional activities	• combine expertise of both research and transfer for specific tasks in order to enhance efficiency and/or effectiveness • exchange of expertise or knowledge between parties for a smooth transition between sequential tasks	• joint adaptive or demonstration trails • joint surveys • joint field visits
Exchange of resources	• exchange of financial and human resources to enhance the capacity of one or both parties • establish a "contractor-client" relationship in order to obtain a set of precise products	• financial agreement • contract for services • exchange of personnel • staff rotation and secondment
Dissemination of knowledge & information	• exchange of knowledge and information	• publications • reports • demonstration trials • field days • audiovisual materials • training • seminars and workshops
Feedback	• get information on performance of transferred technologies	• evaluation surveys • evaluation meetings • evaluation field visits • publication of reports by monitoring and evaluation teams
Coordination	• coordinate the tasks of the flow of information between institutions or units	• coordinator positions • research-extension liaison positions • subject-matter specialists

Figure 2. *Number of mechanisms observed for each linkage function*



Note: The number of recorded linkages for all 20 subsystems was 234.

Even though dissemination of information is, overall, the most common function of linkage mechanisms, there are some differences among countries. For example, in Nigeria and Tanzania coordination is the second most important purpose of linkages, while in Colombia and Costa Rica, it is the least important. Collaborative tasks seem relatively more frequent in the three Latin American countries (Colombia, Costa Rica, and the Dominican Republic) than in Nigeria. In the Philippines, feedback, planning and review, and resource allocation are of the same importance. Differences in function have some bearing on the types and causes of linkage problems encountered in the systems (Eponou and Wuyts 1991). They reflect different stages of development of the technology systems: Some systems are dealing with basic issues of how to link, while for others the main problem is how to operationalize the mechanisms given the system environment and context.

All six functions are important for generating and transferring relevant technologies, particularly those for resource-poor farmers. But merely having mechanisms in place between research and technology transfer is not sufficient. To be effective, they must also be appropriate and properly managed.

The study found that in some subsystems linkage mechanisms were not always in place to perform all these functions. Causes and consequences of the absence of linkage

mechanisms or of their inappropriateness have been discussed in previous chapters. In many cases where they were available, they were not effective for managerial reasons (Eponou and Wuyts 1991).

5.2 Effectiveness of Selected Linkage Mechanisms

It is difficult to generalize about the conditions under which a given linkage mechanism works effectively. This is because the behavior of a particular mechanism depends on the complex set of factors peculiar to the agricultural technology system or its subsystems. The policy environment, the political/bureaucratic structure, and the structural conditions of the country (for example, infrastructure and resource endowment) heavily influence the functioning of linkage mechanisms since they determine constraints and opportunities.

Frequent and recurring factors have been observed that prevent managers from achieving goals and objectives when specific mechanisms are used. For example, joint planning (the function) may be perceived as important for getting input from both research and technology transfer (the interaction) to develop a research agenda (the objective) and to enhance the relevance of technology to farmers or make research address development priorities (goal). However, merely setting up a joint planning committee (the mechanism) does not guarantee that the objective or the goal will be achieved. Why do such committees often fail? Is it because they are not an appropriate mechanism for those particular technology systems? Or is it because they are not managed and used properly? These questions could be asked about each linkage mechanism since each has strengths and weaknesses. To simplify the presentation, we will analyze groups of linkage mechanisms rather than individual ones. Again, grouping them by function is appropriate.

5.2.1 Function 1: Planning and Review

Joint planning and review mechanisms (see table 4) have a specific objective as well as an overriding (or "superordinate") goal. The objective is to obtain technology transfer's concrete input to technology design; the superordinate goal is to meet the technological needs of farmers — a goal which neither party can achieve on its own. Two basic assumptions underlie the use of joint planning and review exercises:

- Researchers' knowledge of the conditions under which farmers operate is sometimes limited, especially when the research system serves an environmentally diverse area. Technology transfer workers, being professionally closer to farmers, have a better knowledge of the constraints and needs of farmers. They can therefore provide researchers with valuable farmer feedback on technologies.
- Research and technology transfer share a superordinate goal and see the relationship between one another as cooperative interdependence.

In reality, joint planning and review are not always effective. There are several reasons for this:

- The second assumption is a fallacy.
- Mechanisms are used improperly.
- Technology transfer is often inadequately represented.
- There are status differences and intergroup conflicts.

Fallacy of the superordinate goal

Lack of a clear mandate for research and technology transfer, competition for resources, poor coordination of donor involvement, and conflicts between researchers and technology transfer agents hinder the emergence of a superordinate goal shared research and technology transfer.

ISNAR's case studies suggest that the existence of a superordinate goal shared by research and technology transfer is the exception rather than the rule. Managers must always seek to address the divergence in interests between research and technology transfer institutions in order to build a consensus on the critical domains that the technology systems must deal with.

Improper use of mechanisms

The mechanisms used for joint planning and review may be poorly implemented because organizational and managerial problems are not adequately addressed. Flaws were observed in the following areas:

- Objectives: The objectives of using the mechanisms are not clearly specified. For example, although the cocoa subsector of Ghana has a scientific committee in which representatives of cocoa transfer participate, the committee has no clear mandate. Extension representatives have no role on this committee, which actually discusses technology generation issues (Annor-Frempong 1988).
- Authority: It is often unclear whether the committee is a decision-making body. For example, the integrated rural development program of Nariño in Colombia has a Departmental Technical Committee to provide technical backstopping and ensure participation of institutions and farmers in departmental planning efforts. The committee consists of department directors who meet monthly to decide on resource allocations and to exchange views on agricultural development issues. In 1983 it organized a planning workshop to determine departmental priorities for crop and animal production. The mechanism, however, was not totally effective because the committee's decisions required the later agreement of the participating directors' superiors (Engel 1989). In contrast, the committee for on-farm research and extension (COFRE) in Zimbabwe has been successful as a priority-setting body because it has decision-making power (Shumba and Fenner 1989). The coffee growers federation of Colombia, the subject of one of the case studies, provides a good example of how decision-making power is vested in the appropriate body. Different committees are used for different functions. Macro-level technology policies are set by the Coffee Congress, Coffee Conferences, and the Federal National Committee. The broader technical issues are discussed by the technical subcommittee of the National Committee. The technical division directors meet every two years to discuss how to implement the decisions made by the higher bodies of the Federation. Mandates, responsibilities, and authority are spelled out at each level of the planning process (Kaimowitz 1988).

- Operating rules: Even when a committee is vested with substantial authority, its operating rules may be too loosely defined or give too much control to one party — research or transfer — allowing it to pursue its own interests. This situation is common in systems where meetings are used as planning mechanisms. In many instances, researchers come to the meeting with proposals already written and are unwilling to incorporate changes (Seegers 1990; Palmieri 1990). The meetings are merely the means by which research informs technology transfer of its plans. In some cases the same exchange of information could be achieved by simply sending the proposals to technology transfer personnel. Apparently, researchers are only open to suggestion if technology transfer is willing to contribute financially to the implementation of the proposals.
- Agendas: Meeting agendas may not be clearly defined. Many topics are broached but none is discussed comprehensively. As a result, the meetings do not produce explicit recommendations.
- Size: The meetings may be too large for effective interaction.
- Stability of membership: Representatives of either research or technology transfer may change too frequently to allow the development of a good working atmosphere in the committee or meetings.
- Resource scarcity: The mechanisms are too costly or the system does not have the resources required to use them.

To ensure that linkage mechanisms are properly used, research and extension managers must deal with organizational problems. They need to:

- clarify and agree upon the objectives of the mechanisms used;
- set up operating rules that allow a true exchange of information among all participants;
- limit the agenda of meetings to a manageable size so as to permit in depth discussion of programs and results and to ensure that decisions are reached based on the discussion;
- choose appropriate participants and limit their number to increase interaction;
- minimize turnover of participants.

More authority needs to delegated to technology system managers in order to enhance the power of planning and review mechanisms. Policymakers should provide the resources required for an effective use of the mechanisms.

Inadequate representation of technology transfer

In problem diagnosis and meetings for program planning and review, technology transfer is often represented either by top-level bureaucrats unaware of the real needs and problems of farmers or by field-level transfer workers unable to communicate clearly. In either case, research does not get the right information. We have identified two effective strategies.

The first can be referred to as the **two-stage meeting**. In some systems, this enhances the contribution of technology transfer. The first meeting is attended by technology transfer agents alone. Problems noted by field-level workers are listed, discussed, and synthesized. They are then reformulated as research problems by top-level technology transfer agents and submitted to research at a planning meeting.

The second strategy is the **regional planning meeting**. By holding it before the national meeting, the contribution of technology transfer is enhanced since, at that level, its

representatives are regional officers who are more aware of farmers' real problems than the bureaucrats from headquarters who will attend the national meeting. Top technology-transfer managers often raise broad development issues rather than practical technological constraints on farmers. All transfer personnel have a role to play in planning, but each group must make its contribution at the level of the hierarchy where it will be most effective.

In general, planning mechanisms seem to work best when they are applied at the regional level, are used by joint operational teams, and deal with technical matters. India's zonal research and extension workshops are a good illustration of planning mechanisms at the regional level. The workshops are organized every six months, before the beginning of the agricultural season, by each State director of research in collaboration with the director of extension. They are attended by senior research staff and district and zonal extension staff, including subject-matter specialists and selected farmers from the zone. The participants discuss:

- proposed production recommendations for major crops in light of research findings and farm trial results;
- research priorities and proposals;
- plans for, and results of, farm trials and applied research activities.

The best case study examples of successful participation of technology transfer in planning are those where surveys and trials are planned and reviewed at the operational level by permanent teams composed of both research and transfer personnel. The reason for success seems to be the well-defined scope of discussion and the mutual respect fostered by other collaborative activities. This was the case in the maize subsector in the Mag-Catie FSR program (Palmieri 1990) and the strawberry subsector of Costa Rica (Coles 1990), and the coconut subsector of Tanzania (Lupanga 1990).

The linkage mechanisms work only if there is an effective exchange of information between research and technology transfer. It is therefore important for managers of both research and extension to identify the conditions needed for an intensive and fruitful exchange of information before they begin joint planning. With regard to participants, the basic question must always be who can provide the needed information rather than who is entitled administratively to represent either research or technology transfer. The coffee growers federation of Colombia provides a positive example of information sharing at various levels for the purposes of planning. (See box 7.)

Status differences and intergroup conflicts

Mutual respect, recognition of the partner's competence, and domain consensus seem to be prerequisites for using linkage mechanisms to integrate research and technology transfer. Unfortunately, these conditions are rarely present. The nature of the relationship between researchers and technology transfer agents, as well as the factors determining this relationship, have been widely discussed in the literature using different theoretical frameworks (Bennell 1989; Sims and Leonard 1989; Arnon 1989). Intergroup conflicts and problems related to status differences were discussed in chapter 4.

Box 7. Representing the interests of stakeholders at different decision-making levels: the case of the Colombian coffee growers federation

The Colombian coffee growers federation, a semiprivate organization representing both large and small private producers, has set up specialized bodies for deciding policy and operational matters on research and technology transfer. This elaborate system of linkages has been highly successful in ensuring that the technology needs of farmers are met.

Broad parameters and policies for the coffee industry are set by the federation's executive board. They point to major issues and provide the vision for Colombia's future coffee economy.

Technology policy issues are identified by coffee congresses and coffee conferences. These are organized by the federation's highest authority, the National Committee, which has 16 members and meets every eight days. The congresses are the federation's most important decision-making forum and are held every two years. They are attended by delegates from each provincial committee. Conferences, which have fewer delegates, meet on the off years when there is no congress.

The technical subcommittee of the National Committee decides on R&D issues. It includes members of the National Committee, representatives of the provincial committees, the federation's administrative, technical, and "diversification" directors, and a representative of the federation's financial office (Barrero and Castillo 1981). The subcommittee presents technology policy proposals to congresses and conferences for discussion and approval. It is also charged with implementing policies that emerge from these deliberations.

At a somewhat lower level, technical division directors meet every two years shortly after coffee congresses. Participants discuss ways to execute technology-related decisions at the operational level. National and provincial officials from research and extension also attend (Kaimowitz 1990).

5.2.2 Function 2: Collaborative Activities

The participation of technology transfer agents in field trials, surveys, and visits is crucial to the effectiveness of the technology system. Collaborative activities can have several objectives. They may seek to enhance effectiveness and efficiency by combining expertise from both research and transfer. They may provide assistance to one party to ensure a smooth transition between sequential tasks or in some cases, particularly joint trials, the objective may be long-term skill development.

According to the neo-Weberian theory of occupational structure, occupational groups compete with one another for status and economic rewards. Each group attempts to erect "barriers to entry" and to show a marketable "professional commodity" that is distinct and recognizable (Bennell 1989). If we apply this to agricultural technology systems, then successful collaborative activities would be more the exception than the rule in many developing countries because both professions are struggling to establish themselves as relevant and important.

In many of these countries, status and income differences between research and technology transfer personnel are great. There is also a tendency for researchers to associate more closely with professions that enjoy a higher status rather than with technology trans-

fer, which is yet to be established as a "profession" in some countries. In French-speaking Africa, for example, agricultural researchers have been struggling for years to enjoy the same status as university professors who are regarded as one of the top professional groups. Technology transfer agents are seldom university graduates. Thus, the professional context is not always favorable for collaboration.

The effectiveness of linkage mechanisms used for professional collaboration between research and technology transfer depends not only on the professional context, but also on the expected gains and losses from collaboration. Gains and losses are partially defined by each party's image of the other and views on interdependence and superordinate goals. The chances of genuine collaboration are better when both parties recognize their interdependence and mutual competence, and when neither perceives the other as a threat to achieving its objectives. Each is willing to be treated as a partner but not as a servant, and neither may want to deal with a competitor. The most frequent problem in collaborative activities, particularly joint trials and surveys, concerns research's use and treatment of technology transfer personnel.

Sharing responsibility and research results

Research has a tendency to treat technology transfer as a simple supplier of labor for collaborative activities, and as a source of information about which farmers to survey or include in trials. Transfer workers often manage trials without knowing the researchers' objectives and hypotheses. Even when they are informed of the purpose of surveys or trials, they are rarely associated with the analysis and they seldom share in the results. The gains from collaborative tasks organized in this way may not be obvious to technology transfer. Institutionally, research may enjoy all the prestige attached to them.

True sharing of research tasks

Lack of effective participation of technology transfer sometimes stems from poor definition of each partner's responsibilities. The sharing of responsibilities or the degree of involvement by technology transfer at different administrative levels must be specified. In the case of surveys, for example, research may see data collection as technology transfer's main role. For their part, transfer agents, aware of the potential prestige from collaborating with research, might prefer a stronger role in the research process. In many cases, limited participation creates resentment that may hinder future cooperation. It may also frustrate technology transfer workers and undermine the objective of the collaborative activity, namely, a smooth transition between tasks. Transfer agents' resentment of collaboration with research and their perception of it as an additional and unrewarded burden was reported in several case studies of the ISNAR on-farm client-oriented research (OFCOR) project (Merrill-Sands et al. 1991).

Research and technology transfer must share research results and the credit accruing from collaborative activities. Joint publications, workshops, and seminars can be useful mechanisms to that end.

Location of mechanisms

Collaborative activities often fail because mechanisms have not been properly located in the hierarchy of the technology system. There may be an agreement, for example, between top-level managers of technology transfer and research on joint activities, but without any mechanisms defining how these are to be organized at the operational level. The effectiveness of activities mostly depends on the goodwill and capabilities of lower-level managers. Informal linkages may be needed to make formal ones at the upper level function well.

Alternatively, mechanisms may have been established only at the operational level Ä for example, at the regional or district levels. If the system is too centralized, the mechanisms will probably not be effective and sustainable. The challenge for managers here is to establish the right mechanisms where they are needed. In Costa Rica, research and technology transfer were integrated by being merged into one directorate. Since no linkage mechanisms were set up at the operational level, the two subdirectorates continued to ignore each other and all the linkage problems identified before the merger prevailed. Having one director general was not sufficient (Palmieri 1990).

Before undertaking collaborative activities, managers must identify the linkages needed to ensure full and successful participation of all actors. Informal mechanisms may operate in the absence of formal ones. But managers must remember that these are rarely long-lasting.

The human element

The choice of collaborators and types of collaboration must be clearly spelled out. The right mix of human resources varies with the type of collaboration. There was a noticeable change in the performance of linkage mechanisms within the Agricultural Project for the Central-West Region of Côte d'Ivoire (PACO) when the leader of the R&D unit was replaced. This highlights the need for matching personnel to the form of collaboration sought. In that subsystem, linkages became less effective when the agronomist who had a partnership with the researcher was replaced by a technician. The relationship became hierarchical and existing mechanisms irrelevant.

Educational gap

Collaborative activities are normally smoother when the educational levels of research and technology transfer personnel do not greatly differ. Communication is easier since the approaches and methods of one party are more easily understood by the other. Avoiding a superior/subordinate relationship is more difficult when technology transfer personnel have a much lower level of education than researchers, as is the case in many African countries. In such situations, communication barriers are difficult to overcome.

Qualifications of researchers

Because senior researchers tend to view collaboration with technology transfer as less rewarding, the least experienced researchers are usually assigned to such activities. The perception here is that the farther one moves from basic research, the less scientific the work is; and the less scientific the work, the less prestige there is attached to it. Thus, it is the younger researchers, those with less authority and no secured niche in the system, who must establish

credentials for their future career by participating in these activities. Motivation is weak, the desire to exploit the opportunity for one's own personal ends (rather than for the institution's objectives) is strong, and the success rate is low. In Costa Rica, for example, when the Regional Research Teams were formed in 1987, they were staffed with newly recruited and inexperienced scientists. This negatively affected the team's work. (Palmieri 1990).

Collaborative activities are often costly, so managers need to ensure they first have the necessary resources to make them work. In some cases, the incentive system must be changed to ensure that good personnel are involved. Further, collaborative activities must be constantly assessed by managers and adjustments made when needed.

Permanence of collaboration

Data from the ISNAR study show that collaboration is especially effective when activities are undertaken by permanent teams of researchers and technology transfer workers. It can be a farming systems unit as in Ghana's maize subsector (Annor-Frempong 1988), or collaborative task groups as in Colombia's Nariño Province (Engel 1989), or a technical crop committee as in the cotton (Eponou 1990a) and tilapia (Eponou 1990b) subsystems of Côte d'Ivoire. In Côte d'Ivoire, the scope and administrative levels of collaboration and the responsibilities of each partner are clearly specified in an agreement.

The special case of farming systems research (FSR)

FSR teams have extensively used collaborative mechanisms. Despite their commitment to developing relevant technologies for farmers, FSR teams have encountered most of the above-mentioned problems. Effective participation of technology transfer in joint activities is not automatic. Disagreements over the sharing of responsibilities and intergroup conflicts exist in many FSR teams. See chapter 3 for a discussion of issues affecting FSR units.

Joint trials

Collaborative mechanisms such as trials can be costly. ISNAR research data show that joint trials are often associated with special projects or commodity-based subsystems that can finance them from a cess on the sale of products. Joint trials, in the case of subsistence crops, are conducted only when there is an FSR unit financed by donor funds. Trials are abandoned when the project ends because few national subsystems can afford the costs.

Surveys

There is often duplication of effort associated with surveys. It often happens, for example, that no use is made of previous survey results before a new one is undertaken. Research and technology transfer may both be engaged in socioeconomic data collection in the same areas and fail to share their results.

The most striking example from the ISNAR study is the bean subsector of Colombia. In 1969, technology transfer workers carried out a survey using the "sondeos" approach and secondary information. In 1975, the United States Agency for International Development (USAID) sponsored another diagnostic survey to assist with project formulation. Technology transfer, in collaboration with the socioeconomic research team, undertook yet another

survey in 1977. Since then, four other surveys have been done. Those carried out by research have generally been separate from those of technology transfer.

Surveys are demanding in terms of the staff time and skill required to interpret and incorporate wide-ranging data. Because technology transfer may use personnel not fully qualified to conduct surveys, the findings are often considered suspect by research. This may partially explain the frequent repetition of surveys.

Joint visits

Joint visits often lack a clear objective. Visits can be used to identify problems, increase researchers' knowledge of local production conditions, assess the performance of technologies, etc. It is important for research and technology transfer to have a common understanding of the purpose of the visit. Visits can be highly effective if they are used along with other mechanisms to achieve a specific objective. In the cotton subsystem of Côte d'Ivoire, for example, visits are used by the joint technical committee of researchers from the research institute and technology transfer workers from the Research and Development (R&D) department to evaluate technologies in farmers' fields. These visits are organized by the head of the R&D department and the liaison research officer (Eponou 1990).

Lack of collaborative activities may result in duplication of effort. Technology transfer may initiate its own adaptive research program if it feels its needs are not fulfilled by research. In many cases however, methodological problems arise because of the absence of qualified scientists in technology transfer institutions. This was the case in the Malian example cited above. Methods were poorly designed and a proper analysis of data was not possible in some cases.

At the present stage of development of the technology systems studied by ISNAR, collaborative activities are essential. Managers should use them more frequently and avoid unnecessary duplication of surveys and trials. Given their importance for overall system performance, these activities must be considered critical activities and funds should be earmarked for them in the budget.

5.2.3 Function 3: Exchange of Resources

The basic objective of resource exchanges is to enhance the capacity of one party to undertake a technology task, or an activity related to a specific task, or to establish a contractor-client relationship to ensure relevance of the task. Research and technology transfer may exchange human resources or sign a financial agreement to develop specific technologies.

Contractor-client relationship

Financial agreements are one of the most important resource allocation linkage mechanisms. Specifically, contractor-client relationships seem to be the best way to make research responsive to client needs. However, there is one major limitation: such agreements have been used for high-value commodities but almost never for subsistence crops. Thus, resource-poor farmers have not benefitted from this useful mechanism.

For food crops, experience has shown that contractor-client relationships cannot be used to build long-term research programs. They are better adapted to immediately solvable problems rather than ones that are chronic and fundamental. For example, they may be used

to overcome short-term difficulties such as a disease or pest. The issue is how to include long-term work on food crops in these relationships.

Another limitation of financial agreements is that they may not be conducive to opening new areas of investigation, since it is unlikely that users will provide funds for high-risk research. Unfortunately, many ground-breaking scientific discoveries are not amenable to prediction. There is also the risk of limiting the scope of the research system to piecemeal problem-solving, if financial agreements become the major mechanism for setting the research agenda.

Financial agreements in some cases are a substitute for external pressure on the research system. They thus enhance system performance, particularly when research funding is linked to the achievements of the subsystem. But for the same reason, in some circumstances, financial agreements may bias research programs to the needs of wealthy farmers at the expense of poor farmers unable to afford a contract with research.

Poor farmers can benefit from this type of agreement if a profit-driven development parastatal enters into some type of production contract with them. The parastatal ensures that farmers have access to efficient technologies by establishing appropriate linkages with research.

This mechanism has been largely used by the French in Africa for cotton, groundnuts, palm oil, and rubber. Interestingly, these subsectors have been the most successful in terms of both technology generation and transfer. The cotton subsector of Côte d'Ivoire (Eponou 1990) illustrates this best. At the beginning of each year, the research institute (Institut des Savannes Ä IDESSA) and the cotton development agency jointly plan a research program for cotton, including the budget. The development agency bears all the operating costs of the program from a cess on the sale of cotton. Linkages between the parallel institutions responsible for food crops, mainly corn and rice, are not as strong as those in the cotton subsector because of the lack of financial agreements for these crops (Eponou 1990). In general, linkages between research and technology transfer for commodities are strong in Côte d'Ivoire, although the two groups are not located in the same ministry. Coffee and cocoa are the only commodity subsectors with weak linkages between their respective research institute and development agency. Yields for both commodities have not noticeably increased over the last 30 years, while those of cotton have quadrupled. The limited impact of research on coffee and cocoa production is partially due to the absence of the development agency as a stakeholder with a formal contract with research, as is the case for all the other commodities.

Rotation and secondment of personnel

The effectiveness of staff rotation and secondment depends on the manner in which they are arranged and the quality of the individuals involved. Short-term rotations may be preferable to long-term ones, since links between an individual and his or her base institution weaken over time.

Motivation of individuals on rotation or secondment may be low if the arrangements are at the expense of their career development, or if the assigned positions are perceived as punishment. To make the arrangements work effectively, incentives may be needed. Secondment in the case of special projects can be a source of tension in an institution, because the fringe benefits provided may create competition for these positions.

5.2.4 Function 4: Dissemination of Information

According to Allen (1970), attempts to regulate the transmission of scientific and technological information within R&D are notable for their failure. If this is true for more structured organizations, then communication difficulties in agricultural technology systems should come as no surprise, given the number of organizations involved and the status differences between the information generators and users. The objective should be to foster a two-way flow of information and knowledge in the technology system. Publications, training, and workshops are the most frequently used mechanisms.

Communication mechanisms alone are inadequate to sustain the integration of research and technology transfer. They can be effective only if there is already some degree of integration fostered through other mechanisms. If, for example, it has been made clear through a mechanism such as joint planning that the two groups must collaborate to make technologies available to farmers, then research will likely choose communication mechanisms adapted to technology transfer workers. Then, concrete technologies — rather than the publication of scientific results — will be the primary output of research.

The issues above raise a basic question about the purpose of research. Should scientific publication be the main output of research? It seems that not many research systems have provided an explicit answer to the question. In general, policymakers perceive technology development as the primary goal of their research system; but the reward system for researchers is based on their scientific publishing record. Not surprisingly, scientific publications often get more attention than technology development or publication of leaflets, bulletins, and brochures for technology transfer workers. Evidence from the case studies shows that mechanisms for disseminating information in general, and publications in particular, are among the least effective linkage mechanisms (Eponou and Wuyts 1991).

Relevance of message

The critical issue for the effectiveness of communication linkage mechanisms is the relevance of the information to the user. Researchers need to recognize technology transfer agents as the major immediate beneficiary of their scientific results. Information to be communicated must be selected with these users in mind; otherwise, the chances of it being actually used are seriously undermined. The same principle applies to technology transfer when it attempts to communicate feedback from farmers to research.

Appropriateness of language

If information is to be applied, it must also be presented in an easy-to-follow format and written in appropriate language. Some publications produced by research are too technical to be used by technology transfer workers because of their lower level of formal scientific education.

Nature of publications

Some systems have attempted to resolve the dilemma by creating a range of publications — from leaflets for farmers and technology transfer agents to highly specialized journal articles for scientists. These subsystems have more than one type of publication, each with a specific audience. In the coffee subsystem of Colombia, for example, CENICAFE is

published for the scientific community while AVANCES TECHNICOS has technology users as its main audience. ICA, the Colombian national technology system, has nine types of publication. INFORMA and extension bulletins are published for technology users while REVISTA is produced quarterly as a scientific journal.

Range of publications

In general, it seems that the range of publications is insufficient, even in subsystems where technology transfer is seen as the main target. In many cases information is not presented in the form of brochures, handouts, bulletins, or leaflets, which are the formats preferred by technology transfer workers. Researchers have little interest in these forms of publication because they are time-consuming to produce and do not contribute significantly to their career development.

Access to publications

Access to publications is often difficult for technology transfer workers. Documents when they exist, are often published in limited numbers and go to headquarters rather than to agents at the operational level. For example, in their surveys of the relation between researchers and transfer workers, Seegers and Kaimowitz (1989) found that 81% of the researchers in Egypt sent their publications only to extension headquarters. In Sierra Leone, extension workers had trouble finding relevant research findings when needed.

Surprisingly, some of the subsystems covered in the case studies do not have any formal publications other than their annual report. And it may have limited distribution or may not even be published regularly. These subsystems rely on other mechanisms to move information between research and technology transfer. This is the case in the cotton subsector of Côte d'Ivoire where most communication is handled through meetings of the technical committees, which are in effect joint planning and review committees. Papers reporting research results, often written jointly by research and technology transfer, are used as a basis for discussion at these meetings.

Joint publications

Jointly produced guidelines and instructions for specific commodities are valuable outputs. They have the advantage of being accessible to technology workers. In the Philippines, through the coordination of the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), the potato program produced a glossy 60-page document entitled *Benguet Potato Technoguide for technicians, farmers, researchers and development workers.* The publication was cosponsored by development agencies, research institutes, the state university, and PCARRD. It covered every aspect of potato production in Benguet province, from adaptation to post harvest handling, and included sections on credit and marketing. The document has had a positive impact on potato production in the province (Francisco 1989).

Joint publications also acknowledge the collaborative efforts of both research and technology transfer in developing and transferring technologies. They can in some ways ease tensions between the two functions and their production should be encouraged by managers.

Producing publications relevant to technology transfer should be included in researchers' job descriptions. Managers should then take the performance of such writing tasks into account when evaluating researchers and considering them for promoting. A scoring system can be set up whereby a certain number of points are earned for each type of publication.

Electronic media

Radio and television programs are generally popular and benefit from established channels. However, language, targeting, time of broadcast, and reception by users can be problems (Eponou and Wuyts 1991). Broadcast programs were used successfully in the Philippines, Nigeria, and Colombia. Good planning and specificity of contents were among the factors that contributed to success.

Appropriateness and the medium

Even if technology generation is the primary goal of the system, relevance is still a problem because of individual or system characteristics. The source of information (research or technology transfer) is not able to put the message into a form easily accessible by users. For example, the main complaint from technology transfer agents about training events conducted by research is that the materials are too theoretical and esoteric for direct use. Often, researchers are unable to adjust the complexity of the training materials to the level of their audience. Researchers explain their disregard for problems raised by technology transfer as the result of transfer agents being unable to express these problems clearly.

Educational differences

Lack of effective communication is not always due to the deliberate behavior of either researchers or technology transfer workers. Rather, it often results from a lack of education or an absence of professional expertise on both sides. The problem may be more noticeable in technology systems where the educational gap between research and technology transfer is very wide. In this situation, training, workshops, and publications are insufficient for effective communication. They provide too narrow a channel to permit a real exchange of information. Used in isolation, joint meetings are also inefficient as a way for technology transfer to communicate problems to research. Other mechanisms, particularly structural ones such as liaison positions or communication units, may sometimes be necessary to improve channels of communication.

Given the gap in the educational levels of researchers and technology transfer agents, a communication unit is often needed. The managerial mechanisms listed above can be effective only if the unit serves as a facilitator. It must not function as a totally separate unit with its own jargon, pursuing ends incompatible with the primary goal of responding to the technological needs of farmers. The Agricultural Extension-Research Liaison Service (AERLS) in Nigeria (Ekpere 1990) and the Communication Department of ICA in Colombia have played the role of facilitator effectively for many years. The main problems with these units are that they:

- create the need for additional linkages in the system since they must be strongly connected with both research and technology transfer;
- have a tendency to develop their own goals and approaches which hinder linkages;
- require human and financial resources not always available.

Agricultural Extension-Research Liaison Service

In the 1960s a research liaison service was established in the northern province of Nigeria. Its job was to ensure the maximum flow of appropriate research information from the Institute of Agricultural Research (IAR) to the Ministry of Agriculture and its field personnel, and to inform IAR of production problems facing farmers. The service had two sections: a subject-matter specialist section and an audiovisual section. Subject-matter specialists reviewed research results in their field and translated them into a form that technology transfer could use; they also brought problems needing research to IAR's attention. The audiovisual staff produced slides and information materials based on the work done by the subject-matter specialists. Both groups also had training assignments (Ekpere and Idowu 1990). Furthermore, an important finding of the study was that expenditures related to communication mechanisms and units are among the first to be cut when the system faces financial constraints. The liaison service in Nigeria and the publication of the annual report in the maize subsystem of Costa Rica are good examples of this (Palmieri 1990). Although the liaison service in Nigeria was effective at making research results more accessible to technology transfer, and despite its role as a "technology champion", it did not have reliable funding. Its budget depended on the overall resources allocated to the technology system (Ekpere and Idowu 1990).

Training of technology transfer agents

Formal training of technology transfer workers by researchers is not a widespread practice in the agricultural technology systems of developing countries. Training of subject-matter specialists and transfer workers occurs under the Training and Visit (T&V) system. Training events and joint workshops under this system are not always successful, either because of their content or the way they are organized. Deficiencies in several areas — planning, logistical support, targeting, and level of resources — often undermine the effectiveness of training events (Eponou and Wuyts 1991).

In Tanzania, seminars organized for transfer agents were particularly successful in bridging the educational level between researchers and technology transfer agents (Lupanga 1990). Similarly, in the Dominican Republic, subject-matter specialists of the National Rice Training Center met with good results when they organized training events for technology transfer agents (Perez 1989). In both cases, logistical and financial support were available through donor funds.

5.2.5 Function 5: Evaluation and Feedback

Scientists need feedback on the agricultural technologies they develop so that they can make adjustments to their research programs. Without it, future performance of the technology system will be weak. It seems, however, that getting the necessary feedback is one of the most difficult tasks facing research since the process starts with the end users — farmers.

A major issue here is whether gathering information from farmers should be the responsibility of research or of technology transfer. In other words, should research go through technology transfer to get feedback? Who is responsible for technology evaluation after adoption? What types of linkage mechanisms should be used? Planning and review? Collaborative activities? Or communication mechanisms?

Suitability of feedback mechanisms

The types of mechanism to be used may vary with the level of development of the system, particularly its transfer component. They may also vary according to the types of technologies involved. If technology transfer does not have the necessary expertise for evaluation, it may be necessary for research to become involved in data collection. Thus, collaborative mechanisms may be needed. There may be cases where certain mechanisms for technology evaluation are unsuitable because technology transfer does not possess the required analytical capacity. Or, if technology transfer is especially strong, its reports may provide research with the feedback it needs. The point is that managers need to choose mechanisms compatible with the capabilities of technology transfer. In some cases, research will have to obtain feedback directly from farmers through informal surveys such as those used in FSR.

Responsibility

Someone must be responsible for ensuring feedback within the system. Technology transfer has primary responsibility for helping farmers adopt technologies. Given the purpose of feedback — namely, to help shape future technology generation — it seems logical for research to take the lead role in obtaining feedback. Research must treat feedback as a component of problem definition. It is therefore desirable for research managers to establish and manage formal feedback mechanisms. This was not the case in most of the subsystems studied.

Another reason for research taking the lead in getting feedback is that farmers sometimes do not adopt technologies because of nontechnological factors (e.g., availability of credit and poor marketing channels) that demand policy changes. The credibility of research may be undermined if such changes are not made. It is important for research to show policymakers how national policies sometimes reduce the country's range of technological options, thus restricting the potential contribution of research to economic development.

It is important to stress that technology transfer also needs feedback. Indeed, managers of both research and technology transfer need to share feedback from farmers to ensure the effectiveness of the system as a whole. Policymakers must ensure that evaluation and feedback are part of the regular activities of research and extension.

In the ISNAR study it was observed that formal feedback mechanisms are almost exclusively used in commodity subsystems. The development agencies responsible for technology transfer often have the resources needed to ensure good feedback, as well as a vested interest in doing so.

In the case of donor-funded projects, socioeconomic units are often set up to monitor activities and provide the necessary feedback. Leadership is assumed by technology transfer which has the financial and human resources for undertaking evaluations and for using the results in reaching agreement with research.

Socioeconomists in technology systems

One feedback-related constraint faced by many systems is the absence of a strong team of socioeconomists. Even if there is such a team, it is often limited to FSR activities. Since linkages between FSR and on-station research are often poor, it is not certain that feedback

will occur. Actually, in some cases, simple farm management surveys can be sufficient to provide feedback.

Appreciating the need for feedback

In general, there were few links between research and technology transfer for feedback purposes in the case studies. This may confirm the assertion of Johnson and Kellogg (1984) that both researchers and transfer personnel do not fully appreciate the need for eliciting information and evaluation from farmers. This may stem from use of the linear model in most of the systems, or from a paternalistic attitude toward farmers. It is also, in some cases, partially due to the overemphasis on formal education and science as the only sources of knowledge in developing countries. Farmers are often perceived as ignorant and incapable of presenting coherent and logical analyses about their environmental and farming conditions.

5.2.6 Function 6: Coordination

The purpose of coordination mechanisms is to facilitate a smooth transition between two tasks or among activities of the same task performed by research and technology transfer. Coordination has been extensively discussed by organizational behavior scientists (Galbraith and Mintzberg 1979; Kast and Rosenzweig 1985). Bourgeois (1990) has analyzed some of the issues specific to agricultural technology systems.

In agricultural technology systems, coordination can be purely technical as when the coordinator's sole role is to ensure a two-way flow of information. This is often the case for liaison positions. However, the position can also have a scientific component. The person in charge must then also facilitate the exchange of information by putting it into a form accessible to the user. The best illustration of this is the position of subject-matter specialists.

Coordination can also be provided by a permanent committee with representatives of research and technology transfer. The committee can have one or several mandates ranging from problem identification to evaluation of research results. In Zimbabwe, for example, the Committee for On-Farm Research and Extension (COFRE) plays the role of facilitator in identifying research problems and running verification trials. It manages the selection of proposals for on-farm projects and organizes workshops to plan farm projects. COFRE has been successful in improving linkages between the Department of Agriculture, Technical Services and Extension, and the Department of Research and Specialist Services (Shumba and Fenner 1989).

The effectiveness of these mechanisms largely depends on the quality of staff in coordination positions and the level of resources available. These people must be committed individuals with good leadership qualities.

One problem observed is that coordinators tend to develop their own jargon. This can hinder rather than facilitate linkages. The issue is really how much autonomy and authority should be assigned to these positions. Insufficient autonomy may block individual initiative needed to make the mechanism work effectively; too much autonomy may undermine the cooperation and common approach needed for research and technology transfer to perform interdependent tasks.

The cotton subsystem of Côte d'Ivoire uses a liaison officer to coordinate the activities between research and technology transfer. This person is the conduit for all exchanges of information between the two parties. Centralization of the information flow reduces the time

needed for managing linkages and allows for more coherence in the activities of the two parties. The researcher in that position also acts as a "technology pusher". This mechanism has functioned reasonably well for many years because either party can request dismissal of the liaison officer if dissatisfied with the officer's performance.

Resources

The use of subject-matter specialists located in a special unit or within the technology transfer component was very common in the systems studied. However, in many cases they were unable to operate properly because of lack of financial resources. In the Nariño region of Colombia, most of the subject-matter specialists were dismissed when the Dutch-funded project was completed because the national system was unable to bear the operating costs of the specialists.

Authority

The case studies also showed that in many instances the lines of command in the technology system are not very clear, subject-matter specialists do not have enough authority, and conflicts emerge between them and technology transfer officers because of overlapping lines of responsibility. Such problems were reported by Seegers (1990) in Sri Lanka. The subject-matter specialists were upstaged by the technology transfer officers during meetings, and were not invited to the regional technical working group meetings. The researchers preferred to deal with the technology transfer officers rather than the subject-matter specialists whom they did not even consider as spokespersons for farmers' problems. Part of the problem in this case was that the subject-matter specialists did not have enough authority. The same type of problem was reported by Kean and Singogo (1991) in Zambia with regard to the Research-Extension Liaison Officer (RELO).

Structures

Coordinators such as liaison officers are often caught between two or more institutions without a clear definition of their mandate. Rules for their promotion are not always specified. This was the case for research-extension liaison officers in Zambia. The situation prevented the system from recruiting and maintaining competent staff for these positions (Kean and Singogo 1989).

5.3 Recommendations

A major task for management is to select linkage mechanisms appropriate to the strengths and weaknesses of the technology system. The types and quality of resources required vary for each purpose and even for mechanisms used for the same purpose. Some require well-trained personnel, while others demand substantial financial resources. Research managers must assess their own resources as well as those of their counterparts in the system. They must also attempt to understand the behavior and attitudes of the managers of other organizations involved in the technology system before choosing specific mechanisms. Behavior and attitudes are not static. They are reinforced by results as well as by changes in the exter-

nal environment, including the policy context. Integration, then, is more a process than an established state.

Linkage mechanisms of agricultural technology systems must be appropriate to the context. Although managers do not have full control over the context or environment, they are able to deal with some system constraints such as organizational problems.

Managers can improve joint planning and review by:

- clarifying mandates;
- defining scope, objectives, and agendas of activities;
- increasing authority delegated to partners;
- improving representation of partners;
- reducing interpersonal conflicts;
- improving allocation of resources between research and technology transfer.

Managers can enhance the performance of collaborative activities by:

- sharing research tasks, responsibilities, and results with technology transfer;
- defining explicitly the form of collaboration;
- establishing appropriate mechanisms at different levels of the technology system for collaborative tasks;
- establishing additional linkage mechanisms for FSR;
- making explicit the objectives for joint visits.

Managers can strengthen linkages with technology transfer by:

- finding opportunities to establish “contractor-client” relationships with technology transfer;
- providing proper working conditions and motivation for staff rotation and secondment.

Managers can improve the flow of information and knowledge between research and technology transfer by:

- making technology transfer an important target for publications;
- increasing the range of publications;
- ensuring appropriateness of language for publications geared toward technology transfer;
- ensuring availability of publications to transfer agents;
- encouraging the production of joint publications and the use of seminars, workshops, and field days;
- enhancing the relevance of training materials for technology transfer.

Managers can encourage feedback by:

- using socioeconomists to enhance the capacity of research to collect and analyze data on performance of technologies;
- taking responsibility for establishing and managing feedback linkage mechanisms;

Managers can make coordination more effective by:

- providing operating funds for coordination;
- defining authority and clear mandates for coordinators;
- choosing committed people with leadership qualities for coordination positions.

Most systems rely heavily on communication mechanisms to link with technology transfer. Managers should know that:

- This reflects the traditional view of the sequential nature of the roles of research and technology transfer.
- These mechanisms, used alone, are not sufficient to ensure integration.
- The effectiveness of these mechanisms depends on other mechanisms.
- Linkage mechanisms cost time and money and must be regularly evaluated.

6. CONCLUSION

The presence of good linkages between research and technology transfer in developing countries is a key condition for agricultural technology systems to be effective. A major finding of this ISNAR study is that the root causes of linkage problems in these systems are diverse and that, in many cases, solving such difficulties may require fundamental changes that go far beyond introducing new linkages or linkage mechanisms. For example, a change of leadership or style of leadership may be needed.

It is obvious that improving linkages between research and technology transfer without also enhancing the effectiveness of those between research and farmers and between research and agricultural policymaking will not be sufficient. In many cases, however, the heterogeneity of farmers could pose serious challenges in efforts to improve linkages with research. But ways of establishing these linkages must be explored and this is a complementary area to which ISNAR is now turning its attention.

Finally, in light of the complexity of linkage issues, borrowing solutions or perpetually reorganizing technology systems, as has been done in many countries, are approaches that have proven untenable. Rather, it is adviseable that managers allocate resources for a thorough analysis of their technology systems to identify and implement solutions tailored to their specific needs.

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ANNEX: GUIDELINES FOR MANAGERS

1. INTRODUCTION

Weak linkages between research and technology transfer have been singled out as one of the major factors contributing to poor performance of agricultural technology systems in developing countries. As the lead center established by the Consultative Group on International Agricultural Research to advise managers of national agricultural research systems (NARS) on research policy, organization, and management, ISNAR receives many requests to help strengthen linkages. In response to these, ISNAR began a study of the subject in 1987.

One basic finding of the study is that while linkage problems are similar across the national systems, causes and solutions to problems are system-specific. This annex briefly presents the problems and provides general guidelines for dealing with them.

2. BASIC LINKAGE PROBLEMS

The following basic linkage problems are commonly found in the technology systems of developing countries.

2.1 Missing Critical Tasks

A "missing task" refers to a serious gap in the agricultural technology production and dissemination process when one of the following critical technological activities is not performed:

- problem identification;
- research program planning;
- technology generation;
- dissemination of information;
- technology consolidation;
- technology release;
- multiplication of technology;
- dissemination of technology;
- technology evaluation.

The gap may be due to poor system design; that is, no unit of the agricultural technology system has been assigned responsibility for the task. For example, there may not be any unit in charge of seed production or adaptive trials. The problem can also stem from managerial decisions not to perform a particular task for want of adequate resources or because the task is not seen as being very useful.

2.2 Missing Linkages

Critical units or tasks may not be integrated because the necessary linkages are missing. Missing linkages may reflect a failure on the part of senior managers to recognize the need for interdependence or to agree on what is known as a "recommendation domain" — a common set of clients and topics. Missing linkages can also result from a simple error in the de-

sign of the technology system. For example, there may not be any means of communicating research results to technology transfer or any mechanism to involve technology transfer in planning research programs.

2.3 Nonfunctional Linkage Mechanisms

In this case, the mechanisms exist but are not used, either for lack of resources or because one or more units do not envisage the necessity for using them. For example, a planning and review committee may have been set up but it rarely or never meets.

2.4 Ineffective Linkage Mechanisms

These linkage mechanisms are operational but ineffective. This may be due to their method of operation, to a lack of cohesion between research and technology transfer, to the nature of the resource base (mainly personnel), or to managerial practices. There may be a planning and review committee which meets, for example, but its decisions are ignored and never implemented.

2.5 Duplication of Effort

Duplication of effort (or redundancy) refers simply to those situations where the same task is performed separately by two different units. For example, research and technology transfer may independently test the same technology in the same area.

2.6 Fluctuations in the Operation of Linkage Mechanisms

The mechanisms function on an ad hoc basic, either when one organization is willing to provide leadership for a specific objective or when donor resources are available. This results in poorly integrated systems which generate technologies that are not relevant to farmers' needs or do not reach their technology transfer component.

* * *

The causes of these six problems are system-specific. They must be identified and analyzed in each case and the solutions must be tailored to the conditions of the system being analyzed. However, there are general principles that require the attention of the various managers of every agricultural technology system. These are discussed below.

3. ISSUES AND RECOMMENDATIONS

3.1 Issues at the System and Policy Level

Systems perspective

Many systems are characterized by the absence of a "systems perspective" at the top managerial level. Systems perspective refers to the view that research and technology transfer are components of one single system whose mandate is to make relevant technologies

available to its constituency, the farmers. The two components must always be perceived as such regardless of the organization and structure in place and where the two are located administratively. The absence of the systems perspective may be due to the failure of various managers, especially top-level managers, to recognize it or their inability to properly manage it.

Despite their being components of the same system, research and transfer differ in their respective roles, specific goals, priorities, and methodologies. Further, their incentive systems and status are not the same. These differences are the source of potential tensions and conflict and can override the complementarity of two components, making them overly competitive. This has implications for policymakers' handling of linkages:

- Overriding goals are not always shared by research and technology transfer and policymakers should be aware of this.
- Linkages cannot simply be established or imposed through administrative or policy rules; they must be based on consensus among the participants on the issues and operational measures for achieving integration.
- The broad strategies and policies to ensure linkages between the two must be defined and managed at the policy-making level.
- Operational strategies and mechanisms must be defined and managed at lower levels of the system.

System-level leadership

The failure to provide sufficient leadership at the policy-making level and to keep and properly manage a systems perspective is a serious constraint to integration. Integration of research and technology transfer requires someone at the apex level to ensure that:

- cooperation between the parts results in continuous synergy;
- decisions are made by consensus rather than unilaterally imposed;
- the dialogue required to establish and operate linkages is a continuous process that includes corrective action;
- the system as a whole, as well as its components and their linkages, are constantly monitored and evaluated (with availability and relevance of technologies at the farm level among the major evaluation criteria);
- an appropriate environment for effective linkages is maintained through appropriate incentives;
- the system goal, as defined at the policy level and agreed upon by research and technology transfer, is compatible with those of other development policies and institutions dealing with agriculture;
- research and technology transfer have the resources (quantitatively and qualitatively) required to achieve their goal;
- research and technology transfer are accountable for their actions;
- tensions are eased and, whenever possible, exploited for the benefit of the system.

3.2 Managerial Issues

Choice of mechanisms

For a technology system to be effective, managers must identify the system's linkage needs and choose appropriate mechanisms. Managers should be aware that some mecha-

nisms will work better than others, depending on the function to be performed and the specific conditions such as the quality and quantity of resources (particularly personnel), the system climate, and managerial capacity. Mechanisms should be chosen with several factors in mind:

- The type of linkage problem to be solved — that is, its nature, size, and location.
- The adequacy of the mechanism in addressing the specific problem.
- The ability of all participants to use the mechanism properly.
- The financial capacity of the entire system and its components to operate and sustain the mechanism.

It is important for managers to note that there is no such thing as a perfect system structure or organization. For each model, there is always the risk of gaps and tensions developing. Managers can avoid them only by establishing appropriate linkages, correctly managing the linkage mechanisms, and creating a favorable climate for integration. However, different models have different resource requirements. Regardless of the configuration in place, the following conditions apply:

- The actors needed to perform the basic technology generation and transfer tasks are in place and are well managed.
- The required linkage and coordination mechanisms are available to allow a steady, two-way flow of information and knowledge.
- Resources are available to activate the linkage mechanisms.
- The system climate is conducive to integration.

Furthermore, a single set of linkages and linkage mechanisms may not be adequate to deal with the potentially great variety of institutional configurations required to serve farmers. This has several implications:

- Linkage needs must be assessed for each configuration. That is, potential gaps need to be identified, alternative solutions need to be evaluated, and appropriate mechanisms needed to be tailored to the configuration.
- The mix of specialized expertise available in the technology system should be well matched to the variety of situations likely to be encountered. For example, a system may require subject-matter specialists for some of its clients growing a specific crop, an FSR unit for its resource-poor farmers, and a communication unit to serve large farmers. These mechanisms call for personnel with different skills and knowledge.

Six basic linkage functions must be performed to ensure an appropriate level of integration and effective operation of the technology system. Linkage mechanisms must be established for each. The functions are:

1. planning and review of research programs;
2. execution of collaborative tasks;
3. exchange of resources;
4. dissemination of information and knowledge;
5. evaluation and feedback;
6. coordination.

Promoting a conducive system climate

Many systems fail to create and maintain a system climate conductive to integration. As discussed earlier, the risk of having conflicts or tensions in the system is high. Conflicts and tensions are often generated at the policy level but manifest themselves at the operational level over the following:

- what to do: goals and priorities;
- how to do it: methodological approach and sharing of responsibilities;
- how to share available resources to achieve goals;
- differences in non-operational resources: salaries, salary scales, incentives, and professional and social status;
- sharing of results and benefits from results: credit and prestige.

The major point here is that avoiding tensions and conflicts is the responsibility of both policymakers and managers at the institutional level. Tensions can be eased by:

- joint planning and review of programs;
- clearly defining goals, mandates, and missions of the organizations within the technology system;
- promoting equity;
- always seeking consensus and compromises;
- avoiding or minimizing competition between research and technology transfer;
- exchanging resources;
- sharing information on methods;
- increasing opportunities for collaboration and joint activities;
- encouraging informal linkages.

Management of mechanisms

Linkage mechanisms must not only be set up but also properly managed — something that unfortunately often leaves much to be desired. To be effective, managers must ensure that, at the operational level:

- the mechanisms are constantly monitored and corrective measures taken when necessary;
- conflicts within the component they are managing are kept to a minimum and the institutional culture of that component is appropriate for an effective use of the mechanisms;
- resources for linkages are available and correctly managed.

Linkages imply gains and losses. These are to be borne both institutionally and by individual actors. It is the manager's responsibility to minimize individual costs and, when necessary, compensate for them through an appropriately designed incentive system. As in any integration, the sharing of gains and costs may not always be equitable. Real losses may be experienced institutionally. But what really matters is overall system performance.

Managers must also be aware that, even though different technology systems face the same kinds of problems, the underlying causes and appropriate solutions vary from one system to another. This means that:

- There is no one recipe for solving linkage problems. In each case, managers must go through several steps — identify and analyze the problem, design alternative solutions, select and implement the best ones, and monitor and evaluate the outcome. In some cases, other courses of action may need to be tried once the manager has gone through the process.
- During the whole process, managers must always bear in mind that mechanisms are effective only if they are agreed upon by partners who, in addition, have the capacity and the resources to fulfill their linkage responsibilities.
- Since a mechanism's effectiveness is related to the system context, it evolves along with changes in the context. Adjusting or substituting mechanisms may be necessary from time to time.

Resources

The inadequacy of resources to make linkage mechanisms operational — and operate effectively — is a serious constraint on many technology systems. Linkages cost time and money. Thus:

- They must be explicitly budgeted for.
- For linkages to be effective, resources must be made available, in a balanced fashion, to all the collaborating organizations in the system.
- Managers should encourage the use of financial agreements between research and extension to ensure funds are available when needed.
- Research and technology transfer must sometimes exchange personnel to improve the balance of skills required to deal with specific linkage situations.

Mobilization for linkages

For the research and transfer functions of a particular technology system to be well integrated, all relevant actors should participate in linkage activities. The inability to mobilize all the necessary personnel to do this seriously hinders the effectiveness and efficiency of the linkage mechanisms.

All the actors in the system, from policymakers to operational-level agents, need to be made aware that linkages are important and that their participation in linkage activities is crucial to the overall effectiveness of the system. Here are four measures that can be taken:

- Through seminars and workshops, provide effective information on the importance of linkages.
- Include linkage activities as explicit components of the job descriptions of researchers and transfer agents.
- Ensure that incentives, rewards, and promotions explicitly take into account the performance of linkage tasks.
- Train both researchers and transfer agents in linkage work. Both on-the-job training and short-term training sessions may be required, depending on the current level of skills.

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