IDENTIFYING OPPORTUNITIES TO IMPROVE AGRICULTURAL TECHNOLOGY MANAGEMENT SYSTEMS IN LATIN AMERICA: A METHODOLOGY AND TEST CASE

by

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PART 1. EXECUTIVE SUMMARY

This report is aimed at donors, and outlines and applies a methodology to help them identify priority needs of national programs of agricultural research in Latin America and the Caribbean.

That a methodology and fresh approach are needed is indicated by a simple fact: many national agricultural research programs in the region are experiencing a financial crisis, in spite of over two decades of generous assistance from external sources. National funding for agricultural research has actually decreased, or its growth has decelerated sharply, in the most mature and best developed programs. Concern is growing that this pattern, seen principally in South America, may be repeated by programs that are developing in Central America, Panama, and elsewhere in the region.

Part 2 attributes this fact to several causes that are spawned by the observation that agricultural research activities are the product of the world around them, rather than the solitary and insulated pleasure of one or more scientists. While hardly surprising, donors do not appear to have taken this to heart. To expand and improve research programs, they have invested directly (and heavily) in the core of the research activity--in physical capital (laboratories and buildings), in training high-level manpower, and in numbers of researchers and work sites. Just as it has been observed that investing only in the poor may not remove poverty, or that providing food may not arrest malnutrition, investments only in scientists and their tools need not improve and stabilize institutions of agricultural research because those institutions are impacted by events from outside.

The methodology proposed in Part 3 of this report recognizes explicitly that public research programs are part of a larger system with which they must interact effectively if technological change in agriculture is to proceed continuously at a rapid pace. Our approach to identifying priority needs for agricultural research begins with a call for understanding the sources of change in agricultural production and productivity, underlying socioeconomic conditions, major actors in the Agricultural Technology Management System (ATMS) and their relation to observed trends in agriculture. At a second stage, four kinds of analyses are undertaken of policies and institutions (public and private; national and foreign) operating in the ATMS, with some emphasis on institutions in the Technology Generating Sector. The purposes, contents, instruments, and procedures for each kind of analysis are described. At a final stage, case studies of significant technological events are undertaken, largely through travel and study at the field level, to test "on the ground" hypotheses emerging from the first two stages of work, and to identify needs and constraints which are beyond their view. Efforts at this final stage are guided by an Interventions

Opportunity Matrix (IOM), which arrays technological events and their benefits along one axis and major resource, management, and external (or environmental) determinants along the other. Entries in the cells of the IOM help pinpoint opportunities for donor investment.

As is true of any effective methodology, ours is flexible and simple. Its strength is in offering a conceptual scheme by which information generated in an ATMS assessment can be ordered systematically to yield proposals for donor action. This should avoid an "ad hoc" approach in future assessments, and thus reduce their costs and increase associated benefits to donors. There is the added appeal that, to the extent that the methodology is widely used, comparable information can be accummulated--and easily updated--on ATM Systems for many countries in Latin America and the Caribbean.

Since "the proof of the pudding is in the eating," Part 4 of the report applies and tests the methodology in a study of Panama's ATMS. That particular system was selected because it is among neither the oldest nor the newest in Latin America; public technology transfer activities practically disappeared after the 1968 Revolution, and thus the effects of the extension linkage could be more clearly distinguished; the government's commitment to agriculture has been large in comparative terms; and key elements of the ATMS there agreed enthusiastically to serving as a test case of the Rutgers/ISNAR assessment methodology. Our presumption, subsequently corroborated, was that Panama's ATMS is also broadly representative of many systems in the region. By far the longest part of this report, Part 4 is organized into four principal chapters, with the first three corresponding to the main stages of an ATMS assessment, and the last reporting on general conclusions and recommendations. More specific conclusions are to be found at the end of each chapter.

We found in Panama an excessive number of interventions by the public sector in agricultural activities which, among other things, has made for a complex ATMS with poorly developed linkages between participating institutions. Without the centripetal force provided by strong, clearly articulated agricultural policies, better organized farm groups were able to capture and bend programs of the ATMS institutions toward their special interests, creating inefficiencies in resource allocations and much program duplication. Some unity of effort was evidenced in the social policies of the 1970's, aimed at redistributing incomes toward marginal farmers and laborers generally. However, these efforts came apart in the 1980s as collective farms failed to become productive and as high labor costs proved burdensome to a government and private sector open to major competition by reason of the country's small size, geographic location, and international exposure. Agricultural production and productivity suffered enormously. By 1985, with the economy in disarray, few prospects to service one of the largest debt burdens in the world (relative to GNP), and the government's continued high level of participation in economic activity patently unsustainable, austerity was the only recourse. The government then fell, and Panama was set adrift on an uncertain, but certainly-to-be-stormy, sea. No amount of agricultural research, nor the existence of an agricultural extension service, could have possibly precluded this.

It was against this background that an agricultural research institute, IDIAP, patterned after the national institute model in Latin America (but after ICTA in Guatemala, specifically), was conceived and established in 1975 on the foundations of a tradition of work by the University of Panama in technology generation. Achievements in governance, human resources development, budget expansion, planning and evaluation, and technology transfer activities are noteworthy for an organization just celebrating its Tenth Anniversary. Our in-depth examination of research accomplishments in rice, maize, beans, cowpea, onions, and tomatoes through the case studies is highly encouraging. Not surprising--in view of the environment for research and technology transfer in Panama--is the fact that these gains, and those of the Faculty of Agronomy at the University, have benefitted from generous funding from donors, especially from the U.S. Agency for International Development, which presently accounts for almost a third of IDIAP's total financial resources. Successful innovations have been associated with individual scientists who combined outstanding acquired skills and high-level training with personal skills of research management that buffered their programs from budgetary and political vagaries and helped harness private and public services to support well-defined research goals.

We conclude that six priority needs must be addressed, if these successful efforts are to be multiplied and Panama's ATMS is to become more effective in the future. First, system-wide planning must be strengthened in ways that will expand participation, arbitrate competing interests, and more sharply focus priorities. We recommend organizing annual national planning conferences for the ATMS to develop greater policy consensus concerning priorities, more coherent action, and clearer divisions of labor among public sector institutions. Priorities emerging from such exercises should concentrate more effort in technology generation on commodities that can support Panama's high labor costs. Second, we believe that donor involvements at various points in the ATMS should be better integrated. Donor funding for manpower training should not neglect opportunities for developing local post-graduate degree programs in key agricultural disciplines that could strengthen research and extension staff capabilities and complement the research of both IDIAP and the Faculty of Agronomy at the University of Panama. Third, and related to the preceding point, is a recommendation that national and foreign funding sources for the ATMS work together to formulate comprehensive plans to raise the percentage of researchers with post-graduate degrees to 60 percent by 1995. Since an expansion in the number of scientists is no guarantee that leadership--capable of designing, implementing, and evaluating research and of generating political support for relevant programs--will also increase, we recommend the development of a research management workshop series for senior scientists. Among other things, this series should give special attention to planning and monitoring skills for research, to discussing ways that scarce resources can be more effectively used by capitalizing on potential ATMS linkages, and to personnel management practices for research and technology transfer programs.

Fourth, we recommend strengthening all field research by increasing operating expenditures to 25 percent of total budgets, and by setting aside at least 45 days of funding to meet contingencies occasioned by disruptions in the government's flow of financing for research. These improvements in financing must be complemented with improved mechanisms of management control at the regional and field level. Thus, our fifth recommendation is that technology generating institutions back decentralized decision-making with control over budgets and manpower, and with responsibility for developing research objectives and for evaluating achievements periodically. If field research is strengthened and management is decentralized effectively, our final recommendation is that Panama should postpone further development of an independent public extension service. In part, this reflects our disagreement with the premise, widely accepted in some quarters in Panama, that technology relevant to a broad range of farmer circumstances is already available. However, we do see the need for continued experimentation--on a limited, regional scale--with alternative extension models. To further that effort, we recommend creating in IDIAP a small group of extension specialists, expanding the University's "student-to-farmer" extension model, and strengthening the socioeconomic analytical capability of those institutions centrally engaged in technology generation and transfer.

Part 5 concludes the report with recommendations to donors concerned with ATM Systems in Latin America and the Caribbean. While these reflect our assessments of needs in the region, derived from Part 2, and some generalizations based on the application of our methodology to the Panama case, they are made with the caveat that any generalization of strategies to the whole region is risky business, given differences between countries and the rapid changes occurring in most systems of the region. Those recommendations concerning future investments that we are most confident about deal with the need for donors to find appropriate mechanisms to provide operating and contingency funds for agricultural research. Similarly, we believe that most systems urgently need donor assistance to accelerate staff and leadership development. Three other recommendations deal with the need to forge internal linkages within ATM Systems, to selectively support linkages with external technology generation and transfer organizations which are responsive to individual ATMS needs, and to reverse the historical neglect of national universities, especially those with strong commitments to agricultural development and some tradition of research.

Our strongest recommendations, however, deal not with how donors should spend their money, but how they should go about developing program strategies for ATMS improvement. The very differences that exist between countries in the region argue forcefully for the creation of an ATMS study capability which can guide program development in individual settings. Many donors have established an individual country strategy on the basis of a set of global priorities for the region that are then adapted and fine-tuned at the country level through a "blitzkrieg" visit by a small team of outside experts who examine the research activity, or (at most) the activities of research and extension. This report recommends standing the usual process on its head by using a methodology to identify individual country needs, first. At some later point, and after several country assessments have been concluded, the foundations should exist for synthesizing a more general, cross-country strategy from individual country reports. Highly cost-effective investments could be made by donors, in our judgment, in creating a capability among one or more developed country institutions to field and train suitable team members for ATMS assessments and to accumulate and analyze information relevant to studies of particular ATM Systems.

PART 3. DIAGNOSING A SYSTEM AND DEALING WITH ITS CONSTRAINTS: A METHODOLOGY

I. Introduction

The methodology proposed for the analysis of Agricultural Technology Management (ATM) Systems in Latin America is designed to be easy to apply, rigorous and yet readily comprehended, adaptable to a wide variety of systems, and capable of providing practical suggestions for system improvements in a short time period and at reasonable cost. It is sensitive to the preeminent role played by the public sector in both the supply of and demand for technology generation and diffusion, and variation in the benefits of technology across commodities or production sectors. Most importantly, the methodology recognizes that the structure and performance of Latin American ATM Systems are products of the agricultural sectors in which they operate, and that research institutions cannot be studied in isolation.

II. The ATM Concept

Cummings (1984) provides a definition of "agricultural technology management":

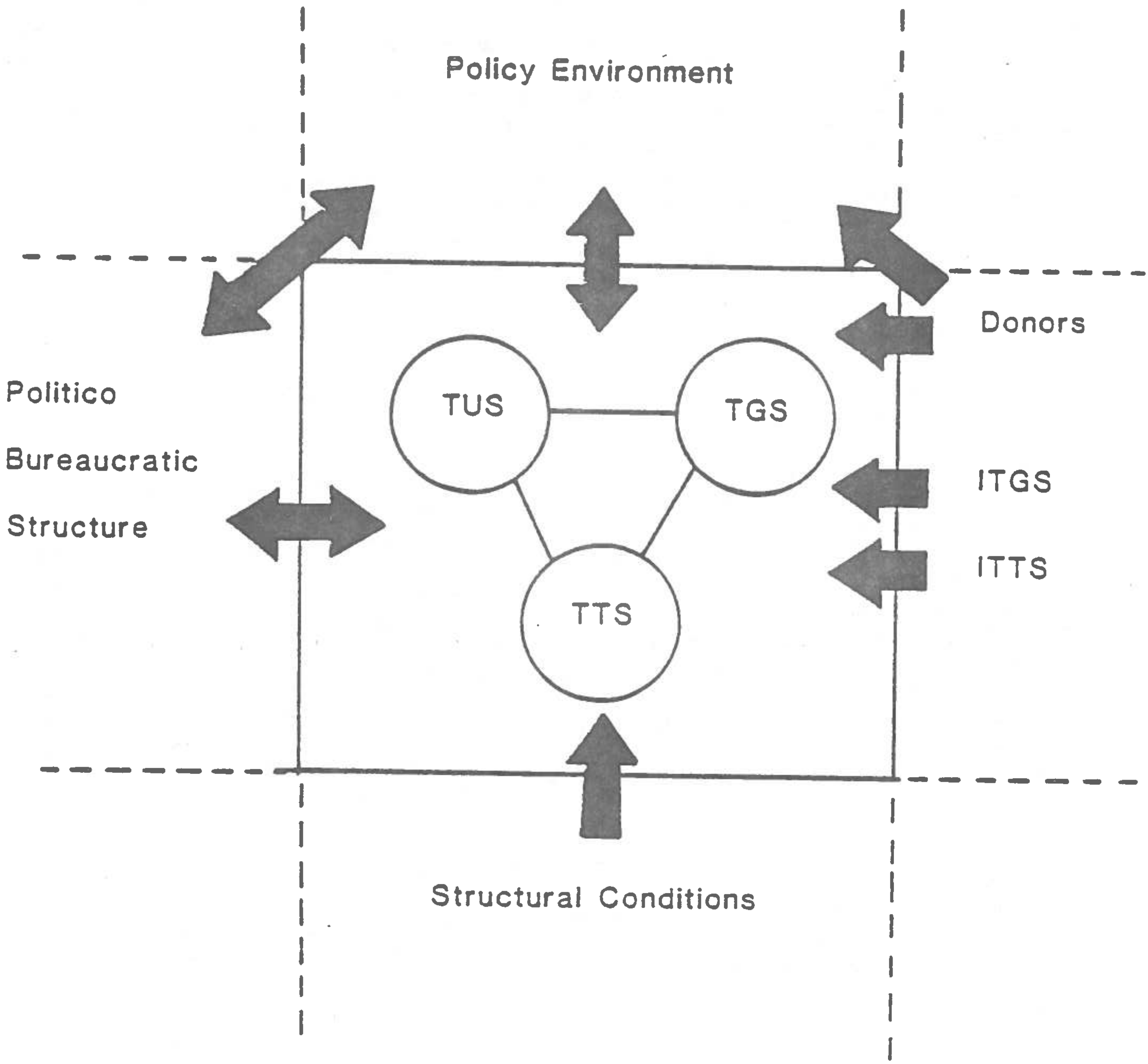
> Agricultural technology management involves the interdependent relationships between new and existing institutions and new and existing technologies as they are directed to meet acceptable and feasible responses by individual producers... What is meant is internalizing, by some management means, as many of the functions as are necessary to generate, assess, and diffuse improved technologies which will increase agricultural production and incomes. The definition of agricultural technology management implies the ability of the component parts, individually or collectively to deal with constraints to the generation and diffusion of improved technologies.

The broader system in which assistance to technology generation and transfer should be planned has been called the Agricultural Technology Management System (ATMS). A generic ATMS is presented in Diagram 3.II.1, which places the component parts of the system in relation to each other. Those are:

*the "technology sector" with its subsectors (the technology generating sector, the technology transfer sector, and the technology using sector);

*the "politico-bureaucratic structure", composed of formal representatives of the government and decision makers, and the channels through which interests of all groups in the system are made known to policy-makers;

DIAGRAM 3.II.1. The Agricultural Technology Management System



TGS - Technology Generating System
TTS - Technology Transfer System
TUS - Technology Using System
ITGS - International Technology Generating System
ITTS - International Technology Transfer System

*the "external sector", composed of donors, international technology generating institutions, and multinational firms engaged in technology generation and transfer;

*the underlying "structural conditions", which include primarily world markets for inputs and outputs and the resource base of a country;

*the "policy environment," made up of all laws, regulations, customs and practices which limit the way in which components of the technology sector behave.

These all-inclusive components influence, and are themselves influenced by, events occurring in the system.

III. Analytical Stages for an ATMS Review

The purpose of an ATMS review is to enable a donor or national authority to identify a list of interventions, and to determine which interventions are likely to succeed and produce the largest payoffs.

The methodology is composed of three principal stages logically linked one to the other. It begins at a high level of aggregation--a macroeconomic view of a country's agriculture--and proceeds sequentially to more detailed levels of analysis. It includes an institutional analysis of the system and its key organizations, and case studies of selected technological events. For conceptual purposes, the approach can be likened to a funnel with screens at each stage which sift information with increasing detail as the funnel narrows.

Each screen is designed to eliminate information not bearing directly on the impact (value and distribution), resources, management and organization, and the environment supporting the agricultural technology and transfer process of a particular country. We argue that resources (R), management (M), and environment (X) are all-inclusive determinants of technological impact (B).

Purpose, contents, instruments of analysis and procedures for each stage of analysis are summarized in Table 3.III.1, and further discussed in the following sections.

Table 3.III.1. ATMS Analyses: Purposes, Contents, Instruments and Procedures

STAGE I

<u>Sector Analysis</u>

Purpose:	Assess the impact of research/extension on agriculture globally and identify key institutions and policies affecting technology generation and transfer.
Contents:	Analysis of production/productivity performance and relationship to research/extension efforts, policy environment, and socioeconomic structure of the country.
Instruments:	Literature search
Procedures:	Review major trends in agricultural outputs and inputs and in activity levels of research/extension agencies.

STAGE II

<u>Functional Analysis</u>

Purpose:	Describe the ATMS in terms of key functions. Establish database on roles of major organizations and mechanisms for participation in key functions.
Contents:	Analysis of 13 key functions of the ATMS and role of major institutions in terms of level of responsibility and mechanisms of participation in each function.
Instruments:	Linear Responsibility Charts, database management program.
Procedures:	Record in database framework information on organizations and participation in key functions. Analyze complexity and coherence of system.

Events Analysis

Purpose: Analyze technological cycles across commodities and through time; document role of institutions and policies with respect to the nature of technological change.

Contents: Chronology of technical, economic, and institutional events in principal commodities.

Instruments: Literature search, interviews, database management

Procedures: For significant events record date, nature of event, commodity, institutional involvement, nature of institution. Array data to relate time, technology and institutions.

Policy Analysis

Purpose: Describe key macroeconomic, intersectoral, and agriculture sector policies which impact ATM. Identify intervention points.

Contents: Study impact of government role, exchange rate, policies affecting relative prices, allocations to agricultural sector, and sector policies impacting ATM.

Instruments: Literature search, interviews.

Procedures: Review economic literature, policy documents

Improvement Analysis

Purpose: Identify improvements in the ATMS as a whole and within resource use and internal processes of key institutions.

Contents: Study of mandate, human resources, infrastructure, and performance of key internal functions of major institutions.

Instruments: Survey of Institutions, Human Resource Inventory and earnings function analysis, literature search and interviews

Procedures: Initiate mission with survey of key institutions, supplement data as mission progresses; analyze using cross-country comparisons.
Preliminary analysis on administrative data, administer human resource survey, analyze conditions of service using earnings functions.

STAGE III

<u>Case Studies</u>

Purpose: Define ATMS by examining specific examples of its operation; identify key actors and forces; identify points of improvement in System.

Contents: Outline key events, actors, and issues in technology generation; assess impact of technological advances. Focus on key resource, management and environmental variables influencing impact of the technology generating sector.

Instruments: Literature review, interviews, Intervention Opportunities Matrix

Procedures: Select cases to highlight issues relating to resource, management and environment variables; identify technological events and positive and negative determinants of ATM success.

A. The Analysis of Agriculture's Structure and Performance

The logical starting point for the first stage of the methodology is a review of agriculture's structure and performance. It provides basic factual information about growth in agricultural production, changes in technology, and the evolution of underlying social, economic and political forces affecting the agricultural sector. Among these factors are patterns of land distribution, inefficiencies in resource use, and the degree of integration between the agricultural sector and the rest of the economy.

The approach is to overlay secondary data and available literature on the agriculture of the country with information on the process of agricultural change in the region as a whole. The purpose is to identify areas of similarity and differences which distinguish the country's agricultural structure and performance from that of other countries. Special attention should be given to understanding salient differences which bear on B, R, M, and X variables.

B. The Institutional Analysis of the ATM System

At this stage, the methodology calls for the identification of principal institutions within the ATM System and an understanding of how those institutions relate to one another. Particular attention is given to identifying institutions and groups which are found to have significantly affected agriculture's performance and structure at the first stage of analysis.

The institutional analysis of the ATM System is composed of a functional analysis of the system, an events analysis, a policy analysis, and an institutional improvement analysis. The purpose, contents, instruments and procedures of each analysis are detailed below.

1. Functional Analysis

a. Purpose

A system review examines potential improvements in both the structures and mechanisms for the performance of key functions of the system. The functional analysis provides a methodology for describing an ATM System in terms of "key functions" and the role which particular organizations play with respect to each function. The ATM System is not consciously defined by most participants in it. Consequently, the functional analysis provides a framework within which improvements can be systematically discussed. A function may be performed inadequately because there are too few (or too many) organizations peforming it, or because the mechanisms for performing it require improvement. A donor organization may also use the functional analysis to compare ATM Systems across countries to assist in the development of regional investment strategies.

b. Instruments of Analysis

The main instrument is a "linear responsibility chart". In the business literature, this is used to identify individuals, tasks, and responsibilities for execution within a project. In an ATMS review, we identify 13 key functions that an ATM System must perform, the important organizations in the system, their level of participation in each function, and the mechanisms for such participation. These become entries in a database of the system.

Conceptually, the 13 key functions are arrayed across the top of a matrix as columns while the component organizations are the rows. By going down a column, all organizations involved in performing a given function and the extent of their involvement can be identified. The number and locations of participants in the ATM System help identify points of weakness. By going across a row, all the functions that an organization performs in the system can be shown and concentration or dispersion of effort can be highlighted.

c. Contents

Thirteen key functions are identified which an ATM system must perform, or at least influence. If the system carries out all 13 functions effectively and coherently, it is likely to be "successful." These key functions, and the analyses that must be undertaken, are:

* Define macroeconomic strategy

Analyze the organizations involved in making basic macroeconomic policies relating to rates of exchange, relative prices, and size of government which set the overall framework in which the agricultural sector operates. These policies impact agricultural innovations.

* Define intersectoral allocation of resources

Determine the share of the government's budget devoted to agriculture and the way in which that proportion is fixed. This is a measure of the importance attached to agricultural development and of the potential resource available for agricultural technology generation and transfer.

* Develop human resources for the agricultural sector

Determine whether ATMS organizations are efficient in developing and managing their own human resources. Management of human resources involves the identification of needs, planning for human resources, the execution of training plans, and the establishment of conditions of service which attract and retain the human resources required by the system.

* Generate domestic political support for agricultural research

Organizations need political support for their activities. Determine whether the ATMS organizations actively seek to generate support or detract from support for agricultural research through inaction or opposition.

* Generate external support for agricultural research

Identify organizations which generate external support for agricultural research/extension, and the mechanisms they use. The external support an ATM System enjoys may be a crucial element in its success or failure.

* Set goals for the agricultural sector

Clarify how goals are set for the agricultural sector. The establishment of realistic goals and the creation of appropriate mechanisms by which they are set are important functions for the success of the sector.

* Allocate resources within the agricultural sector

The amount of resources devoted to research, extension, credit, input supply and marketing guarantees is a decision variable affected by the political-bureaucratic structure. Analyze the mechanisms through which each organization influences those decisions.

* Determine research strategies

The determination of research strategies involves the identification of development objectives, the expression of those objectives as research problems, and the choice of appropriate research strategies to solve those problems. Determine the role and effectiveness of each TGS organization in setting these strategies.

* Generate and assess technology

Identify all organizations which generate and assess technology. Technology generation takes place primarily in national research institutes, but universities, private firms, and external organizations are also involved in generating and assessing technology.

* Transfer technology

Identify and analyze institutions and mechanisms involved in technology transfer. Interfacing between research and extension is an important function of the ATM System. In the absence of an effective public extension service, a variety of other channels emerge for the transfer of technology and for related information exchange.

* Provide support services

Support service organizations in agriculture provide a range of services--from seeds to credit and tractor hire. Identify the principal organizations and the services they provide. Note as well the provision of support services by organizations not primarily part of the support service sector.

* Evaluate impact

Several organizations assess impact on the ATM System of agricultural research. Identify these organizations and analyze the evaluation methods they use.

* Market final output

Describe and analyze the role of agencies involved in market regulation and intervention.

For each participant in the system, its responsibilities and mechanisms for participation in the key functions are described. The responsibilities are: Decide, Finance, Coordinate, Execute, Participate, Advise, Inform, and Request. The mechanisms for participation in a function may run the gamut from formal lines of authority through procedures for consultation or lobbying to informal exchange of information.

d. Procedures

Given the accessibility of microcomputers, even at the field level, information can be stored in a database format and updated as new organizations are created, as the formal functions of old organizations are modified, or as the mechanisms for involvement are changed. At any moment, it is then possible to produce tables showing organizations and ATM functions.

2. Events Analysis

a. Purpose

The events analysis systematically records and analyzes the evolution of institutions, policies, and technologies produced by the ATM System. As part of the institutional analysis, it provides a way of studying the changing roles of public and private sector institutions over time and their relation to the technologies being produced. It can also be used to document the role of the external sector, or that of a particular institution. The events analysis helps integrate the case study analysis and the institutional analysis through its systematic recording of both the technological and institutional characteristics of events. The analysis can be continuously updated by a local mission or research institution.

b. Contents

The proposed method encourages team members to record systematically several important pieces of information about each event cited in the literature and in personal interv ews. This information includes:

*the sector of the ATM System in which the event originated (public or private, external or domestic);

*the responsible component of the ATM System (politial bureaucratic structure, technology generating sector, technology transfer sector, service sector, technology using sector, or post-harvest sector);

*the date on which (or period over which) the event occurred;

*the nature of the event (agronomic, biological, chemical, mechanical, economic, policy, or institutional);

*a description of the event;

*the individual commodity to which the event relates (particularly where cycles of technological change and supporting policies are likely to be different across commodities);

*the principal organization involved in the event;

*the cooperating organizations which participated in the event.

c. Instruments

The events analysis emerges from a systematic management of information gained from personal interviews, and study of available literature. Both the case studies and the institutional analyses will provide raw material for this approach. The use of a database management program for recording and arraying the information permits new information to be incorporated into the analysis at any time.

d. Procedures

Each event is described and stored in a database management program. As additional events are encountered in interviews and the literature, the database of events can be expanded and refined. By reordering and processing data in ways which highlight different relationships, certain hypotheses about the the ATM System and the roles of different agents in the system can be formulated and tested. Some of the analyses permitted are:

*Cycles of technology

These may be studied with a chronological analysis of events by date, nature, and commodity. In the usual Latin American pattern, agricultural improvement took place first through improved agricultural practices, followed successively by mechanization, chemical, and seed technologies. Each of these technologies builds on experience with the preceding technology, and a country which tries to assimilate advanced chemical and seed technologies without having established research on basic agronomic practices may require special assistance.

*Institutional participation

A chronological ordering of events, relating the nature of technological change to the institutions involved, permits the identification of roles played by public and private or foreign and domestic participants and the ways these have changed over time. It may be used to document a history (or absence) of collaboration among institutions, which is important when judging proposals for improvement of the system, or to highlight the contributions of a given organization.

The method provides a way of exploiting all information that may be gathered during the course of a system review. Having identified important events through interviews or reading, the analyst incurs only a small marginal cost to record them in the detail described above and then to have them permanently available for further analysis.

3. Policy Analysis

a. Purpose

In the policy analysis, we study certain key policies and describe both their intended purpose and implications for the agricultural sector. Many policies may be designed to serve non-agricultural interests that have major impacts on the ATM System. The end product of the policy analysis is the identification of policies that are constraints to the ATM System which are subject to improvement through political or management change. If a particular policy cannot be changed, leaders of the ATM System may seek compensatory measures. For example, a country may maintain an overvalued exchange rate to facilitate capital imports, to keep parity with a major trading partner, or to serve the interests of a key sector. The negative effects on agriculture may justify compensatory subsidies, quota restrictions on competing products, and selective taxes to prevent relative prices of traded and non-traded inputs from being distorted.

The key policies studied by the methodology are at three levels: macroeconomic policies that affect the overall economy; policies that affect the intersectoral allocation of resources; and policies within the agricultural sector itself.

b. Contents

At the macroeconomic level, interest focuses on policies affecting exchange rates, the level and role of government in the economy, and relative product and input prices. For most countries, the exchange rate is the key price determinant in the economy. Its value has major implications for all sectors. Since the exchange rate may be fixed, a variety of compensatory measures may be in effect.

In studying the role of government in the economy, interest focuses on the resources the government controls relative to GDP and their allocation. It also focuses on whether or not these allocations to agriculture take place within a context of governmental expansion or austerity, a matter of importance when planning improvements to the ATM System.

At the macro level, policies which affect the relative prices in the economy are examined. They may involve exemptions from taxes, subsidies on capital, controlled interest rates, and social policies toward employed workers which increase real wages. Such policies are generally enacted for the dominant sector, but their effects spill over into agriculture.

Finally, the importance that the government attaches to scientific and technological research is examined since policy toward science and technology may be indicative of the importance government attaches to research, including agricultural research.

At the level of the intersectoral allocation of resources, interest centers on the priority accorded to agriculture (expenditures on research, extension, subsidies, and other services) in relation to the size of the agricultural sector itself. For this analysis, comparisons with other countries provide a frame of reference. Efforts are made to understand whether the ratio of agricultural expenditure relative to agricultural gross domestic product reflects investment, transfers through subsidies, or the costs of bureacracy.

The final level of policy analysis addresses the policies of the agricultural sector itself, and the coherence of research, extension, and related programs. Particular attention is given to the extent to which research, extension, subsidies, and support services operate in the same or opposing directions, and whether or not such policies operate uniformly across the agricultural sector or only for particular crops.

c. Instruments

The policy analysis relies on literature searches, interviews with policy makers, and analysis of basic statistics relating to government expenditures, public finance, and the behavior of the banking system. Sector studies provide much of the information about specific policies.

d. Procedures

Initial attention focuses on identifying policies operating at the three levels described above. Reasons for each policy and its implications for the agricultural sector are described. Where implications for the agricultural sector are negative, the possibility of changing the policy, or enacting compensatory measures, is assessed.

4. Institutional Improvement Analysis

a. Purpose

The preceding analyses help identify key organizations and system-level improvements. The institutional improvement analysis carefully considers individual organizations. It looks at the major technology generating and transfer institutions with a view to suggesting improvements in institutional processes and resource use.

b. Content

The analysis of a particular institution begins with its origins, mandate, and governance structure. An organization emerges out of a given context and both its mandate and governance structure will reflect conditions prevailing at the time of its creation. A first step, therefore, is a synthesis of materials dealing with the creation of the institution: its purpose, relationship to other organizations, its powers and means of action.

The key internal functions found important in other studies provide the focus for the analysis of individual organizations. These are:

*problem identification
*priority setting
*obtaining adequate financial support
*attracting/retaining human resources
*development of adequate infrastructure
*programming research

*managing linkages with the technology environment
*monitoring and evaluating research; and
*communicating results to clients and policy makers.

The institutional improvement analysis compiles the information needed to assess the adequacy of the performance of these functions and to suggest improvements.

c. Instruments

Information for the improvement analysis comes from personal interviews, literature reviews, and the results of two surveys. The surveys and their use are discussed below.

*Survey of Institutions

The analysis of a particular institution requires data of both a quantitative and qualitative nature. Much basic information on the structure, organization, funding, and human resources can be collected through a survey instrument like the ISNAR/IFARD Survey of National Agricultural Research Systems. The standardization of information collected across institutions, and eventually across countries, provides a means of comparing institutions with "norms" for the region. Many countries have already responded to the current Survey and the data are being checked and refined for publication in ISNAR as a data base on national research systems.

*Human resource inventory

The quality and quantity of human resources are the basis of any research system. The collection of comprehensive data about scientific personnel is a first step toward understanding the functioning of the institution. Information must include the age, sex, and educational characteristics of scientists and senior administrative personnel; their career history, their current function and location, and detailed information on remuneration and other benefits. In many advanced systems, this information is available from administrative records and may be compiled by a local research assistant, or drawn directly from the computer. In other systems, not all this information is available and use of a human resource inventory questionnaire is recommended (e.g. ISNAR Working Paper #3).

d. Procedures

Where the data have been compiled in consistent fashion, comparisons across countries or institutions may be the best guide to the relative effort of an institution. Attention focuses on key ratios such as operating budget per scientist, operating budget as a percentage of total budget, and percentage of total budget coming from national sources. We propose the use of standard database information like that being collected by

ISNAR and IFARD, but a major donor is likely to have its own information.

*Analysis of human resource information

The analysis of human resources involves study of three issues: the sufficiency of human resources in quantitative terms, the appropriateness of the disciplinary mix, and the adequacy of conditions of service for retaining and motivating researchers.

The first issue is studied by comparing the ratio of M.S. and Ph.D. scientists to total scientific staff with norms for the region, or with advanced systems. The appropriateness of the disciplinary mix is derived from the basic disciplines and specializations that are critical in the research or extension program. This comparison of needs and resources leads toward a human resource plan.

The attraction and motivation of human resources is a management issue. To analyze the problem, an elementary human capital approach should be taken which treats investment in human beings in the same way as investment in physical capital. Productivity, and therefore salary, are presumed to be related to formal education and experience. In developing countries, the prediction of earnings from a multiple regression analysis of education and experience factors is helpful in summarizing labor market information and in identifying the principal determinants of income. This "earnings function" estimates the relationship between the salary of scientific and technical personnel and formal education, experience, and personal and job characteristics. Income profiles may be derived from the model and compared across institutions. The height and shape of the income profile give important evidence about conditions of service and the ability of an employer to retain personnel. Flat income profiles offering little promotion tend to produce high turnover unless salaries are higher than in other institutions; rising profiles attract and retain staff but become expensive to maintain. Improvements must deal with both the structure and level of salaries.

C. The Case Studies

1. Purpose

The case studies define the ATM System by examining specific examples of its operation at the "field level." Individually, the cases are micro-level pieces of the ATM puzzle. Collectively they form a detailed picture of the System as a whole. Their purpose is to test hypotheses generated in other phases of the ATMS Review concerning the performance and productivity of research/transfer programs in the field. An equally important objective is to identify constraints operating on the System which are not revealed in other phases of the review and which need improvement. The case studies are thus a vital complement to the institutional analyses. Without them, serious misjudgements could be made by failure to understand how policies are actually executed. While case studies are not normally a part of donor assessments, the additional effort yields a more pragmatic awareness of System constraints and more finely tuned recommendations for change. Suggestions for improvements in the System and in individual commodity programs are a principal product of the case studies.

2. Contents

An introduction to each case study quickly outlines key historical events and trends, key actors and issues which determine the performance of the commodity, discipline, region or issue selected. This section closes with a brief identification of the principal problems to be resolved.

An historical and structural analysis focuses in some detail on key indicators of production and consumption trends, on trends in technology generation and application, and on the impact of technological advances. The analysis begins by setting the case in perspective within the agricultural sector, for example, by indicating the importance of a commodity in terms of its production value. Key yield, price and cost data subsequently permit an evaluation of productivity. The next section reviews historical developments in the Technology Generating System (TGS), identifies central institutions, and discusses the most important advances and constraints of the System. A final section analyzes the impact of technological advances on production and productivity in terms of commodity yields and production costs. Comparisons within the region and beyond help set achievements and constraints in perspective.

An important part of the study focuses on key resource, management and environmental variables which have influenced the effectiveness of the TGS. The adequacy of human, financial and physical resources is assessed, as well as their contribution to TGS achievements. An analysis of key management functions follows, indicating how well available resources were manipulated to reach commodity objectives. A final section focuses on key variables external to the TGS -- principally institutions and their policies -- which affect the performance of the TGS. Of greatest interest is whether these external forces have aided or impeded the functioning of the TGS and its impact.

Included in each case study, just preceeding the analysis of key variables, is a table summarizing critical technological events and their impact on the development of that commodity. The determinant factors -- both positive and negative -- are summarized for each event in a subsequent table. Each factor is identified as a resource, management or environmental variable.

A final section summarizes major conclusions and recommendations for improvement which are made throughout the analysis. They are prompted by the analysis of variables determining the performance of the System, and address needs specific to the commodity as well as to the System as a whole.

3. Instruments

The Intervention Opportunities Matrix (IOM) is the unifying instrument of analysis for the case studies. It brings together key resource, management and environmental variables from the studies and groups them to clarify which variables have been most important in determining the benefits of the System.

This final, micro-level stage of the methodology serves to test inferences distilled from previous stages concerning the importance of R, M, and X on field-level outcomes. It is essential since factors which appear to be highly important (or unimportant) to the productivity of technology generating institutions at early stages may have made little difference (or a great deal of difference) when examined in the field. Also, the IOM helps rank the relative importance of each variable, and thereby identifies critical areas for interventions by national and international organizations.

Arrayed along the vertical axis of the Matrix (Table 3.III.2) are significant technological outcomes and their associated impacts, identified in the institutional and case study analyses. Along the horizontal axis are R, M and X variables. Cells in the matrix are filled with measures of the importance of each variable in the observed outcomes.

Ideally, technological outcomes should reflect values of the total economic benefits of the associated research, as well as some measure of the distribution of benefits among consumers and producers. In practice, however, proxy variables of these concepts will need to be devised.

We suggest ranking the total level of benefits for each technological outcome, and similarly ranking the distributional impacts for consumers and producers. In a sophisticated coding scheme, variables could be assigned numerical values from one to five. Hence, if the level of benefits is high and both producers and consumers received correspondingly high shares of the benefits, the technological event would receive a score of 1-1-1. However, a variable which notably constrained the level of benefits but was neutral in terms of its effects on the division of benefits between producer and consumer groups would receive a score of 5-3-3. In a simpler coding scheme, variables could be rated positive, negative or neutral and their importance determined by a tally of these signs.

Scoring schemes for the IOM must be accompanied by narratives which add background and interpretive information. The Matrix is an organizational aid which serves primarily to fix ideas and to summarize observations of the review team, as well

Table 3.III.2. Intervention Opportunities Matrix

VERTICAL AXIS - Benefits of technological events (B)
1. Level
2. Share going to, and distribution among consumers
3. Share going to, and distribution among producers

HORIZONTAL AXIS - Determinants of technological events

Resource Variables (R)
1. Budget resources
   a. level
   b. continuity
   c. balance
   d. source
2. Human resources
   a. quantity
   b. quality
   c. continuity
3. Physical infrastructure
   a. availability
   b. quality

Management Variables (M)
4. Structure and organization
5. Priority setting
6. Evaluation and monitoring
7. Financial resource management
8. Human resource management
9. Management of interactions
   a. inside TGS
   b. with other national institutions
   c. with international institutions

Technology Environment Variables (X)
10. Policy environment
   a. development policies and objectives
   b. fiscal policy
   c. macro price policy
   d. science and technology policy
   e. private investment incentives
   f. service infrastructure
11. Structural conditions
   a. political ideology
   b. cultural and historical environment
   c. socio-economic environment
   d. population
   e. natural factors
12. Donors
13. International technology generation and transfer system

as to highlight especially significant variables and influences. For example, an R variable which seldom receives scores of less than four or five must be interpreted as a pervasive constraint to technological generation. If a variable received low values for many high payoff technological events, we would infer that it has been a very important determinant of the payoff of technological events.

Thus, suggestions for consolidating success in the System flow from an analysis of positive determinants, and recommendations for improvement are derived from the weighing of negative determinants. Nevertheless, the IOM cannot provide exhaustive detail or substitute for familiarity with the System. Instead, it is a tool which assures a systematic approach to an analysis of key variables and their interactions in determining the performance of the ATMS.

4. Procedures

Since the cases should represent a true picture of the whole ATMS when considered collectively, their selection is important. Initial review of available literature and interviews with representatives of central institutions in the agricultural sector should be planned with the goal of identifying suitable cases. These cases should illustrate key interactions of ATMS components with regard to R, M, X and B variables, i.e., cases which reflect differences in allocation of sectoral resources, in the management of those resources and of linkages within the ATMS, in the influence of ATMS environmental variables and in the distribution of benefits. Each case should be chosen to highlight one or more key issues relating to those variables, which are summarized in Table 3.III.3. These issues are clearly related to the IOM in that they are specific examples of the generalized variables making up the matrix.

Identification of a national counterpart broadly familiar with the ATMS to assist in contacting key individuals, setting up interviews and planning field visits is extremely helpful. That individual can also suggest senior representatives of organizations and groups in the TGS, TUS and TTS who would serve as an Advisory Committee to the study team.

Once potential cases are identified, consultation with the Advisory Committee is important to benefit from the members' broad knowledge of the System. Final selection is based on the Committee's recommendations and the study team's knowledge of factors important in regional agricultural systems.

Statistics and literature for each case are then collected and reviewed. Visits are made to interview representatives of key institutions and groups in the TGS, TUS and TTS. Important technological events and their impact are identified, and causal determinants pinpointed. Initial hypotheses are reached concerning principal R, M, X and B

Table 3.III.3. Criteria for Case Selection

Resource Variables (R)
- Financial resource availability
- Research manpower quantity and quality
- Adequacy of physical infrastructure

Management Variables (M)
- Priority of the case in the national TGS
- Urgency of a problem facing the case
- Research expenditure on case in relation to total research budget, and to value of case in agricultural sector
- Research manpower allocated to case in relation to other cases
- Research focus, organization and strategy

Environmental Variables (X)
- Importance of case to agricultural sector product and employment generation
- Growth potential of market for commodity
- Role of national institutions
- Policy environment
- Role of private sector
- Role of international TGS
- Role of donor community

Benefit Variables (B)
- Impact of new technology
- Distribution of benefits among producer groups
- Distribution of benefits among consumer groups

variables. These are discussed with the Advisory Committee, which can assist in clarifying events and reorienting hypotheses.

A second set of field visits is made to fill out the emerging picture, gather additional data and confirm or adjust conclusions. A concentrated period of reflection and writing follows, with major effort devoted to reaching conclusions and recommendations. Another meeting is held with the Advisory Committee to discuss these, with adjustments as necessary. The report is finalized and presented. A seminar is also organized in the host country with top representatives of all key institutions to achieve the greatest discussion and dissemination of results and to stimulate action on the recommendations.

IV. Guidelines for Organizing an ATMS Review

This section is addressed to the manager of an ATMS review and provides guidance for staffing, scheduling, and reporting. The approach stresses the importance of interaction with national staff and a local advisory committee, the need for alternating periods of field work and desk analysis, and the need for structured opportunities to integrate the various stages of analysis.

A. Local Advisory Committee

An ATMS review should be carried out in cooperation with a local authority at a level sufficiently high in the hierarchy to have its recommendations recognized by all components in the system. The methodology calls for the constitution of a local Advisory Committee to provide initial guidance to the study team and periodic review of its findings. Members should be broadly representative of the technology sector and key institutions in the politico-bureaucratic structure; have disciplinary training in the biophysical sciences, rural social sciences, or management sciences; and represent local public and private organizations.

The Committee's initial contribution is to identify principal organizations in each of the components of the ATMS, including actors in the private sector and politico-bureaucratic structure whose roles are often underestimated in reviews concentrating on the public technology sector. It also suggests contacts and provides introductions to many of the organizations. Finally, it plays an important role in the selection of case studies which highlight the impact of resource, management and environmental factors in the ATM process.

Subsequently, the Advisory Committee provides critical review of the findings of the study at its different stages of analysis. This includes discussions of the characterization of the ATM System as presented in the functional and institutional improvement analyses, the evolution of the system described in the sector analysis and events analysis, and discussion of the specific case studies falling within the competence of individual members.

B. Local Coordination

A local coordinator should be appointed by the study team on the recommendation of the Advisory Committee for the period the team is in-country. The person selected would also serve as the the Committee's Secretary. This local coordinator would help arrange a productive and cost-effective agenda of local interviews and assist the team in acquiring necessary data and literature. An agricultural economist, having wide familiarity with the country's agriculture, working in a planning unit of one of the institutions in the technology sector, is an ideal candidate since such a person would be well positioned both to provide information and contacts and to benefit from the study.

C. Information Collection and Analysis

The analysis has been likened to a sieve which begins at a high level of aggregation and narrows its focus progressively to finer levels of detail on particular organizations, processes, and case studies. An initial period of data collection and interviews in the field must be followed by sufficient time for reflection and analysis and to carry out the first sifting of the information. Preliminary conclusions about the institutions and cases can be drafted at home base and provide material for consideration by the Advisory Committee. During a return visit, deeper analysis of key institutions and processes and study of additional organizations can expand and enrich the functional and improvement analyses. More complete detail can be gained on each of the case studies, and additional commodities or events can be added to highlight R, M, and X factors not previously included.

D. Integration of the Institutional Analysis and Case Studies

The institutional and case studies analyses are complementary ways of examining the same phenomenon, notably the impact of resource, management and environment factors on the process of technology generation and transfer. Frequent meetings between individuals engaged in the two analyses are necessary to ensure integration of their findings and to provide hypotheses for further investigation. For example, weak institutional linkages between policy makers and the technology sector may appear from the institutional analyses and be confirmed by the case studies at the commodity level; weak linkages between research and extension may appear at the institutional level but have little impact on the success of technology generation and transfer at the field level. The integration of these analyses takes place through frequent discussions among team members and periodic review by the Advisory Committee.

E. The Role of the Review Team Leader

The role of the team leader extends beyond the actual period of fieldwork and writing that makes up the mission proper. It begins with defining the specific purpose of the mission and its timing to ensuring that the findings are being used. The activities of the leader are:

1. Establish the Purpose of the Analysis

The ATMS review may be undertaken to provide information on a system which is poorly understood or to target particular organizations for improvement while taking account of environmental factors. The attention given to the different parts of the analysis depends on its purpose.

2. Assemble Existing Information for Team Briefing

The leader must identify and assemble relevant studies and sector analyses for briefing of team members. Considerable time may be saved if team members have had the opportunity to study basic documents prior to coming to the field.

3. Discuss the Review with Local Donor Representatives

Local donor representatives can make useful inputs into the identification of key ATMS institutions and processes of donor involvement. They may also have suggestions for individuals to serve on the local Advisory Committee, although final selection will depend on agreement between the team leader and national authorities cooperating with the study.

4. Select Team Members

With strong local backstopping and cooperation, we believe the study steam can be limited to three members: a political economist/agricultural economist contributing to the sector analysis and interventions opportunities matrix; an ATM System specialist to contribute to the functional and improvement analysis, and a biophysical scientist to lead the case studies of technological events.

5. Schedule and Ensure Execution of the Mission

The team leader is responsible for organizing the timing of the mission to ensure the presence of team members at the same time, periods of interaction among them and the Advisory Committee, and a period for integrating the separate analyses. Final publication and submission of the report rests with the team leader.

6. Organize Follow-up

The methodology calls for an in-country seminar to discuss the conclusions and recommendations of the report with representatives of key ATMS organizations. This is a crucial step to turn information and recommendations into action. It will be the first discussion of the ATMS approach for some participants and an opportunity for them to view their institutions in a wider framework. If the recommendations gain wide acceptance among participants, members of the local Advisory Committee could take the lead in promoting improvements in line with the findings of the mission.

V. Costs, Logistics, and Timing

Diagram 3.V.1 outlines the stages of an ATMS review. From left to right it shows the activities which must be carried out in the field and at home base. The preliminary review of literature and briefing of the team members takes place at home base. The discussion of terms of reference of the study, organization of the Advisory Committee, and identification of the principal components of the ATMS takes place during an exploratory mission in the field. Preliminary analysis of the information is carried out at home base. This is followed by an extended period of field work to compile detailed information for the case studies and the institutional analyses. Returning to home base, the team prepares and integrates the institutional analyses and the case studies. A preliminary identification of points of intervention is then taken to the field for discusson with the Advisory Committee. A final report is prepared taking account of suggestions of the Advisory Committee.

The study team of three persons would need a period for pre-study (15 days); another for a first investigative trip to prepare the ground in-country (7-10 days); two periods of intensive field work, with time for writing first drafts in between (90 days); and a final period for drafting the report (45 days). Therefore, we estimate a 16 person-month level of effort by the study team, plus up to three person-months by the local coordinator, for the entire study. Total costs for an internationally recruited team to work in Latin America should not exceed $ 125,000 (Table 3.V.1). This includes the generation of basic information about the ATM System which is needed to support the various analyses undertaken.

The costs of an ATMS review as just described assume that an external review team, working with a local coordinator, must collect and analyze the basic information which supports the various analyses. This includes original data collection on the structure, finances, and human resources of key institutions, as well as undertaking case studies of selected crops. The times

Diagram 3.V.1. Scheduling of an ATMS Review

Activity	Months 1	2	3	4	5	6
1. Pre-Mission Preparation	XX					
2. Exploratory Mission	XX					
3. Preliminary Analysis		XXXX				
4. Main Field Work			XXXX			
5. Main Analysis				XXXX		
6. Review Findings with Advisory Committee				X		
7. Final write-up and publication					XXX	XXX
8. Follow-up with ATMS Seminar						X

Table 3.V.1. Costs of an ATMS Review

Item	Units	Total	Cost/Unit	Cost
Staff				
Economist	months	5.5	$4,000	$22,000
ATMS Specialist	"	5.5	4,000	22,000
Biophysical Scientist	"	5.5	4,000	22,000
Local Coordinator	"	3.0	2,000	6,000
Travel				
International	Round trips	12	1,000	12,000
Per diem	days	180	100	18,000
Domestic	Round trips	6	250	1,500
Support Staff				
Research Assistant	months	2	1,500	3,000
Secretarial	months	4	2,000	8,000
Communications				1,500
Publication and Distribution				7,000
Total				$123,000

indicated for alternating periods of data collection and analysis are the minimum required, given the need to cast a wide net at the beginning, and to sift information at each stage of the analysis to arrive at a detailed understanding of the functioning of the system. Even small Latin American systems are complex and a minimum amount of time is required to visit key officials and technical people. The corollary is that the costs are not likely to rise much as the system to be studied becomes larger.

The cost of an ATMS review is not high in relation to the amounts of money that a major donor is normally prepared to invest. As a one-time investment, the description of the ATM System will become an input to other planning activities. The constraints identified by the methodology fit directly into the log frame analysis of a Project Identification Document. The permanent database on the system will save future missions the task of collecting and analyzing basic material that is often difficult to obtain. Finally, the nature of the policy dialogue over system improvements will be improved by casting of the discussion in a formal framework.

However, there are ways of reducing costs of such reviews. Significant economies could be realized if one or more organizations were given the task of creating specialized capabilities for collecting and analyzing information. Spreading the investment in setting up a permanent database over a number of reviews would certainly bring the average cost of a review down. In addition, this would facilitate the cross-country comparisons that the methodology affords. Second, the members of the consortium could continuously refine the methodology, and this should further reduce the costs of an ATMS review, subject to the recognition that even small systems are complex. Finally, those working with the database and the methodology could brief assessment teams on their use, thus decreasing the in-country time required by team members.

III. Case Studies

A. Introduction

1. Relationship of Case Studies to Institutional Analysis

Given the complexity of the ATM system, it is important to examine specific examples of how ATMS interactions affect the performance of agricultural commodities or other subunits of the sector. Commodities have been chosen in this study because much of the Panamanian Technology Generating System (TGS) is organized along commmodity lines. However, it would be equally appropriate to choose an area-specific focus such as a regional development project, or a thematic topic such as plant protection, particularly when such approaches are taken by the TGS. Given additional time and budgetary resources, a case study of this nature would be undertaken to complement the commodity studies.

The intent of the case study analysis is to examine the working of the ATMS "in the field." Case studies are carried out through extensive interviews with key actors in every component of the ATMS - with researchers, research administrators, producers, private sector representatives, administrators and policy-makers in the support service institutions. Visits are made to laboratories, experimental stations and farms to see the TGS in action, and to processing plants, seed production units, libraries and offices of the many agencies and institutions making up the ATMS. First-hand exposure to the ATMS in the field and to the range of views expressed by participants in the ATMS facilitates an in-depth understanding of the system.

The commodity case studies serve well to identify variation among institutional priorities and policies and to reveal strengths and weaknesses of the system. Analysis of cases in which commodity performance has been unsatisfactory has targeted points of intervention, while cases of satisfactory commodity performance signaled patterns for reinforcement.

Examination of commodity cases confirms, alters and contrasts assumptions regarding institutional priorities. For example, BDA, IMA, ISA and ENASEM are all heavily committed to the rice sector with much lesser commitments to a few other commodities. In contrast, IDIAP focuses its budgetary resources on animal production, rice and maize, but its mandate encompasses over 20 additional commodities. The comparison raises questions regarding the effectiveness of a research organization with such a large mandate, and indicates that policy consensus may be a constraint.

Commodity case studies are particularly useful for analyzing interactions and linkages between ATMS institutions in the public and private sectors. Carefully selected and contrasted case studies reveal factors which favor strong private sector interactions with public sector TGS institutions and those which constrain it.

Commodity analysis elucidates the effects of variables in the TGS policy environment, either at the national or international level. For example, only at the commodity level can the contribution of the ITGS be appreciated. Issues for analysis include the appropriateness of internationally generated technology, management of institutional linkages to the ITGS, and role in national TGS manpower development, among others.

Finally, benefits from the TGS are quantified in terms of increased production and productivity of agricultural sector commodities. Distribution of those benefits is traceable through a structural analysis of farm size and share of production per size class. The information is then used to evaluate the appropriateness and effectiveness of institutional clientele targeting policies. This issue is particularly relevant when judging the effectiveness of the TGS for traditional commodities as opposed to market-oriented commodities.

2. Criteria for Selection of Case Studies

The objective of this process is to select a limited number of cases which best illustrate key interactions of ATMS components with regard to R, M, X and B variables. Cases were selected on the basis of criteria which were summarized in Table 3.III.3.

Justification for the selection of the commodities rice, maize, legumes, onion and tomato is derived from these criteria. Rice and maize were selected because of their major importance as food crops in terms of value and employment generation. The two commodities provide a contrast between R, M, X and B variables for commercial crops versus traditional crops. The rice case is a unique example of the positive effects of policy consensus on the impact of the TGS, in contrast to the lack of consensus and impact characterizing the maize case. Maize illustrates the peculiar constraints placed on the selection of research strategies for traditional crops within the public TGS. The contrasting market orientations of the commodities are reflected in differing weights placed on the distribution of benefits in rice and in maize.

The legume case is actually a comparison of three related commodities - cowpea, bean and soybean. The issues highlighted in these cases relate to market demand and incentives for private sector investment. In the case of cowpea, decline in market demand has resulted in neglect by the TGS and in the policy environment, despite the crop's relative importance in production value and rural employment generation. In contrast, a strong market demand for a particular bean variety has markedly influenced legume research priorities in the TGS. The case of soybean is that of a commodity without producers and without a market. Soybean is unique in that TGS resources were allocated to technology generation for a new crop and technology was successfully developed, yet the policy environment failed to provide incentives for private sector investment to create a market. Soybean also illustrates the ability of the TGS to solve technical problems when research strategies are freed from constraints.

The onion case represents the positive influence of producer groups on the TGS, and the effect of market potential as an incentive to private sector investment. In this case, producer cooperatives have provided leadership for TGS efforts and influenced allocation of research manpower. It will be seen that their support has influenced the policy environment, although it remains unfavorable.

The tomato case highlights the impact of a single private sector organization on technology generation, transfer and adoption to an extent not matched in any other commodity. The company is collaborating closely with the public TGS in tomato research. Transfer and adoption of new technologies is ensured via production contracts with farmers, which also guarantee the market. The company is also successful at influencing the policy environment. This degree of coordination among public and private sector organizations is unique, but raises interesting questions with regard to distribution of benefits.

B. Rice

1. Introduction

From the mid-1940's to the mid-1970's, the principal constraints to rice production in Panama were technical in nature - the need for improved varieties and production practices, including mechanization. Certain resources were lacking - skilled human resources and physical infrastructure. Technologies and expertise were supplied from external sources. The politico-bureaucratic structure focussed its attention on nurturing the development of the rice-producing sector, supplying credit and physical infrastructure, placing human resources in technology adoption and transfer, and developing policies designed to provide market incentives. The private sector was permitted free rein to provide the necessary inputs and to benefit from their distribution.

The Technology Generation System (TGS) was non-existent in the early years, but began to develop with the experience of adopting imported technologies. Skilled human resources were fostered through daily interactions with expatriate scientists and through formal training programs abroad. Direct involvement of expatriate teams in the adoption of rice technologies ceased with the termination of the SICAP program in 1964. National personnel began to take their places, still preoccuppied with the adoption of technology, but already working toward the replacement of other external resources, such as improved seed. Seed multiplication and distribution technologies were successfully adopted and by 1973 had almost totally substituted for the importation of improved seed from external sources.

The young TGS continued to grow into the mid-1970's through many institutional reorganizations. The importance of the TGS was fully recognizing with the creation of IDIAP in 1975. These events culminated in the production of annual rice surpluses by the mid-1970's.

The mid-1970's marked the turning point in the development of the rice TGS. The achievement of surplus production - a laudatory event - signalled the realization of national goals with respect to rice production and the need to reorient agricultural sector priorities. Meanwhile, the release of nationally-developed rice varieties in the late 1970's indicated the maturing of the TGS. However, the politico-bureaucratic structure was slow to make adjustments. Policies and institutions were still oriented toward encouraging rice production, and those who had benefitted (producers, intermediaries) had the political strength to oppose changes. By the early 1980's, economic constraints had increased to the point where the need for reorientation of sector policies was clear. Budgetary resources and external variables have become the most limiting constraints, and management is focussed on increasing efficiency of production - a more difficult task than increasing production per se. The TGS continues to exploit external sources of technology through the international TGS, which is also preoccuppied with similar concerns about production efficiency. However, resources may begin to flow out of the rice TGS as the policy environment is reoriented.

2. Historical and Structural Analysis

a. Production and Consumption Trends

Rice is the most important food crop in Panama, despite its relatively recent introduction in the 18th century. Rice production accounts for roughly 20 percent of the national agricultural product (IDIAP, 1983a) and is second only to bananas in value (Anon., 1984). Rice provides roughly 20% of the calories and 14% of the protein in the national diet. Per capita consumption at 56 kg/year is one of the highest in the region (DEC, 1984; Lasso, pers. comm.).

Rice is produced as a subsistence crop thoughout the country using traditional methods. In sharp contrast, commercial production of rice in Panama is highly mechanized and makes extensive use of aerial applications of fertilizers and pesticides. The most productive province (Chiriqui) accounts for almost 50 percent of the national harvest (DEC, 1985).

Currently, the production area is slightly greater than 100,000 ha. Rainfed rice predominates; only five per cent of the area is irrigated. Mechanized production methods are used on half of the area and traditional methods on the remaining half (DEC, 1985; Lasso, pers. comm.).

Production volume was roughly 200,000 metric tons (t) of paddy rice for the 1983/84 season and national yields averaged 2 t/ha (DEC, 1985). Traditional farmers average only 1 t/ha while mechanized farmers reap 3.5 t/ha, and yields of 5 - 6 t/ha have been achieved in rainfed rice (Lasso, pers. comm.). National yields are low in comparison with regional countries - ten countries have higher yields and only two have lower yields (FAO, 1983).

The structure of rice production is determined by farm size and technological level of production methods. Ninety-six per cent of all rice farms are subsistence farms of one hectare, accounting for 57 per cent of total rice area but only 32 per cent of production. At the other end of the scale, 1.6 per cent of the rice farms occupy 30 per cent of total rice area (averaging 33 ha), but provide 51 per cent of total production (DEC, 1985).

Production costs are estimated at $250/ha for traditional methods and $600-800/ha for mechanized rainfed rice (ISA/IICA, 1982; ISA, 1984; Lasso, pers. comm., Watts, pers. comm.). Costs of fertilizer and other chemical inputs are as much as three times higher than in the U.S. (Anon., 1984). These costs have also been higher than in other regional countries until recently, when regional prices rose to comparable levels due to the strong U.S. dollar (Gordon, pers. comm.). High production costs and relatively low productivity are responsible for national production inefficiencies, despite the good performance of top producers.

Panama achieved self-sufficiency in rice for the first time in 1955 (IDIAP, 1983). Virtually the only rice imported is used as seed. However, contraband rice enters the country from Costa Rica because of high price supports (approximately $300/t for paddy rice) paid to Panamanian farmers. Surplus production has occurred periodically since 1973.

Rice is commercialized through both public and private channels. However, 30 percent of the harvest is consumed on-farm and never enters the market. The largest proportion of the commodity is marketed through an intermediary network of more than 100 private mills (only 40 of which have storage capacity). The national Agricultural Marketing Institute (IMA) purchases and stores 10-20 percent of the production at guaranteed prices. The price paid to producers is set by the Minister of Agriculture, based on recommendations provided by the National Rice Commission. (However, this price is guaranteed only for that portion purchased by IMA - most farmers receive less). The price paid by consumers is set by the Office of Price Regulation. Due to the importance of the commodity, the spectrum of institutions involved in the politico-bureaucratic structure is wide and interactions are complex.

b. Trends in Technology Generation and Application

Currently, IDIAP and FAUP are the principal rice technology generating institutions, with inputs from the international agricultural research organizations and, to a limited extent, from private firms. The development of the present TGS spans four decades and merits a brief review.

Traditional methods of rice production prevailed in Panama until the 1940's and, on many small farms, to the present. However, important events occurred in the early 1940's which set the stage for the rapid expansion of modern rice production in the next three decades: The Ministry of Agriculture, Commerce and Industry (MACI) was created in 1940; agricultural training capability was established in 1941 with the founding of the Instituto Nacional de Agricultura (INA - part of MACI) at Divisa; and the Banco Agropecuario was organized in 1942 (IDIAP, 1983a). INA proved to be a vehicle not only for training, but also for applied research and extension, and for collaboration with international technical assistance agencies. The establishment of the Banco Agropecuario set in place a mechanism to channel public funds to agricultural development. The first efforts to introduce mechanization followed very quickly in both the public (INA) and private sectors and set a pattern for the future

(IDIAP, 1983a). Public and private contributions to technology development in rice proceeded both collaboratively and competitively with almost equal impetus for over two decades.

The decade of the 1950's saw a spurt of technological advances in agronomic practices, plant protection and institutional development. Two important events paved the way for external technical assistance to strengthen the TGS. The first was the arrival of an agricultural mission from the University of Arkansas, which spent the years 1952-58 in residence at INA. The second event was the creation of the Servicio Interamericano de Cooperacion Agricola (SICAP), a cooperative effort involving U.S. and Panamanian scientists who worked together from 1954 to 1963. SICAP provided valuable professional experience for Panamanian scientists, several of whom hold key positions in the TGS today (IDIAP, 1983a; Ocana, pers. comm.). Late in the decade, the Agricultural Faculty was created at the University of Panama (FAUP), which was to play an important role in research and technology generation in the 1960's and 1970's.

Meanwhile, the national Economic Development Institute (IFE) promoted the use of mechanization and fertilization, and new insecticides and herbicides were introduced by SICAP and the Arkansas Mission in collaboration with researchers from MACI. Importation of improved varieties from the U.S. began at the end of the previous decade. These were tall varieties (Nira, Bluebonnet, Rexoro) which yielded 1.4 - 1.8 t/ha and were widely adopted during the 1950's. IFE initiated a program in 1953 to stimulate national seed production capabilities by providing price incentives for high quality seed. IFE also collaborated with the private sector to provide credit for the purchase of fertilizer. Late in the decade, a soil laboratory was established by SICAP to provide soil analyses and to tailor fertilization recommendations more precisely (IDIAP, 1983a).

The 1960's saw a major expansion in land area devoted to rice production and the increased use of mechanization. Rice areas rose from roughly 100,000 ha to 133,000 ha in the middle of the decade. Production jumped almost 50%, from 109,000 in the 1950's to 163,000 t paddy rice by the end of the decade (DEC, 1985). The increase was due as much to expansion of land area as to higher yields.

The private sector strengthened its role in the 1960's by developing comprehensive extension programs, including technical assistance and credit for inputs. They distributed the insecticides and the new herbicide propanil, which were introduced by SICAP. By 1965, propanil was adopted extensively, due to its effectiveness in controlling narrow-leaved weeds (IDIAP, 1983a; Lasso, pers. comm.; Ocana, pers. comm.).

Numerous agronomic studies were carried out during the 1960's. Following the termination of the SICAP and Arkansas programs, FAO initiated collaborative programs with MACI.

Irrigation and fertilization were the focus of two major projects of four and six years, respectively. The seed production program was also transferred to MACI. Significant efforts were made to up-grade soil testing capabilities with analytical procedures from North Carolina State, financed by USAID (IDIAP, 1983a). FAUP conducted experiments through the 1960's on rice technology adaptation and validation, mostly short-term in nature, but important in building human resources (Lasso, pers. comm.).

Early on, rice blast caused by *Pyricularia oryzae* proved to be a major constraint to rice production, to which the American varieties were susceptible. Not until 1963 were improved varieties with genetic tolerance to blast available in Panama, imported from Surinam via El Salvador. These were tall varieties developed prior to the "Green Revolution." The first dwarf variety, IR-8, was introduced in 1967. In the following year a hybridization program was started at INA in Divisa, and INA's mandate was expanded to cover the entire country (IDIAP, 1983a; Lasso, pers. comm.).

Adoption of mechanization was largely completed by the start of the 1970's, and land area devoted to rice declined slightly during the decade. Widespread adoption of the new dwarf varieties was principally responsible for rising yields and total production over the decade. MACI, FAUP and INA played important roles in evaluating and disseminating germplasm and agronomic practices introduced from the outside. Other technological adjustments were needed, however, because the new varieties were susceptible to rice blast. Massive use of fungicides, introduced by INA, was necessary to combat the disease. The first blast-tolerant dwarf varieties, products of national breeding efforts, were released in 1977 (Lasso, pers. comm.). These were significant advances for a country which, little more than a decade earlier, depended on tall, poorly adapted introduced varieties.

A surge in the formation of collective farms, the result of agrarian reform legislation, markedly affected the structure of rice production during the 1970's. These organizations received technical assistance and services from public sector agencies and were quick to adopt mechanization, chemical inputs and improved varieties. Their contribution to national rice production reached 15 percent in the first part of the decade, but declined to 10 percent by the end of the decade, due to reductions in area. This trend continued into the 1980's (IDIAP, 1983a; Ocana, pers. comm.).

A major reorganization of national agricultural institutions in the mid-1970's significantly altered the sector's politico-bureaucratic structure and resulted in a reorganized Ministry for Agricultural Development, MIDA; creation of the national agricultural research agency, IDIAP; the agricultural marketing institute, IMA; and the agricultural insurance institute, ISA. With respect to rice research, the institutional reorganization resulted in the transfer of senior investigators from MIDA and

FAUP to IDIAP, but did not slow the pace of rice research. In fact, collaboration between FAUP and IDIAP is better on rice than on any other commodity. The institutions collaborate on management of international varietal nurseries, production of basic and registered seed, and share seed storage facilities (Rodriguez, pers. comm.). Since the leadership of rice technology generation during the 1970's and 1980's was shared principally by these two institutions, we turn now to a brief review of their programs.

c. FAUP and IDIAP Rice Programs

As the major national cereal crop, rice has received high priority in research at FAUP and at IDIAP. However, research at FAUP has not been as closely coordinated as that at IDIAP due to differences in their respective mandates. FAUP's goal is the generation of technology for teaching purposes, with students as its primary clientele. IDIAP's mandate, in contrast, is the generation of technology for national agricultural development, with farmers as its primary clientele. However, a 1983 review of FAUP research programs led to the recommendation that research be aligned more closely with national needs (Neyra, 1983). Implementation of these recommendations will be incorporated in an expansion of FAUP's research centers, currently under contemplation.

The orientation of rice research at FAUP placed increasing emphasis on genetic improvement during the 1970's. Collaboration with international agricultural institutions such as IICA, IRRI and CIAT provided access to sources of germplasm for evaluation and selection under local conditions. Tolerance to rice blast was the foremost objective (Lasso, pers. comm.). Major efforts were also devoted to the production and processing of improved rice seed, to reduce dependence on imported supplies. The sale of this seed to the national seed company, ENASEM, provides a significant source of income to FAUP's budget (Rodriguez, pers. comm.).

At present, rice research at FAUP is carried out by one senior investigator, one assistant, and three technicians. The annual program budget, exclusive of salaries and maintenance of facilities, is approximately $10,000 (Rodriguez, per. comm.). The 1983/84 research program included 10 projects - five on the evaluation of genetic materials, one on seed production, and four on agronomic practices. FAUP maintains a rice germplasm collection at good seed storage facilities in Tocumen (Panama province) and Alanje (Chiriqui province).

With the creation of IDIAP in 1975, rice researchers assigned to the new institution carried their program with them. However, the two programs are closely coordinated. In fact, the leader of FAUP's rice program recently served several years as IDIAP's Director General. The hybridization program initiated in INA and transferred to FAUP was continued in IDIAP with the same goals of tolerance to blast, in combination with tolerance to drought and to minimum inputs. Justification for a national hybridization program was based on the severity of the disease in upland rice varieties, and the lack of attention to the problem in international programs at CIAT and IRRI (Lasso, pers. comm.). The first blast-tolerant varieties, Anayansi and Damaris, were released by IDIAP in 1977 upon culmination of development initiated in INA. Anayansi still maintains its tolerance today with yields quite comparable to those of introduced varieties (IDIAP, 1983a; Lasso, pers. comm.).

In 1982, IDIAP entered into close collaboration with CIAT on rice breeding research as CIAT intensified its efforts on upland rice (Lasso, pers. comm.). CIAT provided over $10,000 for the collaborative program in 1984 (IDIAP, unpub.) Four new varieties -two developed in the national program and two developed cooperatively with CIAT - are in final evaluation trials and should be ready for release soon (IDIAP, 1983b; Lasso, pers. comm.).

Approximately 75 percent of IDIAP's rice improvement program is devoted to evaluation of CIAT breeding materials, and 25 percent to its own breeding efforts (Lasso, pers. comm.). IDIAP's crossing program is small (100 or fewer crosses per year), but the leader values the experience and flexibility that it provides his program. These efforts contribute to the development of the national TGS.

Results from agronomic studies indicate that weed control, inadequate fertilization and insect control are the most important production constraints, in that order. Improved agronomic packages have been available since 1981 and are continually refined (IDIAP, 1983b). The international TGS is still an important resource for agronomic technology - CATIE has provided roughly $100,000 for research on farming systems including rice production (Bejarano, pers. comm.; IDIAP, unpub.).

IDIAP's 1984 operating budget provided $425,000 for the rice program, roughly 20 percent of the total budget and the largest of any crop (IDIAP, unpub.). In terms of human resources, the staff is composed of one PhD scientist, five technicians and five part-time specialists. The 1984 research plan included 22 experiments on genetic improvement, 16 on agronomic practices including plant protection, nine on physiology and nutrition, and three on validation and improvement of production practices (IDIAP, unpub.).

d. Impact of Rice Technological Advances

An assessment of gains in rice production and yields since 1950 reveals major advances and continuing problems. National rice yields have increased roughly 60 percent since 1950 (DEC, 1985). This modest gain is disappointing when one considers that the yields of available varieties rose 150 percent during the same period. Imported varieties available in 1950 were yielding 1.82 t/ha, compared to yields of 4.54 t/ha of varieties available in 1984 (IDIAP, 1983a). The dramatic increase in varietal yields is roughly comparable to the increases realized by mechanized rice farmers. The slow incremental gains in national yields imply a stagnation in yields realized by a large segment of traditional farmers, offsetting gains achieved by mechanized farmers. National yields lag 30 - 50 percent behind yields obtained in other Central American countries (FAO, 1983).

Of the varieties themselves, 80-90 percent of those planted on mechanized lands are introduced, but a nationally produced variety ranks first in yield and second in area (Table 4.III.1). National varieties are more widely used on traditional farms due to their lower demand for chemical inputs, particularly for blast control (Lasso, pers. comm.). IDIAP estimates that if blast-tolerant varieties were used on 50 percent of the rice area, the savings in production costs for chemical control would be $3.6 million annually (IDIAP, unpub.). The severity of the blast problem and the limited availability of blast-tolerant varieties from external sources justify current national efforts in plant improvement.

Turning to the production of certified seed, efforts by FAUP, IDIAP, ENASEM and precursor organizations, as well as the recent addition of private firms, have had a major impact on the availability of improved seed. Sufficient quantities of nationally produced seed have obviated the need for imports since 1973 (DEC, 1985). Regulations controlling seed quality require strengthening, since millers are still permitted to sell seed of indeterminate quality. The high cost of certified seed is due to small supplies of some varieties. This problem should be ameliorated under a recently initiated BID/ENASEM project.

Table 4.III.1. Panama: Origin, area and yield of principal rice varieties grown on mechanized farms, 1984*

Variety	Origin	Area (ha)	Yield (t/ha)
CICA 8	Colombia	18,074	3.62
T 5430	Panama/FAUP	7,075	3.31
CR 5272	Costa Rica	6,103	3.21
CR 1113	Costa Rica	3,352	3.22
ORYZICA 1	Colombia	3,193	3.44
METICA 1	Colombia	1,594	3.47
ANAYANSI	Panama/IDIAP	1,507	3.46
ELONI	Surinam	608	3.39

*Source: Lasso, pers. comm.

Research on agronomic practices has been particularly influenced by external technologies in the use of chemical inputs to combat weeds, insects and diseases, and to increase soil fertility. For over two decades, experiments were designed to demonstrate the benefits of these inputs and to encourage their use. The contribution of these inputs to high production costs has been recognized for some years, but the public TGS has not been markedly successful in developing and transferring cost-reducing packages. IDIAP, in collaboration with CATIE, is completing the development of a lower-cost, higher-return production package in Chiriqui province (Bejarano, pers. comm.). However, plans for the dissemination of the package have not been laid, since the extension system is only minimally functional pending reorganization. In conclusion, the impact of agronomic programs (particularly in the private sector) has been significant in promoting the adoption of imported technologies among the country's mechanized farmers, but has had negligible impact among traditional farmers. Efforts to reduce production costs through the development of improved management practices are comparatively recent and have not yet had an impact.

Key events in the generation of rice technology and their impact are summarized in Table 4.III.2. Major determinants of those events are presented in Table 4.III.3, and identified as R, M or X variables for entry in the Intervention Opportunities Matrix (IOM).

3. Analysis of Key Variables

a. Resource Variables

Three major resources are considered: human, physical and budgetary. Human and budgetary resources have been the determinant variables, while physical resources have played a lesser role (Table 4.III.3).

The crucial role of human resource development is underscored repeatedly throughout the evolution of the agricultural sector in Panama, and exemplified in the case of rice. Scholarship programs dating back to the late 1920's placed professionally competent people in positions to lead technological development in the public and private sectors, and to assimilate technical assistance provided from the exterior (IDIAP, 1983a). Human resources in the private sector played a role equally as important as their public sector counterparts. Their presence assured an effective distribution system for essential inputs needed to increase rice productivity. Although the technical assistance they provided was unarguably biased toward increased input levels, this served a purpose in the initial stages of technology adoption when farmers needed incentives to change production patterns.

Research efforts are still relatively young in the Panamanian agricultural sector, and a critical mass of scientists

Table 4.III.2. Panama: Technological Events in Rice

Event	Impact
Mechanization	Largely responsible for 30% increase in land area during the 1950's and 60's, which in turn was responsible for roughly half of production increases. Used on half of the production area today.
Introduction of improved varieties	Used on 80-90% of mechanized rice areas. Responsible for half of production increases since 1950 (in combination with improved practices).
Introduction of improved agronomic practices	Used on all mechanized areas, to a minimal extent on non-mechanized areas. Major factor in improved yields, along with improved varieties.
Development of national seed industry	Major impact on local availability of improved seed; imports reduced to insignificant levels.
Development of national varieties with blast tolerance	Planted on 10-20% of mechanized lands, on roughly 50% of traditional lands. Savings in production costs estimated at $2.5 million.
National development of lower cost production practices.	Not yet adopted.

Table 4.III.3. Panama: Major Determinants of Technological Events in Rice*

Event: Mechanization

Positive Determinants:

X 10 a,f	Establishment of institutions & policies promoting mechanization (INA, MACI/Fomentos Agricolas, ENDEMA)
X 13	Role of SICAP, Arkansas Mission
X 10 e,f	Distribution of inputs by private sector Receptivity and initiative of private producers
M 5, 9b	High national priority on modernizing agriculture in 1950's and 1960's; focussed goal
M 9 c	Integration of technical assistance missions
R 1 a,d	Infusion of external resources into public & private sectors

Negative Determinants:

X 10 f	Questionable success of ENDEMA
M 5	Divided research focus today on mechanized & non-mechanized farmers

Event: Introduction of Improved Varieties

Positive Determinants:

M 9 c	Exploitation of international germplasm resources
X 13	Technical assistance from SICAP, Arkansas, CIAT
X 10 e	Receptivity of private sector
R 2 b,c	Two senior rice breeders
X 10 f	Development of national seed multiplication industry

*Refer to Table 3.III.2 for explanation of R, M and X variables.

Table 4.III.3. Continued.

Negative Determinants:

M 5	Divided focus on mechanized and non-mechanized rice farming Loss of confidence by good producers
R 1 a,c	Insufficient budget for field research operations
R 2 a	Limited human resources in extension

<u>Event: Introduction of Improved Agronomic Practices</u>

Positive Determinants:

X 10 e	Receptivity of producers, promotion by private sector Provision of credit by private sector
X 13	Linkages with SICAP, Arkansas, FAO, CATIE

Negative Determinants:

X 10 c	Excessive government intervention in market - no incentive for more efficient production
M 5	Divided focus on mechanized & traditional farming Insufficient focus on agronomic practices and economics
M 9	Limited integration of CATIE's agronomic research
R 1 a,c	Insufficient budget for field research operations
R 2 a	Limited human resources in extension

Table 4.III.3. Continued.

Event: Development of National Seed Industry

Positive Determinants:

M 5 X 10 a,e	High priority in government (IFE) and TGS (MACI, FAUP, IDIAP, ENASEM); private sector ("Central Agricola," Semillas Superiores)
X 9 a,b	Input of National Rice Commission
R 2 b,c	Expertise in FAUP, IDIAP

Negative Determinants:

M 6	Quality control, inadequate supply
M 4, 9 a,b	Need for stricter seed regulations

Event: Development of National Varieties With Blast Tolerance

Positive Determinants:

M 5	High priority in MACI, FAUP, IDIAP Crisis motivated research
R 2 b,c	Two senior rice breeders
M 9 c	Exploitation of international germplasm
X 13	Linkages with CIAT

Negative Determinants:

R 1 a,c	Limited resources for research operations
R 3 a,b	Restricted to on-farm research

Table 4.III.3. Continued

Event: Development of Lower Cost Production Technologies

Positive Determinants:

X 13	Linkages with CATIE
R 2 b,c	CATIE regional representative
R 1 d	Financial resources from CATIE

Negative Determinants:

X 10 c	Government intervention in market - no economic incentive to improve production efficiency
M 5	High priority accorded verbally, but little program support
R 2 a	Human resources limited in research and especially in extension
R 1 a,c	Limited national investment for research operations

has yet to be established. Trained professionals are still a limiting resource, hence the current program in IDIAP to augment its professional staff in numbers and expertise. In the meantime, the pool of human resources with extension expertise has been depleted. Efforts to provide extension training have received much discussion but have been subject to considerable delay, pending reorganization of the extension service.

Physical resources for rice technology development, other than the land itself, have been limited. Physical infrastructure for technology development in the public sector is limited to modest experimental centers belonging to FAUP, IDIAP and MIDA; and grain storage facilities belonging to FAUP. Laboratory facilities are non-existent at IDIAP and extremely restricted at FAUP. However, plans are underway to expand these with the construction of several new laboratory buildings for IDIAP on FAUP land at Tocumen. The lack of extensive experiment stations undoubtedly limited certain kinds of research, but it effectively forced researchers onto farmers' fields. The desirability of a certain amount of experimental land is clear, however, and is planned for acquisition in current FAUP and IDIAP expansion programs. Physical resources external to the public TGS which are nonetheless important to the development of rice production include: ENDEMA's mechanization pool, COAGRO's fertilizer plants, ENASEM's seed processing and storage facilities and IMA's storage facilities; as well as private mills, seed companies, chemical houses, etc. These resources have been adequate to support the achievement of self-sufficiency in rice production.

Rice has received the highest budgetary priority nationally of any crop (excluding bananas) for over three decades. This is true in both public and private sectors for credit, research, technical assistance, distribution of inputs, marketing, mechanization and other services. Private sector resources were effective at promoting the rapid development and application of available rice technology through private banks and agricultural chemical distributors. Private sector credit for rice production has exceeded public credit for most of the past decade, reaching over $18 million in 1980 (IDIAP, 1983a). However, current policy in both public and private sectors calls for reductions in the support price, credit, and area planted. These adjustments are warranted to curb inefficiencies in rice production and should be exploited to promote other commodities of greater potential return to the agricultural sector.

b. Management Variables

Timing and balance are important elements of management which were successfully brought to bear in the 1950's and 60's, when a broad array of human and financial resources were concentrated on expanding rice production. The pursuit of this objective achieved a momentum which successfully brought the politico-bureaucratic structure into line, with the subsequent creation of much-needed infrastructure (credit, insurance, marketing, training, research) for development on a larger scale.

Two significant trends occurred in the 1970's with respect to the allocation of human resources. Extension efforts were reorganized to focus on collective farmers, to the virtual exclusion of other groups. Extension agents were physically located on the collective farms and performed a managerial job, rather than an instructional one. In hindsight, this use of human resources was inefficient and had long-term unfavorable implications for technology transfer in Panama.

In contrast, the assignment of the most highly trained professionals to research activities had a positive impact on the TGS over the long term. The trend began in MIDA and FAUP, and was strengthened with the creation of IDIAP in 1975. Training was a key instrument in professional growth, particularly when linked closely to program needs. Quality and continuity of leadership have also been crucial elements of success. IDIAP and FAUP have valuable resources in senior rice researchers who have contributed skills and long experience to the programs. Institutions such as MIDA have suffered from high turnover of staff due to lower remuneration and poor working conditions. The Government recognizes this problem and recently adjusted salaries of MIDA staff to more favorable levels.

The momentum of the rice "movement" reached a plateau with the achievement of surplus production and now shows signs of a downward trend. Effective management is urgently needed to prevent stagnation. Key issues in the TGS are reduction of production costs and strengthening of socioeconomic capability. Critical issues in the politico-bureacratic structure include limiting of government intervention in the market, collaboration in setting sector priorities and greater commitment to strengthening the agricultural sector.

Public TGS institutions have taken part in several exercises in recent years to set priorities, generally with the conclusion that "everything is important." The result has been that institutional programs continued on their own course and coordination between institutions was limited. The current distance between IDIAP and MIDA conceptions of their interactions with SENEAGRO illustrates the point. Frequent changes in top management at MIDA exacerbate the situation. A consensus on priorities for the agricultural sector will be difficult without a more favorable and stable politico-bureaucratic environment.

Research management involves the coordination of technical assistance. In earlier years, technical assistance programs were coherent because of a close focus on rice. Technical assistance programs today are both more numerous and more diverse. At the national level, IDIAP, MIDA, BDA and ISA all provide technical assistance of one form or another, oftentimes conflicting. Coordination of public sector extension efforts by a central agency with linkages to the private sector would be desirable. Numerous international agencies are also providing technical assistance to various public sector institutions with differing conceptions of how the TGS should function. The existence of an agricultural sector plan would provide the conceptual framework with which to coordinate the input of international technical assistance agencies.

Research to reduce production costs will itself require a greater input of management skills to coordinate biological and socioeconomic inputs. Economic analysis is receiving greater recognition as an integral part of the research. CATIE's collaborative farming systems research project on rice has paved the way for further studies, and IDIAP is already taking steps to strengthen its socioeconomic capabilities.

Crises are an unavoidable variable in research managment which have often served to focus attention and resources on the problem to good effect. The threat of widespread damage from rice blast to susceptible imported varieties in the early 1960's led to the introduction of blast-tolerant varieties from Surinam and later to the focus of IDIAP's rice improvement program on blast tolerance. Such crises are everpresent - the leading variety "CICA 8" is currently menaced by blast and must be replaced. Astute research coordinators should continue to be alert to exploit such crises.

c. Environmental Variables

Variables external to the TGS have played pivotal roles throughout the development of rice technology in Panama. External sources of knowledge (technical assistance) and materials (germplasm and agrichemicals) were critical inputs to the TGS and continue to be important components of the present system. Many representatives of the TGS now believe, however, that the most pressing problems are no longer technical but socio-political in nature.

The National Rice Commission was established in 1983 as a mechanism to bring the diverse entities of the ATMS together to coordinate policies on rice. The Commission has created an incentive for producers and millers to organize themselves and has helped improve the procedure for setting prices (Lasso, pers. comm.). Both IDIAP and FAUP have representatives on the Commission who interact with public and private officials to recommend rice varieties and price support levels. The committee recommended a seven percent reduction in the support price of rice in 1985, in line with recent Government policy to reduce incentives for rice production. Current Government emphasis is on the production of export crops to reduce foreign debt. However, rice is not competitive as an export crop due to high production costs, except in the case of the most efficient producers.

The largest association of rice producers has recently instituted a tax of $1.10/t on rice produced by its members.

Twenty-five percent of the revenues generated will be used for research which the association intends to contract, possibly with IDIAP (Watts, pers. comm.). Acceptance of contract research from comparatively wealthy producers' associations would appear to be an equitable solution to the problem of providing appropriate technological advances to those groups, but could divert limited human resources from national projects to more lucrative private research. One solution would be to set aside a percentage of contract funds for a training program.

The need for greater coherence between the TGS and the socio-political environment is clear. This cannot be achieved without greater Government participation in setting priorities for the ATMS, and adjustment of policies in accordance with those priorities. The essential role of the TGS in solving agricultural problems must be recognized. In the case of rice, the Government should reaffirm its commitment to the TGS with specific goals of greater productivity and increased efficiency. In turn, the TGS must focus its priorities more sharply on meeting those goals.

4. Conclusions and Recommendations

a. Conclusions

*In spite of significant varietal development, rice productivity is low and production costs are high.

*Costly and inefficient management practices constitute the principal technological constraint.

*The policy environment has promoted rice but repeated surpluses are disincentives to the maintenance of this environment.

*There is limited domestic market potential, and Panama's exports are not competitive.

*Mechanized farmers are well organized and gained most from technological change.

b. Recommendations

*Commission rigorous studies of the causes of low productivity and high production costs. Strengthen TGS socioeconomic capability.

*Reallocate resources in the TGS and assign top priority to research on cost-effective agronomic practices with increased efficiency in pesticide and fertilizer use.

*Leadership for reformulating rice policies should be taken by the rice commission.