ages
eme
per
No. 1

A Conceptual Framework for Studying the Links between Agricultural Research and Technology Transfer in Developing Countries

by

David Kaimowitz, Monteze Snyder and Paul Engel

isnar

International Service for National Agricultural Research

The International Service for National Agricultural Research (ISNAR) began operating at its headquarters in The Hague, Netherlands, on September 1, 1980. It was established by the Consultative Group on International Agricultural Research (CGIAR), on the basis of recommendations from an international task force, for the purpose of assisting governments of developing countries to strengthen their agricultural research. It is a non-profit autonomous agency, international in character, and non-political in management, staffing, and operations.

Of the thirteen centers in the CGIAR network, ISNAR is the only one that focuses primarily on national agricultural research issues. It provides advice to governments, upon request, on research policy, organization, and management issues, thus complementing the activities of other assistance agencies.

ISNAR has active advisory service, research, and training programs.

ISNAR is supported by a number of the members of CGIAR, an informal group of approximately 43 donors, including countries, development banks, international organizations, and foundations.

Linkages Theme Paper
No. 1

A Conceptual Framework for Studying the Links between Agricultural Research and Technology Transfer in Developing Countries

by

David Kaimowitz, Monteze Snyder and Paul Engel

May 1989

International Service for National Agricultural Research

INTRODUCTION TO THE ISNAR STUDY ON THE LINKS BETWEEN AGRICULTURAL RESEARCH AND TECHNOLOGY TRANSFER IN DEVELOPING COUNTRIES

David Kaimowitz
Study Leader

In 1987, the International Service for National Agricultural Research (ISNAR) initiated a major international comparative study on the links between agricultural research and technology transfer in developing countries. Like other ISNAR studies, this study was developed in response to requests from agricultural research managers for advice in this area. It is being carried out with the support of the Governments of Italy and the Federal Republic of Germany and the Rockefeller Foundation.

The objective of the study is to identify ways to strengthen the links between agricultural research and technology transfer systems in order to improve:

(a) the relevance of research efforts through a better flow of information about farmers' needs for the research systems;
(b) the transfer of technology to agricultural producers and other users of agricultural technologies.

Why the Study was Initiated

Many sources have noted the problem of poor links between research and technology transfer in developing countries:

"Bridging the gap between research and extension is the most serious institutional problem in developing an effective research and extension system." World Bank, 1985

"Weak linkages between the research and extension functions were identified as constraints to using the research in 16 (out of 20) of the projects evaluated." United States Agency for International Development (USAID), 1982

"All the 12 countries (in which research projects were evaluated) had difficulties of communication between research institutions and extension agencies." Food and Agriculture Organization (FAO), 1984

The serious consequences of this problem is effectively summed up in the following statement by a leading international expert in the field, Monteze Snyder: "The poor interorganizational relations between the extension agency and the research organization almost guarantee that research results will not reach farmers, and if they do, farmers will not be able to use them." Despite this situation, however, no major international study has been dedicated specifically to this issue. While there are a few good evaluation reports and academic studies in individual countries, much of what has been written about research-technology transfer links has been general or anecdotal. The results of the practical attempts which have been made to improve links have been disappointing.

A systematic study is needed to provide a set of simple, but not simplistic, suggestions on how research-technology transfer links can be improved in different situations.

Operational Strategy and Products

The study is to be conducted over a four-year period and has been divided into three stages. The first stage consists of a literature review, the development of a conceptual framework and case study guidelines, the production of 'theme papers' (*see page iii*) and pilot case study activities in Colombia. The second stage involves carrying out case studies in six additional countries — Costa Rica, Côte d'Ivoire, the Dominican Republic, Nigeria, the Philippines and Tanzania. In each of these countries the studies will concentrate on specific subsets of the national research and

technology transfer systems. They will also document the links which were involved in the generation and transfer of a small number of specific new agricultural technologies. In the third stage, the various materials which have been developed will be synthesized into one set of concrete applicable guidelines.

Ultimately, four types of documents will be published as part of this special series of papers on research-technology transfer links:

1. *Theme papers* on key linkage-related topics. These have been written by specially commissioned international experts in the field.

2. *Discussion papers* which analyse one or a few major issues emanating from the case studies. About 15 such papers are expected to be produced, written by the case study researchers. They will focus on the most outstanding features of the links observed in the cases and draw clear conclusions about them for practical use by managers.

3. *Synthesis papers* which present the lessons emerging from the case studies. These are being written by ISNAR staff.

4. *Guidelines* on how to design and manage the links between agricultural research and technology transfer for policy makers and managers concerned with the two activities. These will also be written by ISNAR staff, with input from the case study researchers, managers of national systems, and others.

We expect the theme papers to be published during 1989. Most of the discussion papers will be published during the following year and the synthesis papers and guidelines will probably be available in early 1991. Individual copies of all these papers will be available from ISNAR upon request, at the discretion of ISNAR.

LIST OF THEME PAPERS IN THE SPECIAL ISNAR LINKAGE SERIES (forthcoming in 1989)

A Conceptual Framework for Studying the Links between Agricultural Research and Technology Transfer in Developing Countries
D. Kaimowitz, M. Snyder and P. Engel

The Agricultural Research-Technology Transfer Interface: A Knowledge Systems Perspective
N. Röling

Private Sector Agricultural Research and Technology Transfer Links in Developing Countries
C. Pray and R. Echeverría

The Political Economy of the Development and Transfer of Agricultural Technologies
H. Sims and D. Leonard

The Implications of On-Farm Client-Oriented Research for the Relationships between Research and Extension
P. Ewell

Intergroup Relationships in Institutional Agricultural Technology Systems
P. Bennell

The Effect of Changes in State Policy and Organization on Agricultural Research and Extension Links: A Latin American Perspective
R. Martínez Nogueira

Interorganizational Relationships between Agricultural Research Institutions and Extension Agencies
J. T. Kang (tentative)

Table of Contents

Preface

DURING AN INTERNATIONAL workshop on agricultural research management held by the International Service for National Agricultural Research (ISNAR) in 1986, leaders of agricultural research systems asked ISNAR to help them improve the links between research institutions and technology transfer institutions. The leaders of the more mature systems expressed concern about having technology which in many instances was not being adopted by farmers or, in some cases, was not even reaching them. For the leaders of less developed systems this problem had not yet arisen but they were concerned that when it did, it would often have to be tackled in the context of weaker technology transfer institutions and almost non-existent links.

The leaders' request had a sense of urgency about it because in many countries the national policy makers, dependent upon unreliable information on the impact of agricultural research and faced with intense pressures to cut budgets, have reduced the national allocation of resources to research. In addition, many foreign donors have made improved links between agricultural research and technology transfer institutions a precondition for further funding.

In response to the request, ISNAR initiated a four-year international comparative study of the problem. The objective of the study is to identify the key factors influencing the effectiveness and efficiency of research-technology transfer links, to isolate and examine the weaknesses in these links and to recommend ways in which these weakness might be overcome.

In the discussions on how to implement the study, it became obvious that the existing literature on the subject was largely prescriptive, and would not provide the necessary basis for the study. A fresh approach was needed, and we decided to ask internationally recognized experts on the subject to write a series of papers examining all the issues relevant to research-technology transfer links. Seven papers were written, each one approaching the subject from a different perspective and yet complementing the others in such a way as to provide the basis for drawing up a framework within which the study could be carried out.

This framework is the subject of this paper, and represents the first phase of the ISNAR study. It is the result of 18 months spent synthesizing the experts' contributions and reviewing the available literature. The second phase will use empirical case studies from different countries to assess and illustrate the framework's validity.

The hypotheses presented in this paper range from assertions which are little more than common sense to those which are fairly controversial; the hypotheses appear in italics, to differentiate them from the rest of the text. The key point at this stage in the study is not to rigorously defend the hypotheses, but to throw them open for wider debate and empirical examination.

Acknowledgements

This paper synthesizes the contributions of seven papers commissioned by ISNAR as part of an international project to study the links between agricultural research and technology transfer. The authors of these papers were: Paul Bennell, Ruben Echeverría, Peter Ewell, Jae Tae Kang, David Leonard, Roberto Martínez Nogueira, Carl Pray, Niels Röling and Holly Sims.

The project's Advisory Board played an important role in conceiving the paper. The members of the Advisory Board are: John Coulter, David Leonard, Niels Röling, Burton Swanson, Eduardo Trigo and Taiwo Williams.

All the members of the project's core group read various versions of the paper and made useful amendments and comments. The members of the core group are: N'Guetta Bosso, Robin Bourgeois, Paul Marcotte, Ajibola Taylor, Anna Wuyts and Larry Zuidema. Additional comments came from Anthony Bebbington, Hunt Hobbs, Deborah Merrill-Sands and Willem Stoop. Any remaining shortcomings in this paper, however, are the responsibility of the authors.

INTRODUCTION

MANY STUDIES and program evaluations have identified weaknesses in the links between institutions responsible for agricultural research and those concerned with transferring technology to farmers as a major obstacle to the development and application of beneficial new technologies in developing countries (World Bank, 1985: 79-80). In response to this, the leaders of these institutions, and those who fund and oversee them, have attempted to identify policies and organizational structures that would strengthen the relationship between research and technology transfer.

A number of models have been put forward as possible solutions. Among the most prominent are the US Land Grant model, which combines research, extension and education in one institution; the Training and Visit system, which involves subject-matter specialists and regular training of extension workers; and farming systems research, which emphasizes the role of constraint diagnosis and on-farm trials. Other suggestions include setting up joint committees of various sorts and establishing or strengthening agricultural information departments.

Experience has shown, however, that it is impossible to come up with a set of general recommendations which would be appropriate in all circumstances. Solutions which work well in one context perform poorly in others. While some characteristics are common to all situations where technologies are successfully developed and delivered, these tend to be of a general nature; the specific mechanisms for maintaining research-technology transfer links vary considerably from one situation to another.

However, when asked for advice on how to improve the links, we should be able to say something more than "it depends on the circumstances." This paper presents a conceptual framework and a set of hypotheses which may enable us to offer more meaningful advice once our study has been completed. It does not attempt to prescribe solutions to the problems of linking research with technology transfer, although we have fleshed out our conceptual framework with relevant observations wherever we have felt able to do so at this stage in our study.

In particular, the paper addresses four basic questions:

- What linkage mechanisms exist and what are their characteristics?
- What contextual factors influence which linkage mechanisms are appropriate to use and how?
- Which of these contextual factors can be controlled or influenced by policy makers and leaders of research and technology transfer institutions?
- What limitations do contextual factors impose upon the use of linkage mechanisms?

The term 'linkage mechanisms' refers to the specific organizational procedures used to maintain research-technology transfer links. 'Contextual factors' includes all the factors that affect the use and relevance of linkage mechanisms. Some contextual factors are internal in that they can be controlled or influenced by the leaders of the institutions; others are external and are influenced by the institutions' broader physical, political and socio-economic environment (Merrill-Sands and McAlistair, 1988: 26).

Contextual factors can be divided into political, technical and organizational factors (Lane et al, 1981: 15). 'Political' does not refer here to party politics or broad government policies but to institutional politics and the interest groups which play a role in them; among these groups are those which are internal (such as research and technology transfer personnel), those which are external (such as national policy makers, foreign agencies and private companies) and those whose involvement can be both internal and external (such as farmers). We need to know what role these groups play in the creation of values, rewards and sanctions which inhibit or facilitate collaboration between research and technology transfer institutions. The technical factors are the activities and methods specifically associated with the development and transfer of different types of agricultural technology to different environments and target groups. The organizational factors include the division of tasks, resources and authority between different organizations and individuals, and the internal management and informal dynamics of each organization and its components.

In some situations, the research-technology transfer relationship is not the critical constraint, such that manipulating linkage mechanisms and the contextual factors that condition them would make little difference. Changes in other areas must come first. In those situations where the relationship is critical, the linkage mechanisms and contextual factors which can be manipulated and those which are fixed may vary in each situation. Management must, in each case, identify the factors that can be controlled, determine the options available, and make hard decisions.

This framework, and the study of which it forms a part, are meant to provide a road map for that process. They should help leaders of research systems find out what paths exist and where they lead. The specific routes to guaranteed improved performance are not yet known, but this paper gives some indications of their general direction. It opens with an elaboration of the key concepts of the framework, and then discusses the criteria for evaluating performance. This is followed by analyses of the political, technical and organizational factors which affect linkage mechanisms in the development and transfer of agricultural technology.

KEY CONCEPTS

Research and Technology Transfer

THE TERMS 'research' and 'technology transfer' have both functional and institutional meanings. The functional meaning relates to the *tasks* involved in the development and delivery of technology. The institutional meaning relates to the *institutions and personnel* responsible for carrying out this process.

Throughout this paper we have used these terms in both their functional and institutional sense, as is common practice; it will be evident from the context in which the terms appear which usage is being referred to.

The main tasks of research are:

- discovery;
- exploratory development;
- technology consolidation.

Discovery is the process of collecting information and/or searching for relationships between variables, the specific usefulness of which is as yet undetermined. This process is often also referred to as 'basic research'.

Exploratory development is concerned with the identification, understanding and control of the interaction between a proposed technology and the physical, economic and/or social environment in which this technology will ultimately be used. This process is often labelled 'applied research'.

Technology consolidation is the process of translating the results of basic and applied research into specifications for a new technology and of ensuring that these specifications are appropriate for the type of farmers for whom the technology is intended. This involves some adaptive research, but it also includes all the work which is carried out to determine how to present and package a new technology and to identify exactly who might be interested in using it.

The main tasks of technology transfer are:

- technology production;
- delivery of technologies to farmers;
- monitoring and evaluating the use of technologies.

Technology production is the process of producing the materials (physical inputs and/or information) in sufficient quantity and of making these materials available to those responsible for technology delivery.

Technology delivery is the process in which the technology is promoted and distributed to farmers. In most cases, technology is delivered through many channels and over varying lengths of time; as a result, what the farmers receive is often incomplete and contradictory.

Monitoring and evaluating the use of technologies involves ascertaining whether farmers have acquired the new technology, assessing the extent to which they adopt, adapt or reject it, and identifying the reasons underlying their response to it.

Implicit in the tasks outlined above is the assumption that they occur in a logical sequence; indeed, common sense and much of the available literature support this assumption (McDermott, 1987). In practice, however, many of these tasks may be performed simultaneously. Work may begin with exploratory development rather than discovery, or new research may be carried out on a technology that is already in the process of consolidation.

A variety of institutions and personnel play a part in carrying out research and technology transfer tasks. It is also important to note that many research institutions and personnel may be involved in producing, delivering and evaluating new technologies, while many technology transfer institutions and personnel may be active in discovering, developing and consolidating new technologies.

Technology Transfer or Extension?

We have used 'technology transfer', rather than the more familiar term 'extension', throughout this paper, apart from a few contexts in which national extension services are specifically discussed. The reasons for this decision are:

1. It is important to include the role of inputs and services in the discussion of technology development and delivery. This broader view is captured by the term 'technology transfer', whereas 'extension' implies a more limited focus on education/information.

2. Some of the activities associated with the term 'extension', such as informal education in nutrition and health, are not within the scope of this paper.

3. 'Extension' is now usually associated with conventional public sector extension services. 'Technology transfer', however, can be applied not only to these services but also to those provided by many other institutions or organizations, such as private firms, parastatals, non-governmental organizations, formal educational institutions and producers' associations.

In this paper, 'technology transfer' is not restricted to meaning a one-way flow of materials and information from those who develop and deliver the new technology (usually professional and paraprofessional personnel) to those who use it (the farmers, who are often mistakenly assumed to be less knowledgeable). It implies a two-way flow of technical information between these groups. Materials and information are never simply 'transferred' to the farmers; they are adapted and assimilated. Farmers do not only receive materials and information; they also provide information, both to other farmers and to those responsible for delivering materials and information.

Institutional Agricultural Technology Systems

An agricultural technology system (ATS) consists of all the individuals, groups, organizations and institutions engaged in developing and delivering new or existing technology. This definition is somewhat different from that of Röling (1988) and others, in that we make no assumption that the different institutions in the system work together or in a compatible fashion, nor are we using the word 'system' in the dynamic sense commonly found elsewhere in the literature. ATS participants may nonetheless be linked in terms of their geographical focus or in terms of their focus on a particular commodity, or both (Engel, 1988: 2). 'New technology' refers not only to technology that has been recently developed but also to older technology which is being introduced to a new area or new group of users.

In many agricultural technology systems, some sources of information, knowledge, physical inputs and services may be entirely unconnected with any formal institution, but this feature is not within the scope of this paper. We are concerned here only with those parts of an ATS in which a set of formal institutions or units are involved; to denote this, we have used the phrase 'institutional agricultural technology system(s)' (IATS) in this paper.

In order to carry out their various research and technology transfer tasks, IATS engage in a number of basic activities. These activities can be categorized into:

- those concerned with problem identification and the acquisition, transformation, storage, retrieval, dissemination and use of knowledge;
- those concerned with the production of material goods, including conceptualization, design, prototype production, testing, multiplication, packaging and distribution;
- those concerned with the management of and administrative support for the above activities.

In all three categories, there are various types of skills involved, ranging from specific technical and socio-economic skills to more general managerial, communications and participation skills. This variety of skills, combined with the fact that most IATS encompass many different client groups, agro-ecological and administrative regions, products, approaches and disciplinary fields of interest, makes even the smallest IATS quite complex.

Links and Linkage Mechanisms

As indicated above, 'research' and 'technology transfer' have both a functional and an institutional meaning. Thus, the links between them may be discussed from two points of view: they may be seen as functional links, which relate to research and technology transfer activities; or as institutional links, which relate to the institutions and personnel that carry out these activities. In the former case we are thinking of links as activities which aim to form a bridge between research and technology transfer. In the latter, we are discussing the exchange of resources (such as information, money, labor and materials) between institutions and personnel. In this paper, the general term 'link' is usually used, since both viewpoints are normally included in the discussion. However, there are a few contexts in which we specify our viewpoint by using the terms 'functional links' and 'institutional links'.

The organizational procedures used to establish, maintain or improve links are termed 'linkage mechanisms'. These mechanisms can be characterized according to the following attributes:

- whether they are formal or informal, regular or ad hoc, mandated or voluntary, permanent or temporary;
- whether they are facilitative mechanisms (that is, they provide resources) or control mechanisms (that is, they determine how resources should be used) (Leonard, 1982: 36);

- the amount and type of resources exchanged;
- the administrative level at which they operate;
- whether they focus on programming activities or are concerned with implementation or evaluation;
- the numbers of individuals involved.

A scale can be created going from the least to the most demanding types of linkage mechanisms. Mechanisms for facilitating the exchange of information would be at the lower end of this scale; those for implementing joint activities would be at the higher end; and those for the joint planning of independently implemented activities would lie somewhere in between.

Formal and informal links. The degree to which a link is formal refers to whether or not it is given official sanction (Snyder, 1988: 84). In theory, formal linkage mechanisms follow officially specified patterns, whereas informal ones do not, being built on personal relations. In practice, the distinction between the two is less clear cut: most formal interactions have informal aspects, and vice versa.

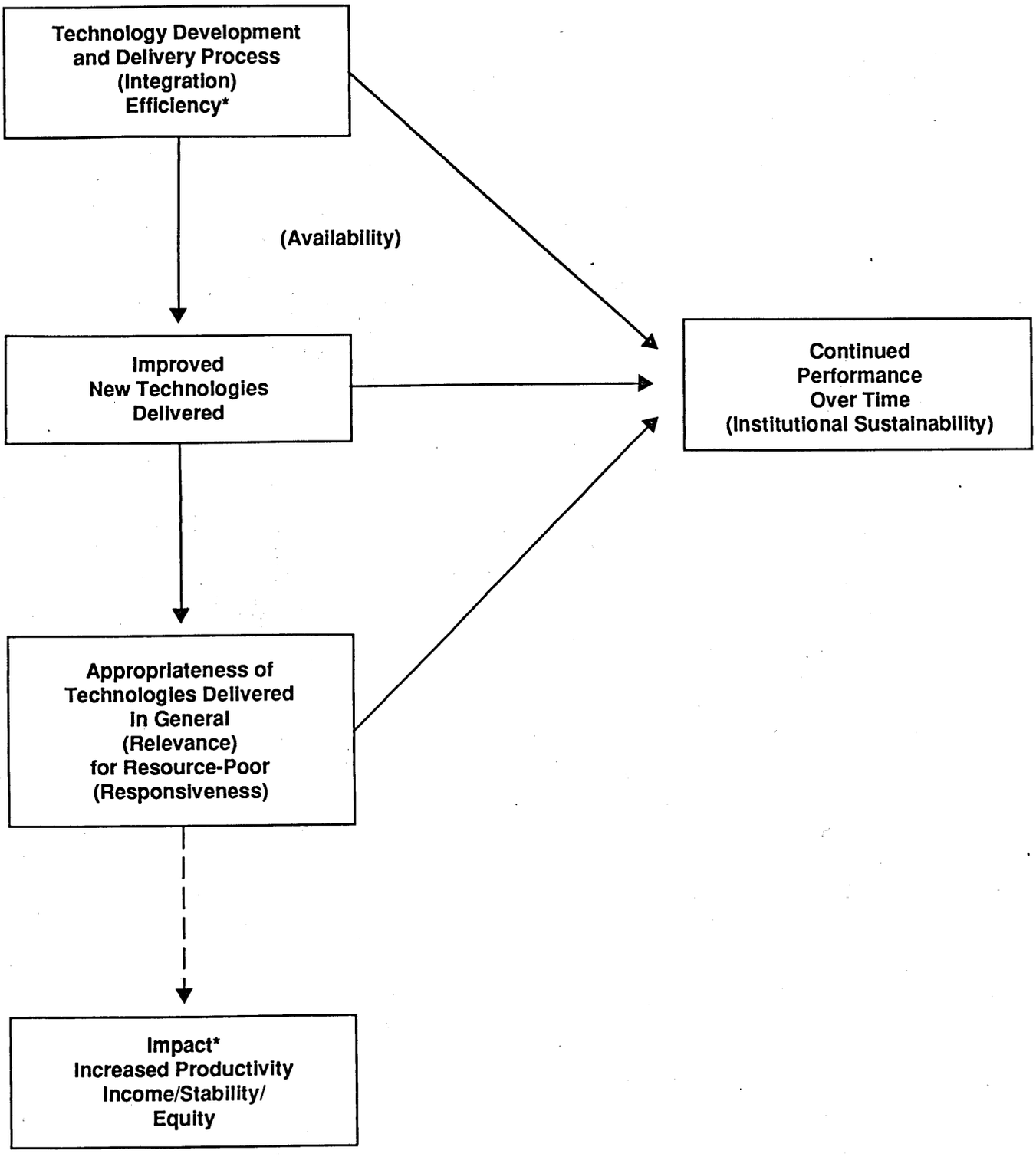
Formal linkage mechanisms which are mentioned in the literature include: committees, task forces, liaison departments and officers, subject-matter specialists, agricultural communications units, pre-extension units, the contracting of research by development agencies, farming systems programs, joint activities, publications, presentations and demonstrations, staff exchanges, inter-agency agreements, service provision, joint plans, matrix management, shared supervisors, policy mandates, and meetings.

Informal mechanisms consist of communication and the exchange of resources without official sanction or through personal contacts. Communications studies have found that people who maintain personal contacts beyond their unit play a key role in inter-unit exchanges of information.

Just because a mechanism is informal does not mean it cannot be managed. Management can either foster or hinder the establishment of informal links. This can be done by changing the physical proximity of groups, promoting joint social activities, encouraging staff rotations, publicly sanctioning informal contacts, placing people in certain positions on the basis of their compatibility and previous personal ties, and a number of other measures.

Institutionalization refers to the degree to which a pattern becomes routine and follows set rules. For the most part, institutionalized mechanisms are more permanent and formalized, ad hoc mechanisms more temporary. Ad hoc and temporary mechanisms, such as task forces, have the advantage of being designed to meet a specific objective. Their extraordinary nature can create a sense of urgency. Institutionalized mechanisms permit the development of mutual expectations and can be improved over time. Although there are important exceptions, recurrent problems lend themselves more to formal approaches.

The Relationships between the Performance Evaluation Criteria



Note: * not explicitly covered in this paper

Source: Adapted from Engel, 1988b

CRITERIA FOR EVALUATING LINKS

ANY DISCUSSION on improving the relationship between research and technology transfer requires some idea of what constitutes a good relationship. We have established five criteria for evaluating the links which form the basis of this relationship:

- IATS integration
- Availability of new technologies
- Relevance of new technologies
- Responsiveness of new technologies to the needs of resource-poor farmers
- Institutional sustainability

These criteria will enable us to study links from a purely analytical and objective standpoint. Although only one criterion, integration, refers to the links themselves, high performance on the others provides indirect evidence of effective links. The criteria are not necessarily the criteria used within IATS to evaluate research-technology transfer links, for such criteria often contain a more subjective element in that they reflect not only the officially stated goals of an institution but also those of the individuals within it. This is an important point, for too often those who evaluate IATS assume that individual goals are the same as the officially stated goals; in reality each individual has his/her own set of personal, institutional, social welfare and/or political goals over and above the official goals. These personal goals may be both rational and legitimate, and should be taken into account when seeking to understand the behavior of an institute and its staff, but they do not provide a basis for evaluating the efficiency and effectiveness of an IATS.

All IATS will perform better with regard to some criteria than to others. Although we have used several criteria, no attempt has been made to weight them; each one is regarded as just as important as the others and must be examined independently. Neither has any attempt been made to produce an overall success indicator. Instead, the criteria are best used simply as a checklist. Policy makers and managers may find there are trade-offs in their achievements.

The criteria are defined below, and a brief note is added on the issue of the impact of new technologies on welfare. Then, in the next three sections, we will examine how political, technical and organizational factors affect the performance of IATS in relation to these criteria.

Definition of the Criteria

IATS integration. The idea that a high level of coordination, collaboration and communication within an IATS is a prerequisite for high system performance constitutes our first criterion, integration. The level of integration is gauged according to the amount of resources exchanged between the parts of an IATS and the importance that each part attaches to these resources.

IATS which regularly make available relevant new technologies will exhibit high levels of integration between research and technology transfer.

However, it must be pointed out that the existence of a high level of integration is no guarantee that relevant new technologies will regularly be made available, since other conditions must also be met. There is little value in coordination, collaboration and communication for their own sake. Similarly, while a low level of integration contributes to the failure of an IATS to regularly make new technologies available, it need not necessarily be the only reason for this failure.

High levels of integration do not necessarily imply the absence of conflict between researchers and technology transfer workers. And where conflict exists, it may make a more positive contribution to research-technology transfer links than is often thought; it can prevent stagnation, highlight important issues which might otherwise be overlooked, stimulate both groups to work harder, foster creativity and provide a forum for problem solving (Arnold and Feldman, 1986: 210-211). High levels of integration are best achieved by effectively managing conflicts, not trying to suppress them.

Another important aspect of integration is efficiency. Integration is costly in terms of time, money and other resources and generally involves a reduction in autonomy. Some integration is necessary, but beyond a certain point devoting additional resources to integration in preference to other activities will be counterproductive. On purely theoretical grounds, efficiency is important enough to be included as a separate criterion. In practice, however, it is difficult to assess.

Availability of new technologies. The term 'availability' is used to cover the process in which a new technology is invented, technology transfer workers and producers are made aware of it, and producers are provided with access to the inputs and services necessary to use the new technology. The degree of availability depends on how

much technology is produced, how effectively it is promoted and how reliable and convenient the inputs and services needed by the producers are.

Relevance of new technologies. A new technology is relevant to a group of farmers if it responds to their needs. The best way to assess the relevance of a technology that is widely available is to look at the extent of its adoption. There are a number of variables which determine the extent of adoption, including the profitability and social acceptability of the technology, its importance to producers' systems of production, and whether or not it was developed in response to a clearly articulated demand from producers or technology transfer workers.

Responsiveness of new technologies to the needs of resource-poor farmers. This is exactly the same criterion as relevance, only it refers to whether the technologies are relevant for resource-poor producers as opposed to other types of producers. It has been included because there is strong evidence that the linkage mechanisms required to serve high-resource farmers may be significantly different and, generally, easier to develop than those needed to serve their poorer counterparts.

Institutional sustainability. IATS which appear quite successful based on an evaluation carried out over a particular period may seem less so during a subsequent evaluation. Thus an important criterion is the ability of an institution to sustain its performance. Because of the sustainability issue and the fact that technology development and delivery is a slow and often discontinuous process which may take years before coming to fruition, performance should be assessed only over a long period.

Impact of New Technology on Welfare

None of the criteria outlined above relates specifically to the impact of IATS on the welfare of producers and consumers.

Integration deals only with the system's efforts, not its results. Availability focuses on the ability to produce and deliver outputs, but not on the impact of those outputs (Snyder, 1987: 26-30). Sustainability deals with the performance of institutions, not with the impact of that performance on producers. Only relevance and responsiveness to the needs of resource-poor producers are in some sense connected to impact in that producers would be unlikely to adopt technologies which adversely affected their welfare.

The impact of new technology on welfare could be examined on the basis of a number of aspects, including increased farm income, reduced risk, resource conservation, improved health, better security and overall economic growth. However, because there are so many variables which affect these aspects, it is practically impossible to establish a direct correlation between research-technology transfer links and the impact of new technology on welfare.

POLITICAL FACTORS

THE POLITICAL factors which influence research-technology transfer links can be divided broadly into:

- those which determine what pressures, external and internal, there are on institutions and personnel within IATS to achieve high levels of performance;
- those which determine the quantity and quality of the resources of IATS.

With reference to the first group, to impose goals on institutions and personnel within IATS and to provide them with all the necessary resources to meet these goals would have little effect unless they had the *desire* to achieve the stated goals; and that desire depends largely on what incentives are also provided. With reference to the second group, many political factors come into play in determining whether or not IATS have adequate resources to fulfil their mandates.

In essence, then, without adequate resources *and* the desire to use them effectively, no mechanism created to improve links is likely to produce satisfactory results.

Political Pressures

In the absence of positive external pressure from national policy makers, foreign agencies, farmers or the private sector, the dynamics of an institution tend to be dictated by internal pressures, resulting in poor performance.

This hypothesis is borne out by the situation found in many low-income countries and is the result of historical factors and current political and social structures (Sims and Leonard, 1988: 1).

The historical legacy. In most low-income countries there is a marked difference between the historical legacy of the commercial agricultural sector and that of the subsistence sector. In the case of the former, foreign settlers and indigenous landed elites had close and generally direct contact with researchers. Researchers endeavored to meet commercial farmers' needs for several reasons: they felt obliged to do so; they had a relatively small group to deal with; and they had similar backgrounds to the farmers and therefore could communicate relatively easily.

Responsiveness to the needs of the subsistence sector, however, was poor. Little or no technology was produced specifically for this sector, and where extension services existed they often focused on non-technological activities. Research-technology transfer links were characterized by a great difference in status between researchers and technology transfer workers and between the latter and farmers. Information flowed only one way, from the researchers 'down' to the farmers. Responsiveness to the needs of resource-poor farmers would often increase significantly in times of famine and other similar crises, only to decrease again once the crisis was over.

Thus, in terms of the criteria defined above, the commercial sector benefited from substantial technology availability and relevance, as well as from institutional sustainability; there was integration in a sense, but much of it was directly between researchers and producers. For the subsistence sector, however, IATS performed poorly in relation to all the criteria.

Current political and social structure. Where external pressures on IATS have not intervened to change the historical pattern, it has persisted or, in some cases, degenerated to the point where the attempts being made to meet the needs of either the commercial or the subsistence sector meet with little success.

In many cases, the IATS in low-income countries face little external pressure to improve research-technology transfer links other than that applied by foreign donors. For political reasons, governments are reluctant to allow farmers' organizations to be formed or to become too powerful. Usually, the only types of organizations found among resource-poor farmers are informal networks of the patron-client type; stronger members take on the role of patrons, the others assume the role of clients. The members of these networks exchange goods and services, with most of the benefit accruing to the patrons.They may take advantage of the credit, inputs or services offered by IATS but they rarely exert pressure on the IATS to produce new technologies.

The dominance of patron-client politics in low-income countries has a twofold effect on research-technology transfer links:

- technology transfer services come under pressure to provide more than just advice and are pushed towards concentrating on activities which are likely to make them less integrated with research; for example, they offer credit and inputs rather than advice and information, or concentrate on servicing the needs of the patrons, who may have some political power, rather than those of the clients, who have none;

- research institutions tend to become oriented towards the rest of the scientific community or towards their hierarchical superiors, which results in the tendency among researchers to prefer to do on-station rather than on-farm work, to concentrate on export crops and to live in urban areas where they can interact with people of similar backgrounds rather than in remote areas where they would have more interaction with resource-poor farmers.

In essence, the lack of external pressures may result in institutions and personnel becoming motivated more by their own social and political needs than by the needs of resource-poor farmers. Many of these institutions suffer from lack of funding, and this further reduces the level and quality of the work done by their personnel.

Effects of external pressures. As implied in the hypothesis, good institutional performance requires positive external pressures on IATS by national policy makers, foreign donors, farmers and the private sector. The nature of these pressures is described here; this is followed by an outline of how external pressure may, in some cases, adversely affect research-technology transfer links.

National policy makers. Generally, national policy makers intervene forcefully in technology issues only in exceptional circumstances, such as disease outbreaks, major crop shortfalls, rapidly rising food imports, rural unrest, a highly publicized international breakthrough in technology or a radical change in government. At such times, they will exert pressure on IATS to cut through red tape and bottlenecks to produce quick results; new resources are brought in, objectives are clarified and there is an overall, albeit often short-term, dramatic improvement in performance. More consistent pressures are exerted by national policy makers usually only in those countries where one or a few crops play a dominant role in society, as in the case with rice in Asia or sugar in the Caribbean.

Foreign donors. This term includes multilateral and bilateral aid agencies, externally sponsored non-governmental organizations (NGOs) and international agricultural research centers (IARCs). These groups provide a substantial proportion of the resources required by national institutions in low-income countries; their tendency to concentrate their funding on program expenses, equipment and training, rather than on salaries, and their ability to elicit government matching funds for their projects give them greater leverage than their overall budget share might warrant.

Until recently, foreign aid agencies regarded research and technology transfer as separate systems. This approach is now changing, and they are making improved links between the two a precondition for further funding. In addition, they are increasing financial support for the development of technologies relevant to the needs of resource-poor producers. Externally sponsored NGOs are carrying out innovative participatory projects. IARCs are providing researchers and, to a lesser extent, technology transfer workers with incentives to engage in more relevant work; they are also trying to mobilize more external funding for linkage activities, such as extension training, agricultural communication and liaison, farming systems research, social science programs and the use of subject-matter specialists. This has provided an incentive for those working in the national institutions to focus more attention on research-technology transfer links.

Farmers. As indicated above, resource-poor farmers in low-income countries are seldom able to exert pressure on national institutions, but there are situations in which they may benefit from the pressures exerted by other producers. This is most likely to occur where there is a group of more affluent and politically influential farmers who have the resources and incentives to invest in research-generated technologies. Although this may bias researchers and technology transfer workers towards the needs of this more affluent group and thus detract from efforts to meet the needs of resource-poor farmers, to the extent that the two groups of farmers grow similar crops, contend with similar agro-ecological conditions and face similar price structures and resource scarcities "poor farmers may gain considerably more benefit from the political ability of the large owners to lobby for agricultural interests than they lose in bias of the systems against their particular needs." (Sims and Leonard, 1988: 49)

Private sector. Private companies influence public sector performance both directly and indirectly. Examples of direct influence are representation on public advisory boards, funding of public research projects, direct contact with researchers and technology transfer workers, and private (or public) delivery of publically (or privately) developed technologies. An example of indirect influence is the implicit competition which takes place when private and public sector agencies are simultaneously involved in similar activities (Israel, 1987: 89-107). The degree of private sector involvement and of its influence on research-technology transfer links depends on the level of a country's development and on government regulations and incentives.

Although the involvement of private companies may strengthen some links between research and technology transfer, it may also bias public research and technology transfer towards producing capital-intensive technologies which have little relevance to the needs of resource-poor farmers. However, as in the case of the pressures exerted by more affluent farmers, the spin-offs for the poorer farmers may outweigh this disadvantage, at least in the short term; in the longer term, because of the profit motive, private company involvement may mean that little attention

is paid to the effect of new technologies on the physical environment.

An important aspect of private sector pressures on IATS is the influence exerted by large plantations and processors, particularly those with monopoly power. These concerns are usually in a position to finance technological activities and to make full use of new technologies; sometimes they develop and deliver technologies themselves, sometimes they contract out these activities to the public sector or a private company. This will have a positive effect in terms of all the evaluation criteria except responsiveness to resource-poor farmers, few of whom grow crops for processing.

Limitations of external pressures. External pressures are often heavily resisted by the institutions within the IATS. This is partly because of people's natural tendency to resist any incursion on their autonomy, but there are several other, more valid reasons for such resistance.

Firstly, those exerting pressure often do not adequately understand the problems they wish to see solved. Thus they may demand results which are not feasible or cost-effective, may overlook potential dangers or secondary effects, and may place undue emphasis on short-term problems and on the symptoms of problems rather than the underlying causes.

Secondly, the technology development process is often long term, whereas external pressures often emanate from transitory and unstable sources. For example, frequent changes in government result in changes in national priorities and policies; within the international donor community, topics and approaches go in and out of fashion. If institutions always respond to these fluctuating external pressures by changing their structures and activities, the chances of building up the effective relationships needed to create sound research-technology transfer links are severely reduced.

Thirdly, competing external demands may have a very damaging effect on institutions. The emphasis placed on one aspect of an institution's activities by a foreign donor might conflict with the demands made by government ministries, and this conflict will be echoed in the institution's performance. In some countries, competition between donors has brought national institutions to a state of complete paralysis.

Fourthly, as already noted, external pressures often reduce rather than increase the responsiveness of researchers and technology transfer workers to the needs of resource-poor farmers.

Lastly, external pressures may force leaders of institutions to indulge in 'window-dressing' to create the impression that they are responding to external demands. For example, if improvement in research-technology transfer links is a precondition for external financing, committees may be constituted and documents published to create the illusion this improvement is under way; but such manoeuvres may bear little relation to the real situation (Röling, 1988: 80, 96). Although 'window-dressing' may have some positive results, it does add to the workload of institutions and it makes critical assessment of linkage mechanisms difficult.

The Ability of IATS to Command Resources

The quantity and quality of resources available for technology development and delivery varies according to region, country, client group and commodity. In general, high levels of appropriate resources are associated with:

- agricultural products which are strategically important because they generate foreign exchange or are staples in the diet of the urban population;
- client groups who have the ability and incentives to exert pressures on technological institutions;
- favorable agro-ecological and socio-economic environments in which there is substantial use of purchased agricultural capital goods.

A more tentative relationship exists between those IATS with high resource availability and the 'size' of the commodity, client group or area they serve. Size is difficult to define; possible factors on which a definition could be based are value of output of the IATS' clients, the number of people served and the availability of resources which can be tapped to support technological activities.

Greater access to resources implies the ability to sustain larger, more sophisticated institutions. This assumption underlies the following hypothesis:

IATS which have high resource availability are more differentiated than those with low resource availability, leading to more complex, well-endowed and sophisticated linkage mechanisms.

IATS with high resource availability are generally characterized by a greater division of labor than that found in IATS with low levels of resources, and by a greater ability to make use of slack resources, to allocate more funds to linkage-related activities and to create more structured and formal linkage mechanisms (Stoop, 1988: 25). Researchers and technology transfer workers in well-endowed IATS

tend to be from similar backgrounds and to share similar values, which promotes better communication and empathy between them; however, it should be noted that this communication suffers if these personnel become too specialized.

IATS with high resources are generally those in areas which offer a relatively wide range of amenities (schools, hospitals, cultural opportunities, etc) for researchers and technology transfer workers. Hence, these IATS are able to recruit and retain more educated, specialized, higher caliber personnel, which in turn promotes more effective communication. As technology transfer workers become better educated, they are more able to assume responsibility for adaptive research and specialist tasks formerly handled by researchers.

Farmers served by high-resource IATS are often better educated and organized and thus more able to pressure institutions and to understand the information provided by them. There tends to be more direct contact between farmers and researchers in these circumstances and a larger variety of channels through which farmers receive and provide information (Stoop, 1988).

In the light of the points outlined above, it might well be asked what can be done for those regions, countries, client groups and commodities where the quantity and quality of resources commanded by IATS are low. There are three possible courses of action.

Firstly, an attempt could be made to improve the resource base through the use of people who have an ideological commitment to working in situations where others, motivated solely by material considerations, would not be willing to work. Such people can be found within NGOs which have a humanitarian or religious base; other possible candidates are politicized professionals and, in developing countries ruled by highly ideological regimes, the young people.

Secondly, the tasks carried out by IATS can be simplified to allow them to be performed with the resources, particularly human resources, that are available. It may be feasible, for example, to carry out farmer-to-farmer interchanges, simple trials and practical experiments with new plant species using relatively limited local resources. More use can be made of paraprofessionals and farmers. Although the results of such efforts will probably be more limited than those when specialists are involved, some results are better than no results.

Thirdly, efforts can be made to provide disadvantaged groups with skills and levels of organization that will enable them to interact effectively with the institutions in the IATS and to demand resources from policy makers and external agencies. In some cases it may be more effective to devote any available resources to creating this organizational capacity than to spend them on the IATS.

In discussing the ability of IATS to command resources it is necessary to distinguish between resources which are externally generated and those which are generated from within the group or area the IATS serve. As noted previously, externally generated resources may be unstable. Internally generated resources might be more stable in those situations where the relevant group's own resources and its concern with technological issues are relatively stable; groups which provide IATS with resources during a crisis, or are vulnerable to fluctuations in the prices of their products, are unlikely to be able to sustain their efforts in the long term.

TECHNICAL FACTORS

WHAT TYPE OF research-technology transfer links are most appropriate depends a great deal on the nature of the activities the IATS is assigned to carry out. This section discusses the technical factors relevant for linkage design. It looks first at the problem of how to involve the farmer in technology development and delivery and then examines how the activities associated with these tasks vary according to the types of environments and technologies involved.

Farmer Input and Targeting

Linkage mechanisms that give farmers and technology transfer workers opportunities for input and feedback early on in technology development, and the accurate identification of target groups, are both required for the production of relevant new technologies.

Links may be direct, consisting of participation by farmers in setting the research agenda, or of diagnostic research in the farming community to assess user preferences and needs (Röling, 1988: 28). Alternatively, inputs and feedback may be channeled through technology transfer workers, who then serve as an indirect link.

For these links to be effective, producers, researchers and technology transfer workers will often have to be taught participation skills to allow them to interact effectively with each other. These skills may include the learning of local languages, the use of instruments to obtain technical measurements, how to articulate needs and how to take part in experiments.

The early targeting of user groups is a prerequisite for the successful development of new technology. Within the broad category of agricultural producers there are many subgroups, each with its own technological requirements. These subgroups and their needs must be identified, and the development and delivery of technologies must take their existence into account. This targeting process is closely related to what the farming systems literature calls 'identifying recommendation domains' and commercial marketing research refers to as 'market segmentation' (Röling, 1988).

Environmental Diversity

The level of integration and the complexity and/or differentiation of the tasks performed by IATS must increase as the environment becomes more diverse or unknown.

Complex tasks are those involving many variables, high levels of abstraction, and sophisticated analysis. To carry out such tasks institutions must have highly trained staff from a wide variety of backgrounds. Often, complexity is also associated with the dispersion of work locations (Snyder, 1987: 44-45). To be handled effectively, complex tasks require a more open communication system than that found in hierarchical decision-making structures, and flexibility at lower levels in determining appropriate technological responses (Lane et al, 1981: 154). Decentralization of authority, whether formal or informal, is also essential (Martinez, 1988: 6).

Hierarchical systems are those with heavy constraints on communications outside the vertical authority channels, more authoritative decision making and greater status differentials (Lane et al, 1981: 154). Examples are the Training and Visit system of extension, agricultural technology promotion campaigns, and commodity systems such as the Kenya Tea Development Authority (Chambers, 1988: 51). Such systems are normally successful only where few commodities are grown in relatively uniform, controllable and predictable conditions.

Thus task complexity is closely related to environmental diversity. This is especially marked outside the relatively uniform green revolution areas. Physical and biological diversity is found in arid areas, but it is most pronounced in the semi-arid, subhumid and humid zones. Physical variations within the same field can require different crop varieties or combinations. Differences of soil, slope and vegetation compound the problem, while multiple canopies of plants, multiple tree-crop-livestock interactions and the sheer number of different species used can be bewildering. Moreover, social diversity is interwoven with environmental diversity, such that each place and social group can be seen as unique, requiring its own path for development (Chambers, 1988: 51-52).

Diverse environments require more location-specific diagnosis of constraints and adaptation of technologies. As a result, research efforts must be more widely dispersed. This dispersion, while it separates researchers from one

another, often brings them into closer contact with technology transfer workers, offering opportunities for increased communication.

The most marginal farming systems tend to be the most complex and diverse and to face the greatest risks. Rainfed cropping systems in upland areas are generally both less productive and more diverse than irrigated systems. These environments pose more complex technical problems not only because of the multiple activities associated with them but also because less is known about them and the constraints are greater.

If IATS are to perform as well in these environments as they do in more homogeneous ones that are better endowed, they must accomplish more complex tasks. This, in turn, requires features typically found only in well-endowed IATS. The more difficult environments are usually served by IATS with very limited resources. "There are far fewer scientists per farming system, both because of the scarcity of scientists and because of the many farming systems" (Chambers, 1988: 52).

The adaptive, problem-solving approaches demanded by these diverse environments require levels of experience, education and professionalism that cannot usually be found among those working there at present. Most people with alternative employment opportunities prefer not to work in these environments, and leave after short periods of time. This imposes strong limitations on the levels of performance achievable. Thus, producers with the greatest need for a sophisticated IATS are least likely to have one.

Other Environmental Factors

Other important environmental factors which affect IATS tasks include:

- the availability of communications channels and infrastructure;
- the development of the necessary infrastructure and traditions for farmers to make use of inputs and information produced outside their communities;
- the level of pre-existing knowledge about the environment;
- the dispersion and accessibility of the farming population.

The choice of communications channels that could be used as links will depend on producers' access to and ability to use them. Thus the level of literacy among producers, the availability of television, radio, telephones and reading materials, and the way producers normally use these channels, have an important bearing.

Where input distribution channels, particularly those in the private sector, are weak, extension services often concentrate on input delivery. Dissemination of technical information becomes a less important part of their work, reducing the links with research.

Researchers face limitations in the types of technologies they can productively work on, since for many inputs the necessary infrastructure is simply not available to produce and distribute them. Furthermore, as we have already seen, producers who make little use of research-generated technologies, particularly purchased inputs, are less likely to pressure their IATS for results.

Knowledge of the environmental conditions, farming systems and technologies that producers work with also has strong linkage implications. As recent literature has shown, producers have a great deal of practical knowledge to contribute regarding the regions, technological regimes and systems for organizing production with which they are familiar (Tripp, 1988). The same may also apply to technology transfer workers. However, this advantage disappears when these groups face new situations, as is the case when farmers are resettled, radically change their farming system, or move from individual to collective production. In these unfamiliar circumstances input from producers and technology transfer workers may still be important, but it will reflect preliminary impressions rather than detailed knowledge.

Research, when faced with new environmental conditions, often has to concentrate on basic exploratory work, and in the short term has little of practical value to offer. When young institutions are pressured to produce immediate results at the stage when they are still putting together the knowledge base to respond to their task, the results are often disastrous. Progressing prematurely to technology consolidation in these conditions may be especially dangerous. In these situations researchers and technology transfer workers have the greatest need for information from producers.

When services are provided to dispersed and inaccessible farm populations, researchers and technology transfer workers have fewer opportunities for direct interaction. To be effective, technology transfer workers must be close to the population they serve. Research, however, must for reasons of cost be concentrated in relatively few locations. The resulting lack of contact between the two groups is not necessarily bad: in many cases direct contact is not the most effective or efficient means of linking research and technology transfer.

The relative dispersion and inaccessibility of researchers and technology transfer workers increases the need to decentralize decision-making on minor administrative matters. If such decentralization does not take place, communications problems between the central offices and the field locations can paralyze operations and/or make those activities which do occur less relevant to local conditions.

The Activities Associated with Different Types of Technology

Different types of technology require different linkage mechanisms; one set of mechanisms will not be adequate for IATS which deal with a wide variety of technology types.

Discussions on how linkage mechanisms work tend to be based partly on unsubstantiated generalizations. Most existing literature implicitly takes as a model the links required to develop new plant varieties. There is little reason to believe that this pattern is applicable to other technologies.

Technologies should be classified into different types only if they require distinct links for their development and delivery. The broad types we have so far identified include:

- existing and new technologies
- physical inputs and information
- private and public goods
- complicated and simple technologies
- centrally and locally generated technologies
- producer-, research- and policy-driven technologies

Existing and new technologies. *Specific linkage mechanisms are required to effectively develop and deliver new technologies in addition to the mechanisms used for delivering already existing technologies.*

Most of this paper discusses the development and delivery of new technologies. Much of the work within IATS, however, involves technologies which are already well established, at least nationally or internationally, for which the IATS does no original research or adaptation.

Most links between research and technology transfer concern such already established technologies. For example, researchers often give extension workers lectures on the production of a specific crop based on the general state of the art rather than on new trial results or a new technology. Nor is any new technology involved when a technology transfer worker comes to a researcher with a sample from a diseased crop and asks for assistance in identifying the pest which caused the damage. Similar comments could be made regarding a wide variety of support activities which researchers typically provide to technology transfer workers, such as drafting manuals or recommendations, providing laboratory and library facilities, and backstopping extension activities.

In high-performance IATS, most researchers will play some, even if only a small, role in technology transfer, and most technology transfer workers will play some part in research. In addition, those who work on the exploratory development of a new technology should also be involved in its consolidation and production.

Product champions are essential for the development and delivery of new technologies. These are people who have both sufficient interest and authority to push the new technology through the development and delivery process and help to overcome obstacles (Peters and Waterman, 1982: 203-207).

Work with already established technologies does not necessarily require either product champions or the direct involvement of researchers. In fact, most high-performing IATS shield researchers from having to devote a large proportion of their time to this type of work in order to ensure they have sufficient time for their primary responsibilities.

To be delivered and produced, completely new technologies require substantial modifications in the technology transfer infrastructure (in the case of physical inputs). This slows down the rate at which they become available. Greater contact between research and technology transfer when and/or before the technology is being consolidated reduces this time lag (Snyder, 1987: 95-96).

Crops and other technologies with which producers and technology transfer workers are completely unfamiliar have similar implications to those described for new environments. In other words, researchers, technology transfer workers and producers must work closely together to ensure that they gain maximum advantage from each other's insights.

Physical inputs and information. Some technologies take the form of physical goods. Others involve only information or cultural and management practices. The units which must be linked, the predominant communications channels, and the output control mechanisms required are different in the two cases.

The delivery of physical inputs requires a set of actors and roles which do not exist in the case of pure information technologies. These actors include input producers and

distributors and, where high levels of investments are involved, credit agencies. The presence of these additional actors/roles greatly alters the linkage dynamic. Whereas educational materials, both scientific and popular, lie at the heart of links in the case of information technologies, product distribution and market promotion are more important when physical inputs are involved.

The relation between research and input suppliers provides a potentially important additional channel for user feedback and market information. Indeed, the importance of the links between research and the supply of inputs can eclipse extension's role in disseminating technical information. Thus, breeders' relations with seed multipliers can prove more important for transferring new varieties than their relations with extension.

A more formal process for approving recommendations is generally advisable for physical inputs, because it is more costly to produce or import a new good than to recommend a new cultural practice. New products may also pose higher health, safety or environmental risks. In the case of new plant material, seed committees meet to decide whether a new variety should be released. Formal requirements are usually established for determining a pesticide's effectiveness and toxicity before it can be sold. These processes provide a forum for interaction between researchers and technology transfer workers. In contrast, a new recommendation for planting dates, pruning methods or similar practices need not be subject to a formal review process.

Private and public goods. High performance according to all our criteria except responsiveness to the needs of resource-poor farmers is more likely if the technologies are private goods. Most physical inputs are private goods, the main exceptions being goods which can be produced easily by farmers, such as self-pollinating plant varieties and natural fertilizers. As these inputs are less profitable to produce and farmers may have no interest in purchasing them, it is often as difficult to achieve high performance with them as it is with pure information technologies.

Complicated and simple technologies. Technologies which are more complicated to use or produce require greater and more sophisticated educational efforts. Manuals and/or intensive training efforts may be required. Researchers will probably need to be in regular direct contact with manufacturers.

Skills training for producers and even for technology transfer workers is often a prerequisite for using complicated technologies. This, in turn, requires changes in the roles of researchers, technology transfer workers and producers.

If use becomes very complicated, specialists (veterinarians, professional fumigators, tractor mechanics, etc) may replace farmers as the principal users. The use of these complicated technologies in concentrated areas (for example, in large irrigation projects, capital-intensive horticultural concerns or fully mechanized farms) lends itself particularly well to the development of these specialized groups.

The livelihood of these groups depends on detailed knowledge of the research-generated technologies they work with. This makes their interaction with researchers and technology transfer workers quite different from that of most producers in developing countries at present. They have more direct contact and make greater use of specialized communications channels. In time, farmers too may become more sophisticated in their approach to research-generated technologies, as their enterprises become more specialized.

Centrally and locally generated technologies. Certain technologies lend themselves to being generated in one or a few central locations. Others do not.

Technologies applicable over wider areas or in many situations can more easily be generated from central locations. For example, a new pesticide may be developed at the international headquarters of a multinational corporation for use around the world. Other technologies have only very local applicability and require multilocational field trials or other adaptive research activities.

Research on topics such as livestock and perennial crops tends to be concentrated in a few places because it is both costly and complicated. While the need for adaptive research may be great, such trials are expensive. Thus only a small number of trials can be done and the potential losses caused by doing them badly are very high. This research is also longer term and more difficult to do on farm (data requirements are heavy and farmers are less willing to risk their animals or tree crops).

Economies of scale in the production of inputs favor the concentration of research. Even if it is preferable to have a wide variety of pesticides, inorganic fertilizer formulae or tractor models to meet local conditions, producing them is usually prohibitively expensive. (Economies of scale also affect the organization of input delivery, and thus have other linkage implications).

When research is not concentrated, the physical dispersion of researchers makes them more directly accessible to technology transfer workers, whose knowledge of local conditions is likely to be relevant for the generation of location-specific technologies. Technology transfer workers also have more opportunities to become involved in research when this consists of a considerable number of decentralized, low-cost field trials with relatively unsophisticated data requirements.

Producer-, research- and policy-driven technologies. Technology transfer workers and producers concentrate their demands for research on the problems which they perceive as urgent. Frequently these concern pests or diseases. These groups also pay more attention to technologies that offer a clear short-term advantage than they do to those that appear only marginally superior to current practices or that require effective management to bring substantial benefits.

When clearly advantageous technologies become available, a considerable amount of pressure may be exerted on research for additional information and adaptation. Most research, however, tends to concentrate on the less spectacular technologies or on providing maintenance to sustain technologies which have been developed previously. The incremental improvements thus provided are harder to perceive, and hence they elicit less interest and participation.

Producers and technology transfer workers rarely emphasize long-term or less obvious problems such as preventative (as opposed to curative) health issues or resource conservation. Röling refers to technologies responding to these latter problems as 'policy driven', because getting producers to adopt them usually requires incentives provided by policy makers (Röling, 1988: 71). These incentives can be positive (bonuses, subsidized credits and inputs) or negative (regulations, sanctions) and must be incorporated into the overall activities of the IATS.

As a result of the bias in the type of technologies demanded by producers and technology transfer workers, some researchers will be under constant pressure, while others will be practically ignored. Since performance improves when external pressure is high and there is producer input, performance for producer-driven technologies will tend to be better than for those technologies which are policy- and researcher-driven.

ORGANIZATIONAL FACTORS

Institutional Structure

THE RANGE OF tasks which are performed by IATS can be divided among institutions, units and individuals in a variety of ways.

Formal boundaries between different entities simultaneously increase the interaction and communication of those within the boundary and limit access to those outside. They permit each entity to specialize with regard to the tasks it undertakes, the inputs it uses, the outputs it produces and the groups with which it interacts. While conflicts and diverging interests or strategies do not disappear, within the boundaries it becomes easier to accommodate them.

The evolution of institutional structures is a complex process. IATS change slowly through the interplay between competing interests. Personalities and informal links play an important role. Key decisions are made at many different locations within the government hierarchy. In addition, private companies, NGOs, producers' associations and other external agencies over whom the government has only a limited amount of control are now beginning to play a more important role in IATS. Differences in current structural arrangements can often be traced back to models copied from or promoted by different external groups.

While managers have some opportunities to manipulate structure, they frequently find themselves constrained by inertia, political opposition and existing legislation and regulations. This may be just as well, since major structural reorganizations are costly, create uncertainty and, if carried out too frequently, lead to attempts by lower level staff to preserve the status quo. The historical record is full of reorganizations which failed because they focused only on structure and did not address the other issues discussed in this paper.

For these reasons, structural reorganization should usually be an option of last resort. This does not mean that institutional structures are irrelevant. Structural differences have strong implications both for linkage mechanisms and for the performance of IATS. We will now discuss these implications.

Interdependence. This can take the form of task interdependence (joint activities and interchanges necessary to perform a specific task) and/or resource interdependence (where one component of the IATS depends upon another for the resources necessary to carry out its activities and meet its goals).

The literature has identified various types of task interdependence (Thompson, 1967; Van de Ven et al, 1976). The four broad categories are:

- pooled, in which each part uses a common resource base and makes a contribution to a common overall goal but there is minimal interaction among them;
- sequential, where resources flow from one part to another asymmetrically;
- reciprocal, when each part produces a product which is an input for the other;
- team, when resources and products flow freely between all members of a communications network which combines two or more parts.

Perceptions concerning the interdependencies between research and technology transfer activities have changed. "Initially both activities were considered independent but contributing to a common purpose [as in pooled interdependence]. Then, extension was thought to be sequentially linked to research, receiving its inputs from it and integrating them with other components of a package of services to farmers. Subsequently, their reciprocal dependence was recognized, with extension feeding research through the identification of problems and the supply of information for defining priorities" (Martinez, 1988: 14). Finally, as in team interdependence, there is now less distinction between the two groups, with extension agents participating in experimentation and researchers coming closer to producers.

This change of concept in the literature has not, however, been fully accepted by the relevant institutions themselves. A major current linkage problem is that while research institutions tend to recognize their dependence on extension for promoting the application of research results, extension institutions frequently feel less dependent on research. In a recent survey of extension directors from 59 low-income countries, technology and linkage problems consistently received low rankings on the directors' lists of major concerns (Sigman and Swanson, 1985: 6, 9). Either extension directors believe sufficient technology already exists for their institutions to extend, or they give lower priority to promoting new technologies than to input distribution, credit supervision or other non-technological activities.

Given the tendency for formal boundaries to create obstacles to the free flow of information and of other resources, in theory it might be desirable to try to organize structures so that all the people dependent on each other

were grouped together in a single institution. In practice, however, this is rarely possible. First, there are just too many different interdependencies (Mintzberg, 1979: 104). Secondly, factors other than interdependence must be taken into consideration when designing the structure of an IATS.

A classic example of the problems of trying to accommodate too many interdependencies through structural means can be seen where input distribution, credit supervision and the dissemination of technical information have been combined in a single agency. This improves coordination between the three activities, but dilutes the technical information component of the resulting organization to such an extent that interaction with research is sharply reduced.

The opposite can also occur. Strong research-extension links may be achieved by removing activities other than the dissemination of technical information from extension's mandate, but this will probably hinder the integration of input distribution and credit supervision. This has frequently occurred in the case of the Training and Visit system.

Other important determinants of structural design. Besides interdependence, there are five other factors of importance in designing organizational structures. These are:

- the compatibility of the management styles required by different tasks/activities;
- whether the tasks/activities involved have the same sources of legitimacy;
- size considerations;
- the proven capacity of different units;
- differences in staff orientation.

If two activities require different management styles and practices, they are generally better placed in separate units. The same holds true if they receive their political support from widely divergent groups. Administrative and supervisory economies or diseconomies of scale for different activities imply that institutions and units have a certain optimal size. There are sound arguments for assigning essential activities to a unit with a proven capacity to get the job done, even if it is not the one whose overall mandate would normally cover it. Differences in orientation among staff are another potential reason for division.

The institutional merger of research and technology transfer. Merging research and technology transfer institutions is frequently recommended in the literature as a way of increasing integration (Samy, 1986: 8,9). However, bringing the two activities together in one institution is usually problematic.

In practice, research and technology transfer often exhibit surprisingly few interdependencies. Their management requirements and political constituencies are frequently divergent and somewhat incompatible. The combined institution's resulting size may be unmanageably large. The potential benefit of increased interaction may be limited by putting the two in separate units within the same institution, and the loss of autonomy caused by being in the same institution can lead to conflicts and growing resistance among personnel who see their independence increasingly threatened (Klauss, 1979: 162).

The only situation in which bringing research and technology transfer activities together within a single institution is successful is where a system is organized around a specific region, commodity or problem. The interdependencies between research and technology transfer in these situations are much greater because both activities focus exclusively on the same crop or on the same client group. In addition, the combined size of the research and technology transfer institution is generally more manageable than it would be if broader mandates were involved.

Even if research and technology transfer are combined in the same formal organization, this will not, in itself, guarantee adequate functional links between the two activities.

Functional and market-based organizations. Another common structural issue is whether to organize the IATS on a functional basis (for example, research, extension, input distribution) or a market basis (for example, client, output, place). The evidence suggests that market-based grouping is generally more successful according to all our evaluation criteria, at least when task complexity is not very great.

Structural divisions which are based on function lack a built-in mechanism for coordinating the work flow. In contrast, "market-based grouping is used to set up relatively self-contained units to deal with particular work flows. Ideally, these units contain all the important sequential and reciprocal interdependencies.... And because each unit performs all the functions for a given set of products, services, clients or places, it tends to identify directly with them, and its performance can easily be measured in these terms. So markets, not processes, get the employees' undivided attention" (Mintzberg, 1979: 125).

The empirical evidence provides qualified support for these conclusions. One study concluded that "commodity-specific extension agencies exhibited greater coordination and less conflict than did general extension agencies" (Kang, 1984: 138). Another study found a commodity extension program performed better than general extension according to seven out of eight criteria, including the

"organization of joint programs with staff of other agencies" (Ekpere, 1973: 147).

While commodity-specific agencies may be more integrated, their integration is still far from ideal (Kang, 1984: 138). Moreover, performance differences are sometimes more related to commodity-specific agencies' greater access to resources than to their organizational characteristics (Ekpere, 1973: 158).

When geared towards cash crops, such agencies are relatively easy to set up and operate. It is more difficult to create them for subsistence crops and in low-resource areas, where they have problems dealing with the interactions between their crops and other elements of the farming system.

Missing tasks. Often no unit is assigned to or effectively carries out one or more of the tasks necessary for the development and delivery of new technologies. Who should take on missing tasks is a difficult problem for IATS leaders.

Such tasks can be assigned either to units which already exist or to new ones. The existing units have established work patterns which would have to be altered to accommodate a new task. Hence, this task may not receive sufficient attention; or, if it does, the personnel assigned to traditional unit tasks may become resentful. On the other hand, assigning the task to a new unit inevitably creates an additional set of barriers which have to be overcome before the task can be effectively integrated with others with which it is interdependent.

To achieve high performance, there must be at least one unit responsible for, and with the capacity to carry out, the following tasks: exploratory development, technology consolidation, technology production and technology delivery; as well as to provide the links between them.

Often it is not clear whether these tasks should be carried out by researchers or technology transfer workers, or both. Unless each group's responsibilities are clearly defined, researchers will generally prefer the task of exploratory development, while technology transfer workers will prefer the task of technology delivery.

This leaves no-one to assume responsibility for either technology consolidation or (to a lesser extent) technology production. McDermott calls this the "fatal gap" and argues that, unless it is filled, the division between research and technology transfer will be too wide to bridge by establishing linkage mechanisms (McDermott, 1987).

Where high performance does take place it is generally in technology consolidation and technology production that the greatest degree of integration occurs. Some linkage-related activities within these tasks are often weakly performed. These are:

- the publication and synthesis of research results;
- the assessment of the economic and social viability of new technologies;
- the transformation of experimental results into specific recommendations;
- the production of information materials for technology transfer workers;
- the organization of information to make past research results more accessible;
- the production and distribution of physical inputs.

Duplication of efforts. While there are some tasks or activities for which no-one takes responsibility, there may be others in which more than one unit is involved. These are either joint activities or represent a duplication of efforts. In this section, only the latter situation is discussed.

Redundancy results either from attempts to seek greater autonomy or from competition for resources. It leads to conflict between the redundant units, but is often associated with higher performance.

One reason for duplicating efforts is to increase a unit's autonomy. Rather than relying on someone else to provide information or get something done, a unit decides that it will carry out this task itself. A unit is more likely to seek autonomy if relations between it and the other unit are already strained, if it perceives the costs of the necessary coordination to be high, or if it has doubts about the capacity or motivation of the other unit to fulfil its responsibilities.

The second major reason for the duplication of efforts is competition for resources. Units take on new activities which they perceive as being of interest to donors or policy makers if this will bring them additional funding, power, or prestige. In so doing they may weaken their mandate focus. The pursuit of the same activities by several units brings them into competition and often precipitates conflicts.

The existing literature is divided about whether the net result of duplication of efforts is positive or negative (Landau, 1969; Leonard, 1982). Although the waste of resources created by duplication of efforts is frequently deplored, the worst consequence of such duplication is probably the deterioration of relations between institutions. This deterioration results in an unwillingness to share information, learn from each other's experience and coordinate activities. On the other hand, redundancy does increase the chances of getting the job done. It permits multiple approaches to a problem, and can promote healthy competition.

The Differences between Researchers and Technology Transfer Workers

For high performance, specific linkage mechanisms are required to manage the conflicts and communication problems caused by differences between researchers and technology workers in background, training, experience, responsibilities, status and physical location.

Informal groups. Informal groups, which may or may not reflect formal divisions, have shared languages, values and attitudes, making internal communication and collaboration easier. However, as with formal boundaries, such groups also lead to inter-group differences, resulting in a 'them-and-us' attitude that makes communication between groups difficult. Among the most important determinants of informal groups are differences in staff background, training, experience, responsibilities, status and physical location. Important staff background attributes include age, gender, rural or urban origin, ethnicity, nationality and educational level.

These differences have major implications for communication between researchers and technology transfer workers. One of communication research's most consistent findings is that people communicate most frequently and effectively with those who are most similar to themselves (Röling, 1988: 44). Thus, sharp differences between research and technology transfer staff with respect to their backgrounds and other characteristics may make it very difficult for the two groups to communicate with each other.

Two particularly important differences between the two groups are their distinct work environments and responsibilities. These differences lead to different orientations with respect to goals, use of time, interpersonal relations and formality (Lawrence and Lorsch, 1967: 10). Researchers' goals are said to be broader, less precise, but more measurable. Researchers look mostly to the broad research community for approval, whereas technology transfer workers tend to seek approval within their specific institutions. Researchers' time perspectives are supposedly longer. They are also more used to working in informal and collegial environments (Bennell, 1988: 22-23).

Occupational groups. Occupational groups, such as researchers or extension agents, have many of the same characteristics as informal groups, as well as some important additional ones. Occupational groups compete with each other for status and rewards. The main form this competition takes is the attempt to exclude rival groups. 'Barriers to entry' are erected mainly on the basis of academic qualifications (Bennell, 1988: 48). Thus, to justify their own status and rewards, researchers may perceive a need to distance themselves from lower status occupations such as extension.

In most low-income countries, at least outside Latin America, extension is not regarded as a professional occupation. It has also had a low status because of its association with farmers and rural life, which themselves have very low status. Generally speaking, the status distinctions between professional and subprofessional occupations are greater in developing than in developed countries, and researchers often adopt patronizing attitudes towards extension agents (Bennell, 1988: 55). Low pay means extension services are unable to attract quality recruits, and this has only worsened the status problem.

Strong status differences between occupational groups are difficult to bridge through linkage mechanisms. These will be more difficult to design in such a way as to allow the flow of information from lower to higher status members. Where low status members have significant information about environments and technologies not well understood by researchers, poor performance will result.

In recent years extension agents have tried to solve the status problem by making their occupation more professional. This has involved taking over some activities previously performed by research, such as carrying out field trials or deciding whether to recommend a new technology, a move which has elicited mixed responses from researchers. In some cases they have resisted what they perceive as an incursion into their domain. In others they have willingly relinquished activities to extension, but only after down-grading them and reserving the higher status activities for themselves. On rare occasions, researchers have chosen to accept an equal role with extension, and to collaborate fully.

Although differences between the two groups is a problem, so also would be too great a similarity between them. Similarity between groups erodes the unique contribution that each group can make and the advantages of specialization. This implies that there is some optimum level of dissimilarity.

Personnel and Financial Management

Personnel and financial management policies and practices which encourage integration and provide flexibility in IATS result in higher levels of performance.

Differences in policies and practices between research and technology transfer institutions can greatly hinder the integration of the two activities. Policies and practices are

among the contextual factors most subject to control by managers.

Recruitment, job responsibilities and training. For high performance, staff should be recruited who are capable both of fulfilling their specialized tasks and of interacting effectively with other specialists. Job descriptions (as well as informal expectations) should specify the linkage-related activities required. Managers of each unit should ensure all parties involved are clear about these responsibilities.

Status, as well as links, can be enhanced by building an emphasis on collaboration into the work programs of both researchers and technology transfer staff. When a researcher is assigned to an adaptive trial run by an extension worker, this gives status and incentives to the latter. An extension worker who provides diagnostic information for developing research projects and thereby improves the design and relevance of the project improves both his or her status and that of the researcher.

In practice, these goals are rarely met in full. The pool of candidates for both research and technology transfer jobs is limited and may not include people with the right qualifications, skills and characteristics. It is hard to attract staff to some geographical areas. Communication problems may prove unsurmountable. Job descriptions are often vague, non-existent or soon forgotten. Normally, little emphasis is given to collaborative activities. Rigid civil service structures create pressures to hire large numbers of staff who cannot be effectively used. These problems hamper an institution or unit's capacity to develop effective relations with other groups.

Limitations on the staff recruitment side can be partly overcome by subsequent training or work experience. To promote effective links it may be necessary to teach people additional technical or communications skills. Staff exchanges and rotations can improve knowledge of counterparts' activities and build empathy. A common orientation program or joint participation in training activities also helps create mutual understanding. Although specialization is not abandoned, professionals in integrated IATS which regularly make relevant new technologies available usually participate in or have enough experience of the work of their technology transfer counterparts to understand and wish to enhance what the other group does.

Again, in practice, IATS often fall short of these ideals. Many training programs fail to encourage researcher-technology transfer worker interaction, provide few tools for effective interaction, and reinforce status distinctions.

Compensation. The earlier discussion of political factors pointed to the fundamental importance of incentives, at both the institutional and individual level, in promoting performance.

The most direct and effective incentives are those accruing to staff as compensation. Compensation includes salaries, honorariums, promotion opportunities, working conditions, prestige and positive feedback, fringe benefits, the attractiveness of the work involved, and opportunities for earning supplementary incomes. These benefits can be distributed on a number of different bases, one of which is the performance appraisal/evaluation of staff members. The criteria used for performance appraisal communicate the values of an organization. The emphasis given to collaboration and the types of behavior evaluated will determine the value given to linkage behavior.

Compensation affects performance in various ways. Workers perceive the rewards or punishments resulting from their performance (including their interactions with others). The levels of conflict, competition and coordination vary as a result. Compensation packages can be perceived as fair or unfair and can diminish or increase the distinctions and divisions between groups. Compensation levels and criteria which result in high levels of staff attrition and transfer can hinder effective institutional links because the parties involved have less time to develop stable expectations and communications channels.

Service orientation. No matter how enlightened the management, researchers and technology transfer workers almost always experience some tension between their duty to respond to the concerns of management and their obligation to respond to the needs of the population served. IATS in which field staff respond exclusively to management desires are rarely very successful. They also tend to have poor flows of information up the organizational chain. However, if staff respond only to demands from below, this is likely to hinder the institutions' capacity to serve as instruments of policy. The IATS with the highest performance are those in which management promotes a service orientation and allows staff sufficient flexibility to provide it, yet maintains firm control over general policy.

Financial management. The principal aspects of financial management which affect integration and performance are the sufficiency, flexibility and reliability of funding, and the existence of slack resources. Here we are referring to funding both for the IATS in general and for the financing of linkage mechanisms in particular. With respect to the latter, many IATS have practically no funding available for such key linkage-related activities as the publication of research results, visits by researchers to extension field offices, and in-house training events.

The aim of providing slack resources is to assign more resources to an activity than are strictly expected to be necessary, in order to increase the probability that the job will be completed. In our context this could mean financing redundant linkage mechanisms so as to ensure greater integration.

Integration

The role of higher authority. Often, collaboration between separate units of the IATS is ordered by a higher authority, such as a common director, an official mandate, a government regulation or plan, or a donor agency.

Instructions to collaborate usually work only when the higher body simultaneously intervenes to convince the staff concerned of the need for integration. Otherwise, the higher body must have both adequate power and sufficient information to impose its will. This is rarely the case.

The development and delivery of new agricultural technologies is complex and difficult to monitor closely. Instructions from above are usually vague and it is implicitly understood that not all of them can be carried out. Again, a great deal of information is lost or deliberately withheld or distorted as it moves up the hierarchy. Senior managers are beset by a wide variety of problems besides their concern for integration. In practice, research and technology transfer managers and staff have effective veto power over external efforts to achieve integration, and thus must be persuaded or motivated, as well as directed.

Failure to persuade frequently results in the creation of formal (relatively ineffective) linkage mechanisms whose principal purpose is to please superiors. In these cases open conflicts may be eliminated, but only to be replaced by more subtle forms of mutual avoidance and hostility.

Policy makers and managers can facilitate integration through the creation of superordinate goals and/or the promotion of a shared institutional culture.

Superordinate goals are those that have "a compelling appeal for members of each group, but which neither group can achieve without the participation of the other" (Bennell, 1988). Bennell adds that "such superordinate goals are only likely to be accepted when:

- the status and/or reward grievances of disadvantaged and dissatisfied groups within the IATS are adequately resolved;
- individual goals are sufficiently compatible with superordinate goals;
- sufficient weight is given to staff interactions in performance appraisal and rewards systems."

Organizational cultures conducive to integration are easier to promote under conditions of staff homogeneity and organizational stability, and when staff have had long and intense shared experiences.

Preconditions for voluntary linkage. *Significant integration occurs only if the parties involved perceive all of the following to exist: (1) interdependence, (2) domain consensus, (3) ideological consensus, (4) domain correspondence, (5) competence, and (6) the capacity to deliver on agreements.*

Since cooperation implies a certain loss of autonomy, groups will normally want to cooperate only if they perceive the potential gains to outweigh this loss. One factor in the decision whether or not to cooperate will be external pressures for improved performance, but there are also a number of strictly internal organizational factors which are important.

The first of these is whether interdependence is perceived. Both parties must feel the other has something they need. The second and third factors are domain consensus and ideological consensus. Domain consensus means that the units agree about each other's appropriate role and scope. Ideological consensus means agreement regarding the nature of the tasks confronting the units and the appropriate approaches to use of resources (Benson, 1975: 235). For domain and ideological consensus to occur, neither unit must perceive the other's role, scope and approach as potentially threatening to its own resource base.

A fourth important factor is domain correspondence. Correspondence exists when two units share a common set of clients and topics of concern. The lack of domain correspondence between research and technology transfer institutions is a common problem. Typical examples are:

- research is organized on a national basis, while technology transfer is provincial;
- research units follow agro-ecological distinctions, while technology transfer follows administrative ones;
- research is divided on a disciplinary basis, while technology transfer is divided by commodity or geographical area;
- research focuses on a single commodity, while technology transfer has a more general focus;
- research services are targeted to one client group, technology transfer services to another.

Often there is a fine line between domains being closely related and therefore complementary, and their being overlapping or even identical. Yet the likely outcomes in each case are markedly different. In the first case task interdependencies and common orientations will be greater, facilitating interaction. In the second, competition may arise for funds.

Competence and capacity to deliver on agreements are other necessary preconditions for voluntary linkage. If one group depends on another for resources or activities the

latter is unable to provide or carry out, the first group will eventually seek alternatives which eliminate that dependence (or else use the second group's incapacity as an excuse for poor performance).

Perceptions about the other group's importance, relevance, effectiveness, efficiency and reliability are as important as whether or not these attributes really exist. Beliefs about other groups are based at least in part on stereotypes and limited information, but are heavily influenced by past experiences.

Other factors, such as a group's absolute and relative age, size, power and access to resources, have also been mentioned as affecting its inclination towards voluntary linkage. Immaturity and insecurity in organizations weaken their willingness to integrate with others. Organizations are immature if they have not yet clearly defined their domain. Insecurity implies that an organization perceives its resource base to be vulnerable.

The use of liaison positions. Liaison positions or units are sometimes used as buffers to contain the differences between groups which must communicate with each other. They may be within one or both of the groups, or they may form a separate entity. In the latter case the idea is that if two groups differ so much that it is very difficult for them to communicate, a third group which combines features of each of the others can act as an intermediary.

The use of such positions is often suggested as a solution to the communication problems associated with people who specialize in the different stages of technology development and delivery. Since there is typically a larger gap between researchers, technology transfer workers and farmers in low-income than in high-income countries, more liaison-type roles are probably needed in the former.

Taken to its logical extreme, however, the communications chain could become very long. The problem with having many steps in the communication process is that the clarity and content of the information communicated diminishes rapidly with each additional link in the chain.

There is also a danger that liaison positions will accentuate rather than attenuate the integration problem. If liaison staff begin to take on the attributes of a separate group — with their own interests, beliefs, attitudes, orientations and work styles — they can become an obstacle to communication rather than a facilitator. Two mechanisms which can prevent this from happening are the incorporation of liaison positions into one of the units being integrated, and the rotation of staff members assigned to liaison positions.

The use of liaison positions as intermediaries may prove more problematic ultimately than the difficulties such positions were originally designed to overcome. Even when there are liaison positions, they do not obviate the need for direct communication between the parties being linked.

Decentralization and institutionalization. *Formal and informal linkage mechanisms at several administrative levels (for example, national, regional, operational) are essential for high performance. The level of integration between researchers and technology transfer workers is higher when adaptive research is decentralized and dispersed. This higher integration leads to more relevant new technologies becoming available. Moreover, decentralization and the delegation of responsibility within an IATS require well-developed linkage mechanisms at the operational level.*

If, for example, an exchange of technical information is required, it will not be sufficient to bring together managerial staff who lack familiarity with the topic concerned. Links must also be organized between the technical staff. Conversely, regional coordination committees in highly centralized IATS frequently fail because participants cannot speak authoritatively for their institutions.

Institutionalization refers to the degree to which a pattern becomes routine and follows set rules. For the most part, institutionalized mechanisms are more permanent and formalized, ad hoc mechanisms more temporary. Ad hoc and temporary mechanisms, such as task forces, have the advantage of being designed to meet a specific objective. Their extraordinary nature can create a sense of urgency. Institutionalized mechanisms permit the development of mutual expectations and can be improved over time. Although there are important exceptions, recurrent problems lend themselves more to formal approaches.

SUMMARY

THE MOST IMPORTANT environmental factors affecting IATS performance and links are: external pressure, the resources provided to the IATS for servicing its clients, and the diversity of its environments. More integrated systems, which are more successful at making available relevant new technologies, generally face strong external pressures, have access to substantial resources, and focus on simple and homogeneous environments.

High-resource IATS are more differentiated than low-resource ones, with more sophisticated links to which more resources are devoted. Diverse environments are associated with the need to perform complex tasks to achieve IATS objectives. These tasks require greater professionalism, decentralization and less hierarchical management.

Less important, but still significant, environmental factors include the availability of different communications channels, the development of the necessary infrastructure and traditions for farmers to make use of inputs and information produced outside their communities, the level of pre-existing knowledge about the environment and its production systems, and the dispersion and accessibility of the farming population served.

Because these environmental factors are outside the IATS, managers have relatively little control over them. They must, however, take them into account in making decisions regarding the scope of their institution's activities, its organizational structure, its working methods, and the management of its links.

High performance requires that IATS have the responsibility and capacity to undertake the activities associated with each task in the technology development and delivery process (with the possible exception of discovery), and that identifiable functional links exist between them. In practice, the most important missing tasks tend to be technology consolidation and production. Hence these must be given special attention by managers, who are often in a good position to deal with these problems.

Different links will be required for different types of technology. In particular, activities related to already established technologies require different links to activities concerned with developing and delivering new technologies. Managers can exercise considerable control over these links.

Organizational structure, personnel management and financial management strongly affect both IATS performance and links. While managers of technology institutions have only moderate control over organizational structure and should be cautious about exercising it, they can have greater influence over personnel policies and should take maximum advantage of that influence. Their control over financial policies is limited.

Difficult personnel problems arise from the differences between researchers and technology transfer staff in background, training, experience, responsibilities, status and physical location. These problems can greatly affect performance and need to be addressed as part of efforts to increase system integration.

Successful IATS address task and resource interdependencies through a combination of organizational grouping and linkage mechanisms. Their structural arrangements take into consideration the compatibility of the management styles required by various tasks/activities, divergences in the sources of political support for different tasks/activities, size considerations, different units' proven capacity to perform, and differences in task orientation.

A market-based grouping is generally more successful at achieving integration and relevance. However, this type of arrangement is not often feasible in diverse environments served by poorly endowed IATS.

Redundancy can have negative and positive consequences. It arises when there are strong incentives for increasing unit autonomy and competing for resources. While it wastes resources, it may ensure that objectives are met.

High levels of integration are facilitated by interdependence, domain consensus, domain correspondence, ideological consensus, competence and the capacity to deliver on agreements. The creation of superordinate goals and the promotion of an institutional culture conducive to integration are also important.

Increasing system integration is not an end in itself, but it is important because IATS that perform well according to other criteria are characterized by high levels of integration. These systems have many formal and informal linkage mechanisms, at multiple administrative levels. Many have liaison positions and departments, but these complement, rather than substitute for, more direct links.

References

Arnold, H., and D. Feldman. 1986. *Organizational Behavior*. McGraw-Hill.

Bennell, P. 1988. 'Intergroup relationships in institutional agricultural technology systems.' ISNAR Staff Note 88-41.

Benson, K. 1975. 'The interorganizational network as a political economy.' *Administrative Science Quarterly* (vol 20, June: 229-249).

Chambers, R. 1988. 'Bureaucratic reversals and local diversity.' IDS Bulletin (vol 19, no 4, October: 50-56).

Ekpere, J. 1973. 'A comparative study of job performance under two approaches to agricultural extension organization in the Midwestern State of Nigeria.' Unpublished PhD dissertation. University of Wisconsin, Madison.

Engel, P. 1988. 'Rural development, knowledge systems, and extension.' Mimeo.

Engel, P. 1988b. 'Working model and data collection frame for country case studies.' Mimeo.

Galbraith, J. 1977. *Organization Design*. Addison-Wesley.

Israel, A. 1987. *Institutional Development, Incentives to Performance*. John Hopkins University Press/World Bank.

Kang, J. 1984. 'Interorganizational relations between extension agencies and other agricultural development agencies in Asian and Oceanian countries.' Unpublished PhD dissertation. University of Illinois, Champaign-Urbana.

Klauss, R. 1979. 'Interorganizational relationships for project implementation.' *International Development Administration (Implementation Analysis for Development Projects)*. Eds: Honadle, G., and R. Klauss. Praeger Press.

Lane, H., R. Beddows, and P. Lawrence. 1981. *Managing Large Research and Development Programs*. State University of New York Press.

Lawrence, P., and J. Lorsch. 1967. *Organization and Environment: Managing Differentiation and Integration*. Richard D. Irwin Press.

Landau, M. 1969. 'Redundancy, rationality, and the problem of duplication and overlap.' *Public Administration Review* (vol 29, no 4: 346-358).

Leonard, D. 1982. 'Analyzing the organizational requirements for serving the rural poor.' *Institutions of Rural Development for the Poor: Decentralization and Organizational Linkages*. Eds: Leonard, D., and D. Marshall. Research Series 49. Institute of International Studies, University of California.

Leonard, D. 1982b. 'Choosing among forms of decentralization and linkage.' *Institutions of Rural Development for the Poor: Decentralization and Organizational Linkages*. Eds Leonard, D., and D. Marshall. Research Series 49. Institute of International Studies, University of California.

Leonard, D. 1985. *Reaching the Peasant Farmer: Organizational Theory and Practice in Kenya*. University of Chicago Press.

Martínez, R. 1988. 'The effect of changes in state policy and organization on agricultural research and extension links: A Latin American perspective.' ISNAR Staff Notes 88-21.

Martínez, R. 1988b. 'El apoyo político a la investigación agropecuaria en America Latina.' *Temas prioritarias y mecanismos de cooperación agropecuaria en America Latina y el Caribe*. CIAT.

McCann, J., and J. Galbraith. 1981. 'Interdepartmental relations.' *Handbook of Organizational Design* (vol 2: 160-184). Oxford Press.

McDermott, J.K. 1987. 'Making extension effective: The role of extension/research linkages.' *Agricultural Extension World Wide*. Eds: Rivera W., and S. Schram. Croom Helm.

Merrill-Sands, D., and J. McCallister. 1988. 'Strengthening the integration of on-farm client-oriented research and experiment station research in national agricultural research systems (NARS): Lessons from nine case studies.' Mimeo.

Mintzberg, H. 1979. *The Structuring of Organizations*. Prentice Hall.

Peters, T., and R. Waterman. 1982. *In Search of Excellence, Lessons from America's Best-Run Companies.* Harper and Row.

Pray, C., and R. Echeverría. 'Private sector agricultural research and technology transfer in developing countries.' ISNAR Staff Notes 88-33.

Röling, N. 1988. 'The agricultural research-technology transfer interface: A knowledge systems perspective.' ISNAR Staff Notes.

Samy, Mohamed. 1986. 'Linking agricultural research and extension in developing countries.' Paper presented at the Annual Meeting of the Rural Sociology Society in Salt Lake City, Utah.

Sigman, V., and B. Swanson. 1985. 'Problems facing national agricultural extension in developing countries.' Interpaks Publication, University of Illinois, Urbana-Champaign.

Sims, H., and D. Leonard. 1988. 'The political economy of the development and transfer of agricultural technologies.' ISNAR Staff Notes 88-22.

Snyder, M. 1987. 'A framework for analysis of agricultural research organizations and extension linkages in West Africa.' Unpublished PhD dissertation. George Washington University.

Stoop, W. 1988. 'NARS linkages in technology generation and technology transfer.' ISNAR Working Paper 11.

Thompson, J.D. 1967. *Organizations in Action.* McGraw-Hill.

Tripp, R. 1988. 'Farmer participation in agricultural research: New directions or old problems?' Mimeo.

United States Agency for International Development (USAID). 1982. 'AID Experience in Agricultural Research: A Review of Project Evaluations.' Evaluation Discussion Paper No. 13. USAID.

World Bank. 1985. *Agricultural Research and Extension, An Evaluation of the World Bank's Experience.* World Bank.

International Service for National Agricultural Research

Headquarters
Laan van Nieuw Oost Indie 133
2593 BM The Hague
Netherlands

Correspondence
P.O. Box 93375
2509 AJ The Hague
Netherlands

Communications
Telephone: 070-496100
Telex: 33746
Cable: ISNAR