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

by

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CONTENTS

LIST OF TABLES AND DIAGRAMS

ACRONYMS

ANAGAN	Asociación Nacional de Ganaderos (National Cattlemen's Association)
ANDIA	Asociación Nacional de Distribuidores de Insumos Agrícolas (National Association of Agricultural Input Distributors)
ASOCANA	Asociación de Productores de Caña (Association of Sugarcane Growers)
ATT	Agricultural Technology Transfer (Transferencia de Tecnologia Agropecuaria)
BDA	Banco de Desarrollo Agropecuario (Agricultural Development Bank)
BID	Banco Interamericano de Desarrollo (Inter-American Development Bank)
BNP	Banco Nacional de Panamá (National Bank of Panama)
CAN	Consejo Agropecuario Nacional (National Agricultural Council)
CAL	Consejo Agropecuario Local (Local Agricultural Council)
CAR	Consejo Agropecuario Regional (Regional Agricultural Council)
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (Center for Tropical Agronomical Research and Teaching)
CCAR	Consejo Consultivo Agropecuario Regional (Regional Agricultural Consultative Council)
CENICANA	Centro de Investigaciones de la Caña (Center for Sugarcane Research)
CGIAR	Consultative Group on International Agricultural Research (Grupo Consultativo sobre la investigación Agrícola Internacional)
CIAT	Centro Internacional de Agricultura Tropical (Internacional Center for Tropical Agriculture)

CICE	Centro de Información Comunicación y Educación (Information, Communication and Education Center)
CIDAGRO	Centro de Información e Documentación Agropecuario (Agricultural Information and Documentation Center)
CIID	Centro de Internacional para la Investigación del Desarrollo (Internacional Development Research Center)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Center for Maize and Wheat Improvement)
CIP	Centro Internacional de la Papa (International Potato Center)
CNA	Consejo Nacional Agropecuario (National Agricultural Council)
CNS	Comisión Nacional de Semillas (National Seed Comission)
COAGRO	Confederación de Cooperativas Agropecuarias (Confederation of Agricultural Cooperatives)
CONAC	Confederación Nacional de Asentamiento Campesino (National Confederation of Collective Farms)
CONIA - FONAIAP	Consejo Nacional para el Fondo Nacional de Investigaciones Agropecuarias (National Council for the National Research Fund)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria (Brazilian Agricultural Research Corporation)
ENASEM	Empresa Nacional de Semillas (National Seed Enterprise)
ENDEMA	Empresea Nacional de Maquinaria Agrícola (National Agricultural Machinery Enterprise)
FAO	Food and Agriculture Organization
FAUP	Facultad de Agronomía de la Universidad de Panamá (Faculty of Agronomy of the University of Panama)
FECI	Fondo Especial para la Compensación de Interés (Special Fund for Interest Compensation)
FEDARROZ	Federación de Arroceros (Federacion of Rice Growers)

IARC	International Agricultural Research Center
IBRD	International Bank for Reconstruction and Development (World Bank)
IBTA	Instituto Boliviano de Tecnología Agrícola (Bolivian Institute for Agricultural Technology)
ICA	Instituto Colombiano Agropecuario (Colombian Institute of Agriculture)
ICTA	Instituto de Ciencia y Tecnología Agrícola (Institute of Agricultural Science and Technology)
IDIAP	Instituto de Investigación Agropecuaria de Panamá (Panamanian Institute for Agricultural Research)
IFARD	International Federation of Agricultural Research Systems for Development
IFE	Instituto de Fomento Económico (Institute for Economic Promotion)
IICA	Instituto Interamericano de Ciencias Agrícolas (Interamerican Institute for Agricultural Sciences)
IITA	International Institute for Tropical Agriculture
IMA	Instituto Agrícola de Mercadeo Agropecuario (Agricultural Marketing Institute)
IMF	International Monetary Fund
INA	Instituto Nacional Agronómico (National Agricultural Institute)
INIA	Instituto Nacional de Investigaciones Agrícolas (National Institute of Agricultural Research)
INIPA	Instituto Nacional de Investigación y Promoción Agropecuaria (National Institute for Agricultural Research and Promotion)
INTA	Instituto Nacional de Tecnología Agropecuaria (National Institute for Agricultural Technology)
IPACOP	Instituto Panameño Autónomo Cooperativo (Autonomous Panamanian Cooperative Institute)
IOM	Intervention Opportunities Matrix

IRRI	International Rice Research Institute
ISA	Instituto de Seguro Agropecuario (Agricultural Insurance Institute)
ISNAR	International Service for National Agricultural Research
ITGS	International Technology Generating Sector
MAC	Management Analysis Center
MACI	Ministerio de Agricultura Comercio e Industria (Ministry of Agriculture, Commerce and Industry)
MIDA	Ministerio de Desarrollo Agropecuario (Ministry of Agricultural Development)
MIPPE	Ministerio de Planificación y Política Económica (Ministry of Planning and Economic Policy)
PCCMCA	Programa Cooperativo Centroamericano para el Mejoramiento de Cultivos Alimenticios (Cooperative Central American Program for the Improvement of Food Crops)
PRECODEPA	Programa Regional Cooperativo de la Papa (Regional Potato Cooperative Program)
PROTAAL	Projecto Cooperativo de Investigación sobre la Tecnología Agropecuaria en América Latina (Cooperative Project for Latin American Agricultural Technology Research)
RENARE	Recursos Naturales Renovables (Renewable Natural Resources)
SENEAGRO	Servicio Nacional de Extensión Agropecuaria (National Service for Agricultural Extension)
SICAP	Servicios Interamericanos de Cooperación Agropecuaria (Interamerican Service for Agricultural Cooperation)
SONA	Programa de Desarrollo Rural Integrado del Sur de <u>Zoná</u> (Integrated Rural Development Program of Southern Zoná)
TGS	Technology Generating Sector
TUS	Technology Utilizing Sector

TTS	Technology Transfer Sector
USAID	United States Agency for International Development

PREFACE

This monograph was a team effort that worked! Drs. Reed Hertford and Judith Lyman-Snow participated from Rutgers, the State University of New Jersey, and Drs. Howard Elliott and Eduardo Trigo from ISNAR. Dr. Hertford served as overall project coordinator, and Dr. Snow was chiefly responsible for the case studies appearing in Part II, Chapter 3, as well as for the preparation of the final draft of Part II. Dr. Elliott provided materials for other sections of Part II, and assisted with the assembly of the first draft of the manuscript in New Brunswick. Dr. Trigo developed useful materials on issues and analytical perspectives concerning Agricultural Technology Management Systems in Latin America; and he and Dr. Elliott are the inventors of several of the tools appearing in Part I, Chapter 2 and Part II, Chapter 1. Our conclusions and recommendations, provided in the Executive Summary, are largely the products of discussions by all team members in Panama, the Hague, and in New Brunswick at various points in time.

The Panama case study was greatly assisted by the coordinating efforts of Lic. Miguel Cuellar, who served until recently as IDIAP's Director of Planning and Socioeconomic Studies in Panama. He also collaborated on much of the analysis dealing with human resources which appears in Part II.

During the report's preparation in the field, the study team was provided valuable guidance from an informal advisory group. It met frequently with team members, and read and commented on early drafts of the manuscript. The group included Ing. Jaime Adames, Manager, Servicios Agroquimicos, S.A.; Ing. Omar Chavarria, Director of IDIAP operations in the Western Region of Panama; Ing. Pedro Gordon, a manager of the agricultural conglomerate, Melo y Cia.; Ing. Diego Navas, Director of Research in the Office of the Vice Rector for Research and Postgraduate Studies at the University of Panama; Ing. Bernardo Ocana, then responsible for technical cooperation in IDIAP; and Dr. Gaspar Silvera, Director of Crops Research in IDIAP.

This monograph was first drafted in December 1985, and was then extensively revised and reduced in length during 1986, following the very helpful suggestions of numerous interested reviewers. Foremost among them was Dr. Margaret Sarles of the U.S. Agency for International Development, who ably served as manager of the project which funded the majority of this work. Her assistance throughout is gratefully acknowledged.

The secretarial assistance of Ms. Marilyn Kluberspies of Rutgers must be acknowledged at all stages, as well as that of Ms. Hanny Murray and Ms. Rosemary Snaith of ISNAR, who assisted

with typing materials for the December 1985 draft. Mr. and Mrs. Eduardo Zappi did the translation and typing of the Spanish version.

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EXECUTIVE SUMMARY

This monograph is aimed at donors and decision-makers of national programs of agricultural research in Latin America and the Caribbean, and it develops and applies a methodology to help them identify priority program needs. Part I describes the rationale for the methodology and its specific analytical tools. Part II reports on an application of the methodology to the case of the Agricultural Technology Management System (ATMS) in Panama. Our conclusions and main recommendations are presented in this executive summary.

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 ATM Systems that are developing in Central America, Panama, and elsewhere in the region.

An ATMS views the performance of agricultural research activities in any setting as the product of events that are both internal and external to those activities. The System is so defined to recognize explicitly the fact that, just as investing in the poor may not remove poverty, or providing food may not arrest malnutrition, attention only to scientists and the other tools and mechanisms internal to an agricultural research program need not accelerate technological change in agriculture because research activities are influenced by, and interact vigorously with, events in the world around them.

The methodology of Part I builds on a synthesis of received theories and experiences dealing with agricultural research. Such theories are placed into eight sets of propositions--those of the induced innovationists, the structuralists, the political economists, the monetarists, the technological determinists, the internationalists, the institutionalists, and those concerned with the methodological approaches researchers use--and the main variables suggested by each that can influence the agricultural research payoff are detailed and re-categorized in four comprehensive determinants, summarized in Table 1:

* "Research Resource Inputs" include the human, fixed, and operating capital variables of research programs.

* "Resarch Management" incorporates internal management variables of research programs (for example, the methodological approaches of researchers), as well as the management of program linkages with external research support mechanisms.

* "<u>External Research Support Mechanisms</u>" include variables of national policy, national technology transfer programs, other national support institutions, and the international community.

* "<u>Farm Production Environment</u>" is defined by the farm resource, economic, social, biophysical, and farmer decision environs, viewed largely from the prospective of individual producers.

These determinants are then placed in a simple model of the demand for and supply of agricultural technology which (in its reduced form) permits an examination of their relative influences on changes in production attributable to innovations emerging from agricultural research activities.

The methodology calls for collecting data for variables of this model in three interrelated stages that satisfy the assumptions that, in any country setting, no more than $100,000 and six months of time will be available to support an internationally recruited, three-person study team and that systematic studies of technological change are not available locally, but that there are informed nationals who can guide the team in ways that will economize its effort and meet its time-efficiency imperatives. Stage I leads to a "functional display," or map, of the main institutions, policies, and environments of the ATMS under study. Working hypotheses emerge at this stage concerning the influences on technological change of most all variables categorized as External Research Support Mechanisms. Stage II yields an "institutional analysis" of the main organizations (public and private) in the Technology Generating Sector, and helps quantify the research resource and research management variables. State III brings under especially close scrutiny the production environment through travel and study by the team in field locations, though it also permits "ground-truthing" findings and testing hypotheses formulated at Stages I and II. Stage III is termed the "technological performance analysis."

Results and data at every stage are summarized in an "Intervention Opportunities Matrix" (IOM). Along one axis of the IOM are arrayed the main determinants, and related variables, of the model. Along the other axis are listed quantitative measures of the production impacts of major technological events. Cells of the matrix contain descriptors (scores) of the hypothesized influences of the main determinants on the observed changes in production. At the conclusion of all three stages of analysis, a multivariate regression is estimated between the values of the determinants appearing in the cells of the IOM and a single dependent variable--the change in output attributable to each technological event. Results permit highlighting those determinants and variables that represent major system constraints, in production terms.

Attractive features of this methodology are that it is:

* *Systematic*. It provides guidelines which will facilitate greatly the planning and execution of ATMS reviews.

* *Comprehensive*. The major determinants, and related variables, of the model constitute a comprehensive checklist of factors influencing system performance.

* *Adaptable*. While the stages of analysis are logically sequenced, constraints imposed on available time and resources for an ATM System review can be accommodated by not entering fully into Stage II or Stage III. Further, the methodology makes clear the likely loss in study benefits associated with such restrictions.

* *Quantified*. The methodology forces study team members at each stage of analysis to summarize and quantify conclusions within the Intervention Opportunities Matrix. This guarantees more rigorous and conclusive results.

* *Output-related*. Results of the analysis are expressed in terms of their impacts on agricultural production and productivity. This should avoid spurious conclusions--for example, that "there is a shortage of high-level scientific manpower," unless such manpower shortages have, in fact, impacted production.

* *Summative*. The Intervention Opportunities Matrix can be refined and added to by the successive efforts of study teams working over a period of years, including national study teams. In this sense, the IOM becomes a permanent, summative building block for understanding and improving the performance of a given Agricultural Technology Management System.

Part II reports on the results of the three stages of analysis conducted on the Panamanian ATMS. That system was selected because it is among neither the oldest nor the newest in Latin America; the government's commitment to agriculture has been large, though productivity levels and changes through time appeared to be low in comparative terms; and key elements of the System agreed enthusiastically to collaborate with the Rutgers/ISNAR study. Our presumption, subsequently corroborated, was that Panama's System is also broadly representative of many in the region.

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 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 1980's as collective farms failed to become productive and as high labor costs and the weight of rigid labor codes proved burdensome to a government and private sector open to major competition by reason of the country's small size, geographic location, international exposure, and national currency convertible to the U.S. dollar on a one-for-one basis. 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.

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 which recently celebrated its Tenth Anniversary. Our in-depth examination of research accomplishments produced reasons for optimism about the future. Not surprising--in view of the environment for research and technology transfer in Panama--is the fact that past gains, and those achieved by 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 resources to support well-defined research goals.

The IOM, shown in Tables A.20, A.22, and A.25 (table and diagram numbers preceded by "A" are in the Appendix), summarizes the information developed on each survey observation, or case study, associated with a technological event in the Panamanian ATMS. Twelve such observations were ultimately made--four relating to rice, four to maize, two to legumes, one to onions, and one to tomatoes. These particular technological events were selected because they promised to shed light on findings and hypotheses that emerged early-on in the study (at Stages I and II), because the System had invested heavily in rice and maize at all levels, and because significant technological change had been reported to have occurred in legume crops, onions, and tomatoes.

The independent variables of the model were assigned values of +1, -1, or zero (or left blank), respectively, when it was concluded that they had been on net contributing, inhibiting, or neutral in terms of their influences on the change in output attributable to the technological event under study. The change in output for each event was estimated as indicated in Tables 10 through 14; and the reasons for the scores assigned the independent variables are detailed in Tables A.19, A.21, A.24, A.26, and A.27. One member of the study team was chiefly responsible for scoring to maintain consistency between survey observations of the IOM.

In an attempt to preserve all entries made in the IOM, given the number of case studies performed, the scores of the independent variables were aggregated by major determinant for each observation and regression analyses were performed of the dependent variable on the four major determinants, or on particular aggregations of those determinants. The IOM data, summarized in this form, are presented in Table 15; and a representative set of regressions estimated from them is presented in Table 16.

Our main conclusions follow:

1. At no stage of analysis was evidence found of widespread technological change. Current yields of major Panamanian commodities are low when compared with those of other countries in the region, and the estimated increases in productivity for individual technological events appearing in the IOM were modest. These facts are not surprising to find in a country where organized technology generation efforts have been underway for only a decade and technology transfer activities were resumed by the government just recently.

2. The model's determinants were found to influence significantly the estimated production impacts of technological change, though different coefficients could not be reliably identified for each determinant. Therefore, the mean scores of individual determinants and variables in the IOM provided a ranking of system constraints, with lowest negative scores pointing to factors most severely inhibiting technological change.

3. It was found that socioeconomic constraints in the farm production environment most severely inhibit technological change in the Panamanian ATMS, with most of those being associated with the case of maize, though these priority problems impact negatively technological change in practically every survey observation.

4. While the socioeconomic constraints of the system are numerous and complex, results reported in the IOM underscore problems in three areas: market management, existing farmer practices, and farmer organization.

Market mis-management is best exemplified by the cases of maize and onion production where mixed signals, sent producers by national authorities, have spawned widespread uncertainty that has been inimical to technological change. Maize yields in

Panama, where the natural, ecological conditions for production are favorable, are currently half of those obtained on average in South America.

That existing cultural practices are inhibiting technological change signals really two problems: that technological development activities have not met the requirements of disadvantaged areas and farmer groups, on the one hand, and that existing technologies have not been adequately bridged to "marginal" areas and producers through extension-related activities, on the other. It will be noted in the IOM that existing cultural practices are not inhibiting, in our judgment, in the case of rice, where technological testing has been intense and widespread geographically, or in tomato and onion production, where producer requirements are more homogeneous due to the concentration of production in geographically limited areas.

Finally, farmer organizations have become exceedingly important to technological change in Panama in the absence of an extension service through the 1970's and until 1984. Strong farmer organizations have successfully filled this void and gained national resources, while weak groups have lost. This is most apparent in the case of maize, where production and farmer requirements are highly diverse and an effective producer group has not materialized.

5. While of somewhat lower priority, selected problems involving research resource inputs, research management and external research support mechanisms were observed. The development of lower cost production packages for maize and rice does require additional fixed and operating capital resources. Though human capital inputs received frequently positive scores in the IOM, it is our judgment that any substantial expansion in the research program, or a shift towards more basic research, will require additional, high-level research leadership. It is interesting that, until the IOM was completed at Stage III, we had concluded that high-level manpower represented a major constraint to the national research program. That this was not borne out by our final results, demonstrates the value of the matrix and the importance of checking first-round impressions against technological outcomes and production.

Research management, similarly, has not posed severe limitations in production terms, except in the case of the introduction of improved maize varieties, though some needs are signalled by the IOM--on the side of internal management, in the case of rice (for evaluation and problem identification/priority setting activities) and, with respect to the management of research linkages, in the case of cowpea (for linkages with national policies and technology transfer programs).

National macroeconomic policies spurred the introduction of new rice varieties and the tomato industry, but otherwise were an inhibiting or neutral force for technological change. This finding is consistent with the Stage I analysis, which pointed to little national consensus on agricultural sector goals, a fragmented ATMS, and poor coordination among public agencies as they deal with the agricultural sector. A most significant fact about the operations of other external research support mechanisms is that the inputs received by Panama's ATMS from the international community have been positive and pervasive in their influences on technological change. International institutes and universities provided germplasm resistant to bacterial wilt in tomato which, when recombined in a national breeding program, ultimately saved the processing industry. Similarly, bean germplasm obtained abroad and resistant to web blight--previously the major constraint--is responsible for a doubling of bean yields in less than a decade.

Ten principal recommendations were derived from these and related conclusions obtained from our three-stage analysis of Panama's Agricultural Technology Management System:

* <u>Strengthen all ATMS socioeconomic units</u>

Enhanced socioeconomic capabilities are greatly needed to evaluate the impacts of technological advances at both micro- and macro-levels. Social scientists should address micro-level farm production environment factors influencing technological adoption, and economic evaluations of technological impact. Their assistance is also needed in orienting priorities and identifying problems in the technology generating sector, and in improving market management. IDIAP should emphasize costs and returns in determining commodity research strategies, and those should include high-value specialty crops that support high labor costs (e.g., winter vegetables); in traditional crops, efforts should be undertaken to economize on high-cost labor; and the production of commodities with low labor requirements (e.g., range fed beef) should be encouraged. Social scientists can help with these and other related efforts that can improve the focus and effectiveness of all research and technology transfer programs.

* <u>Improve market management</u>

Opportunities for market expansion must be sought to stimulate production and create demand for new technologies. Market surveys and feasibility studies should be commissioned with contributions from producer and other private sector groups. Donors could assist these groups in establishing a national marketing council that undertakes economic studies and promotes agricultural commodities. Such a council could also coordinate the development of a computerized information network for export market outlets of targeted commodities.

* <u>Reinforce area- and crop-specific research stragegies</u>

IDIAP's limited human and financial resources would be more effectively utilized, if the Institute's research agenda were narrowed to fewer commodities and more carefully targeted to specific regions and client groups. One or two key constraints should be identified on which to focus research efforts in each commodity.

* Expand extension services.

An expansion of extension services should be supported and carefully phased to exploit technolcgies validated by the technology generating sector. Close collaboration between research and extension has proven to be an essential component of success, as demonstrated in the cases of rice and tomato. Extension without technology was notably unsuccessful on collective farms. Producer input in designing and implementing the programs should be sought.

We recommend that extension specialists with joint MIDA/IDIAP/FAUP appointments serve as coordinators for the implementation of extension programs in key commodities. These specialists should assist in targeting particular regions for extension-related activities and in coordinating extension training.

We also believe that the cost-effectiveness of on-farm research as an extension cum research tool should be evaluated and suggestions made for improvement. Comparisons should be made between the costs of validation/demonstration plots and experimental plots to signal potential economies.

We endorse FAUP's plan to expand formal training for SENEAGRO agents. Training should include a disciplinary or commodity specialty, and farm management and farming systems skills, in addition to communications instruction.

* Improve farmer participation

Producer group capacities to participate effectively in the ATMS should be fostered. It is important that this be done in parallel with efforts to expand extension services within the ATMS. One suggestion is that producer groups be drawn into an annual national planning conference that seeks to improve communications and goals of the ATMS broadly. Another is that producer representation in decision-making and advisory bodies of IDIAP and FAUP be increased. Especially IDIAP would benefit from more direct input of producer groups to help build its national clientele. Producer involvement would renew interest in cooperation and increase the Institute's responsiveness to producer needs.

* Increase and stablize field research funding.

IDIAP should seek a national commitment to increase operating funds for research to regional standards, targeting 25 percent of total budget. Earnings by IDIAP from its farm operations should not reduce the government's obligations. The

Institute should also adopt the standard used elsewhere of maintaining a contingency fund. Permission should be sought from the government (and donors) to use carry-over monies to establish the fund. Donors might also make a one-time grant to set it up, or guarantee credit with national or private banks. The feasibility of securing two-year budgets should be studied. Research planning should incorporate fallback positions that anticipate budget cuts and do not further restrict field research funding--operating expenses and fixed capital investments.

* Plan for future research leadership

A long-range training plan for the technology generating sector should be developed so that the requisite research leadership will be in place when it is needed. M.S.-level training needs should be coordinated with the development of FAUP's graduate programs. A major opportunity exists for donor involvement in the preparation of the training plan, in providing training abroad, and in forging long-term linkages with foreign universities that could provide both student and faculty training. Staff development plans should be accompanied by adequate conditions of service to retain skilled professionals. Institutional policies should be articulated with respect to expectations and rewards for professional staffs generally.

* Research management control mechanisms should be strengthened

Our principal concern here is with improving processes for identifying research priorities and for undertaking meaningful evaluations of research. Several other recommendations above should strengthen these processes. In addition to what has already been said, however, we recommend that IDIAP and FAUP take leadership for launching annual research reviews and evaluations that involve national and international peers. These reviews should evaluate accomplishments with respect to progress toward goals cast in specific time frames, and provide recommendations for improvement. Internationally-funded projects should be evaluated as an integral part of this process. Results and recommendations might be summarized at the national planning conference, suggested in an earlier recommendation.

* Clarify and coordinate external donor support for the ATMS

External assistance could be oriented more effectively with direction from a national plan. Donor participation should be coordinated with the goal of maximizing effectiveness and minimizing dependence. National plans should insist that proposed projects fit within national goals and address high-priority ATMS needs. Future funding implications of donor-initiated activities should be carefully evaluated before projects are approved. Monitoring and evaluation by national scientists and international peers is needed to determine the impact and effectiveness of donor projects and to assure that objectives remain on target.

An ATMS review is a good rallying point for donor coordination. It fixes the framework in which improvement efforts are discussed and identifies intervention opportunities for individual donors. Interventions could then be inscribed in a coordinated plan for external assistance. Donors would not approve activities with implications for national budget without checking them against such a plan.

* Reduce ATMS fragmentation.

Major efforts are needed to reverse declining government confidence in the agricultural sector and to revitalize its contribution to the national economy. The ATMS should concentrate on improving performance and building stronger political support. The technology generating sector should take some initiative in setting system-wide goals, seeking maximum collaboration among all government and private sector groups. Activities which lead to greater policy consensus, more coherent action, and clearer divisions of labor within the ATMS should be strongly supported.

Finally, we make a more general recommendation: that capacities be built to conduct periodically ATMS reviews and to synthesize results across countries. These should be established within donor institutions, as well as within institutions based in developing nations and in a few developed countries. They would lead to further refinements and testing of the ATMS methodology outlined here. They would also provide training in the use of the methodology by field personnel and national researchers. And they would asist with the important task of accummulating ATMS results and drawing out useful cross-country lessons. That donors and national institutions have not developed these capacities, has sometimes led to fragmented and isolated attempts to improve individual components of agricultural research programs, and often to the sort of impatience with achievements that has produced the premature withdrawal of external support and reduced national funding for agricultural research. Particularly these latter problems could be lessened were clearer, more comprehensive understandings available of the full range of ATMS complexities and constraints.

PART I: A METHODOLOGY

Chapter 1

The Model

This first part of the monograph describes a methodology recently developed by Rutgers University and ISNAR to help donors and national program leaders identify priority needs of Agricultural Technology Management Systems in Latin America.

A. Problem

Our goal is to accelerate technological change in agriculture. Technological change is important because it reduces costs. Two examples often cited are qualitative changes in existing inputs, such as a disease-resistant variety of seeds, and new cultural practices, such as minimum-tillage cropping. To the contrary, expanded use of labor and land infrequently involves technological change, because the increased outputs are generally offset by increased costs. Farmers have learned how to obtain the greatest possible benefit from these traditional resources (Schultz, 1964). Opportunities for producing surplus benefits over costs have been largely exhausted.

By implication, technological change requires the development of new knowledge and inputs outside the environment farmers know so well. For this reason, agricultural research programs are primary movers of technological change in agriculture and have been credited with large returns (Ruttan et al., 1977).

The problem most central to this paper and the methodology it proposes is: How can investments in research be most effectively made to produce technological change in Latin American agriculture?

B. Model

Technological change in agriculture is generally a quantifiable and measurable event, involving one or more factors of production. This permits treating the employment of new technology by farmers as economists treat the employment of any production input--as the result of interacting demand and supply forces.

In Latin America, agricultural technology is generated by private- and public-sector institutions--in the latter case, mainly by national institutes of agricultural research, public extension programs, and universities, though the institutes have assumed leadership positions in most countries of the region. With the private sector as yet a weak partner in the technology-generating process, the aggregate supply of technology is presumed to be dominated by the activities and resources of the national institutes. There is also a presumption that the aggregate supply of technology is insensitive to its costs and aggregate supply of technology is insensitive to its costs and returns. Commonly 90 percent or more of all funds for research are allocated by the national institutes to personnel costs, leaving an unusually small fraction of the total budget for the mobilization of research programs in response to changing technological needs and opportunities (ISNAR/IFARD, 1984).

By contrast, the demand for technology by farmers in most all Latin American settings is thought to be responsive to its returns. It is known that this response is greater where the price elasticity of final product demand is larger; where traditional technology can be substituted by new technology easily; and where production practices have already undergone some modernization, and non traditional production inputs represent a significant share of total costs.

Diagrams 1 and 2, and the first two functional relations below them, depict the model. The final two functional relations state the variables of the model, which are to be explained in terms of their supply and demand determinants, S and D, i.e., the dependent variables ($ and T) as functions of the independent variables (S and D). S includes factors affecting the costs of producing a given quantity of new technology, while D includes variables influencing the productivity of that technology.

To complete the specification of the model requires defining the variables in S and D and then estimating their impacts on technology and its returns. In other words:

1. What are the main variables in S and D?
2. Which of the variables that can be influenced by investments in research have been (and are most likely to be) the principal contributors to technological change in agriculture in a given country of the region?

Another question is commonly asked: "What are the major constraints to technological change in agriculture that can be addressed by investments in agricultural research?" This, however, is the flip side of the second question posed above, for a major constraint is a variable in S or D with a large potential impact on technology, were its value increased through research investments. For example, the observation that high-level manpower has been an important constraint is fully equivalent to the statement that well-trained scientists have a large, positive impact on technical change, but that not enough were employed in research for that impact to be realized.

A brief review of existing theories of technological change in Latin American agriculture is used in the next section of this paper to develop answers to the first of our two queries. The following chapter then addresses the second.

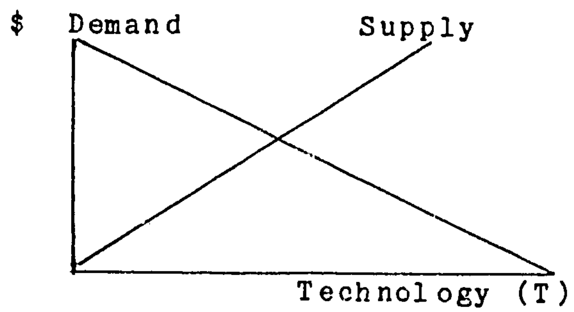

Diagram 1--Model, General Case

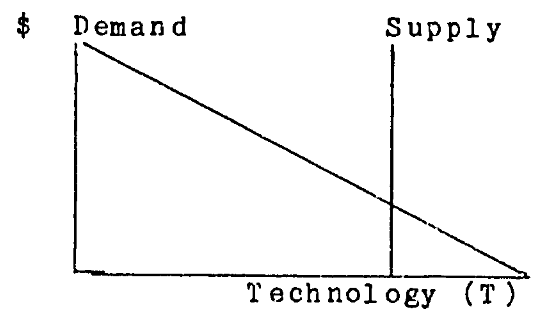

Diagram 2--Model, Unresponsive Supply Case

Demand: $T = t^d[\$; D]$

Supply: $T = t^s[\$; S]$

$$\$ = f_1\ [D; S]$$

$$T = f_2\ [D; S]$$

Demand: $R = t^d[\$; D]$

Supply: $T = t^s[S]$

$$\$ = g_1\ [T, D]$$

$$T = g_2\ [S]$$

C. Variables

1. Inherited from Theory

The induced innovation theory of technological change claims that technology generation and adoption are guided by the relative scarcities of traditional factors of production (Hayami and Ruttan, 1971). If labor is the scarce resource, mechanical innovations will be forthcoming and adopted; and, if land is the scarce resource, such land-saving technologies as fertilizers and high-yielding crop varieties will be generated and used by farmers.

Structuralist theories emphasize the distribution of landholdings as a key determinant (Barraclough, 1973). Where land is concentrated in large farms held by absentee landlords with abundant supplies of cheap labor, obtained from nearby less-than-subsistence farms or from the labor force of the hacienda itself, there are weak inducements to innovation and technological change in agriculture. For those to strengthen, land reform is needed.

Political economists largely hold the structuralists' view of agriculture in Latin America, but argue that the management costs of harnessing a labor force for production eventually induce the development and adoption of some mechanical technologies. As this process progresses, labor-machinery substitution exerts an increasing demand on previously cheap land. Large landowners, finding themselves vying for this resource, support the development of chemical and biological technology-generating activities that can raise yields and economize on land use in those commodities they produce--for the most part, export-oriented cash crops like cotton and sugar cane. Thus, the political economist attaches major importance not only to the structure of agricultural production, but to the organization of special interest groups for technology generation and adoption (De Janvry and Garramon, 1977).

Monetarist theories of technical change emphasize the need to get input and output prices right and market signals better tuned, with less noise and disturbance (Schultz, 1978). When prices and markets are politicized, they are uncertain and poor-quality transmitters of information for technology generation and adoption. Technical change is curtailed and innovation activities may bounce with each shift in national leadership from one priority commodity to another, producing little of value for any one.

Technological determinists view technology generation as an independent and somewhat unpredictable process that springs from the inspirations of dedicated, high-powered minds of science. Eventually, important new technologies emerge that are so productive that no farmer--large or small, producing for subsistence or for export--can overlook them. Technological determinism emphasizes mainly the need for more and better trained researchers (Pinstrup-Anderson, 1982).

There is also a related school of internationalists that holds that national programs of agricultural research need to be fueled by the expertise and germplasm from the international agricultural research centers, or from other linkages of national researchers with external sources of information and technology. It is on the models for establishing and nuturing those linkages with the outside world, as well as on the support of international technology generation, that their attention is focused (Plucknett and Smith, 1982).

The institutionalists are concerned broadly with the management and scale of national programs of agricultural research, mainly in the public sector (ISNAR, 1985). They assume that technology will be produced and adopted if the relevant institutions are running smoothly and productively. Institutional performance is measured in terms of the capability to identify important research problems, prioritize those problems, outline suitable research methodologies, obtain adequate financial support for research, attract and retain research personnel, develop necessary research infrastructure, program and evaluate research, forge productive linkages with related institutions, and communicate and transfer results of technology-generating activities. The institutionalists' view of technical change is guided by a prototype institution with these capabilities and a "critical mass" of resources for research arrayed across a set of functions, disciplines, and commodity priorities. For this reason, program scale becomes an important determinant in its own right and is cited in explanations of why some small countries or commodities representing small shares of national product have not experienced technological change in agriculture.

Finally, there are those essentially concerned with research methodologies, who claim that research conducted with appropriate methodologies is more likely to generate technologies that are acceptable to farmers. Farming systems research approaches are their banner--approaches which require that researchers investigate the interdependent components of a farm unit (the physical, biological, social and economic factors) when designing and introducing new technologies. However, the "on-farm" orientation of these approaches, involving interactions between farmers and researchers at all stages of technology development and transfer, is probably their most distinctive feature. It is also that feature of farming systems research which has tended to make the methodology somewhat less holistic in practice than was intended in theory (Shaner et al., 1982).

2. Generalized from Theory

The main determinants of the theories of technological change in Latin American agriculture just described can be placed in two categories: those dealing with the "research environment," associated with S of our model, and those dealing with the "farm production environment," associated with D. The theories suggest additional variables that further describe S and D, and in the following paragraphs those are identified.

In the case of the research environment, S, the following determinants are defined:

* **Research Resource Inputs.** Scientific manpower, internationally available germplasm, and program scale--key variables for the theories of technological determinism, internationalism, and institutionalism (respectively)--all deal with the levels and patterns of use of the research resource inputs of the research environment. Logically these may include as well other dimensions of human capital (for example, support staff), fixed capital (experimental fields, labs/equipment, and library and transportation facilities), and operating capital (international germplasm, facilities maintenance, publications and other research services not included in the human and fixed capital inputs).

* **Research Management.** The performance variables of the institutionalists influence the effectiveness with which most research resource inputs are used in the research environment to generate technology. We will term these the research management variables and define two types: internal variables (such as priority-setting mechanisms, suggested by the institutionalists and research methodologies, suggested by the methodologists) and linkage variables (including connections between the research environment and the production environment, for example, which are key elements of the induced innovation theory).

* **External Research Support Mechanisms.** When the importance of the management of linkages with factors external to the research environment is recognized, external events themselves become key determinants of technology-generating activities. We will term these the external research support mechanisms. They involve the production environment of farmers (mainly the relative scarcities of traditional inputs, farm size, land tenure patterns, farmer organizations, and final product prices/markets), national policies bearing on research (macroeconomic, fiscal, and science/technology policies), programs of national research support institutions (private research/extension, public input suppliers, and non farm interest groups/users), and the international community, including the store of basic science knowledge, the international agricultural research centers (IARCs), and donors of most relevance to the view held by internationalists.

In the case of the farm production environment, D, we identify the farm resource, economic, social, biophysical, and farmer decision environs as major determinants.

* **Farm resource environs.** This first set of variables includes the relative scarcities of traditional production resources (land and labor, in the main) and farm size (land area

and output per farm), which are critical variables of the theories of induced innovation and structuralism (respectively).

* **Economic environs.** These incorporate, among others, the input and final product/price and other market variables that are central to the monetarists' view of technological change.

* **Social environs.** The social sub-environment includes land tenure arrangements and organizations of farmers that are part of the structuralists' and the political economists' theories.

* **Biophysical environs.** Climate, pests, and diseases are recognized by technological determinantists. Their incidence most certainly affects the productivity of new technologies and, through the management linkages of the research environment, the directions and costs of technology-generating activities.

* **Farmer decision environs.** Interactions among the sub-environments of production affect the complexity and uncertainty within which farmer decisions concerning the use of technologies are made; and they can materially alter the productivity of these technologies, depending, for example, on farmer attitudes toward risk, existing farming systems, and acquired levels of formal and informal education.

These determinants generalized from the theories of technological change in Latin American agriculture--three in the case of the research environment and five in the case of the farm production environment--are the main categories of variables that define S and D in our model. They are summarized in Table 1 and assigned capital letters to facilitate exposition.

Diagram 3 casts the main determinants of our model in a system perspective--the Agricultural Technology Management System, which includes everything inside the three outer circles. The inner circles bound the Technology-Generating Sector (TGS), the Technology-Users Sector (TUS), and the Technology-Transfer Sector (TTS). We will refer to these three sectors as simply the Technology Sector. The inner circle encompasses the Technology-Users Sector, mainly farms and farmer organizations directly engaged in agricultural production and technology employment. By placing it at the center of the diagram, we call attention to the fact that the importance of technology is in its impacts in reducing production costs at the farm level. Connections and interactions are assumed among elements within a ring (for example, among national policy, national support institutions, and the international community), and the arrows crossing circles denote the interactions between rings that are described by our model. The straight line cutting through the Agricultural Technology Management System denotes new technologies, as well as their costs and returns--the dependent variables of our model.

The I and M determinants of the research environment--that is, research resource inputs and management, respectively--are

Table 1 -- Major Determinants of S and D Generalized from Theory

Research Environment (S)

Research Resource Inputs (I)	Research Management (M)	External Research Support Mechanisms (X)

Human
  Senior
  Graduate-level
  Scientific/technical
  Support staff
Fixed Capital
  Experimental fields
  Labs/equipment
  Documentation/libraries
  Vehicles
 	
Operating Capital
  Facilities maintenance
  Field research expenses
  Gasoline
  Publications/outreach services
  International germplasm (acquisition/maintenance)
	Internal
	  Problem identification/ Priority setting
	  Planning
	  Evaluation
	  Research Methodologies
	  Personnel management
	  Financial management
	Linkages
	  Farm production environment (D)
	  National policy
	  National technology transfer programs
	  National support institutions
	  International community
		Farm production environment (D)
		National policy
		  Macroeconomic/development
		  Fiscal
		  Science/technology
		National technology-transfer programs
		  Human Capital
		  Fixed Capital
		  Operating Capital
		National support institutions
		  Private research
		  Private input suppliers
		Public input suppliers
		Other consumer/user groups
		International community
		  Store of basic science knowledge
		  Foreign universities
		  IARCs
		  Donors
		  Other international groups

Farm Production Environment (D)

Farm Resource Environs (R)	Economic Environs (E)	Social Environs (SE)	Biophysical Environs (B)	Farmer Decision Environs (F)
Land/labor scarcity Farm size Existing cultural practices	Markets/market management Prices/price interventions	Land tenure Farmer organizations	Climate Insects Diseases Soils	Risk/uncertainty attitudes Existing farming/systems Informal/Formal education

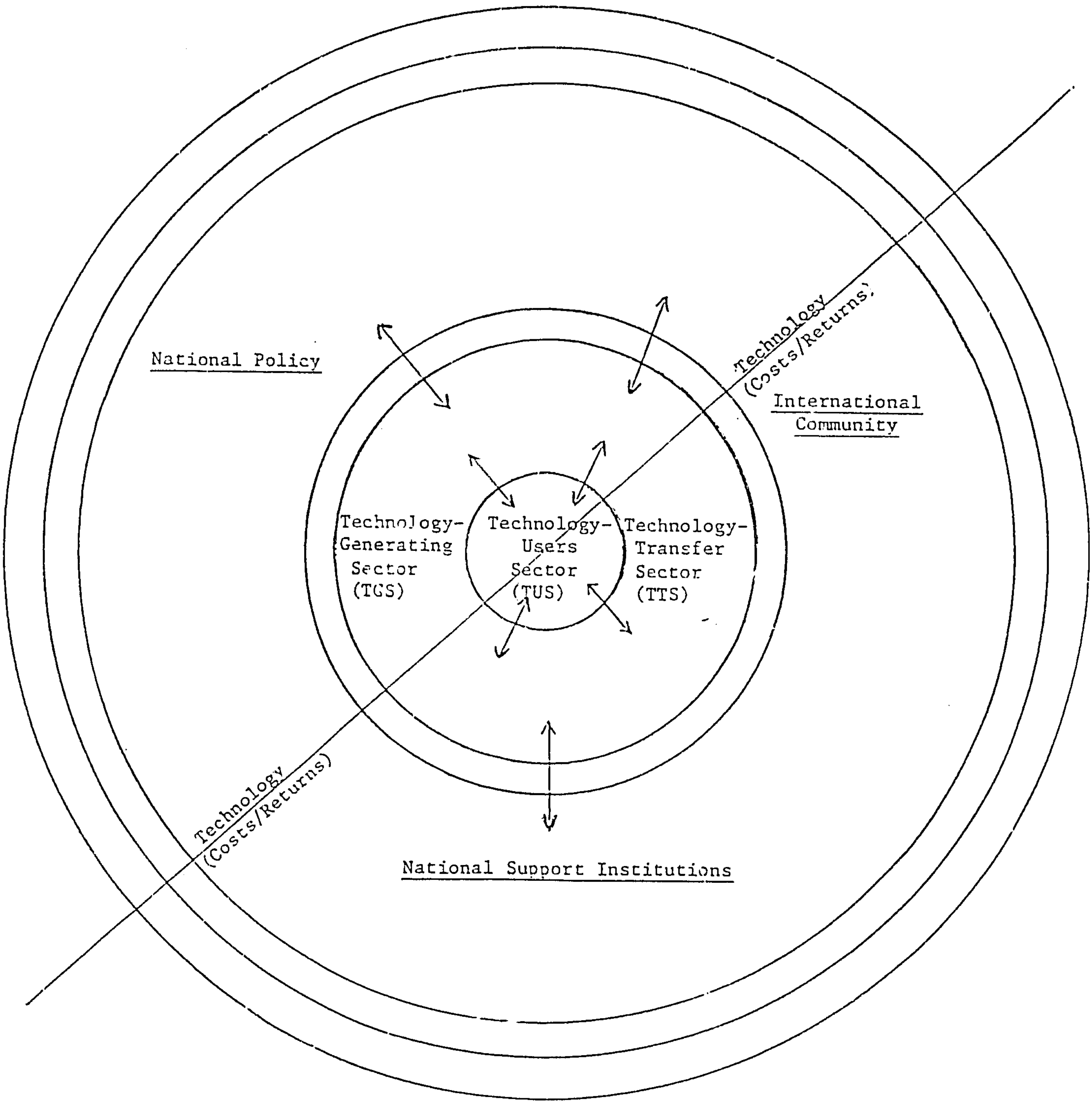

Diagram 3 -- Agricultural Technology Management System largely internal to the TGS. Most major determinants in D are in the TUS, while the TTS incorporates national technology transfer programs in the private and public domains. Variables in X other than those already mentioned (namely, D and technology transfer activities) lie outside the Technology Sector and include the influences on technological change of national policy, national research support institutions, and the international community.

Chapter 2

Estimating the Model

This chapter is intended to detail means by which the main determinants of S and D can be prioritized in a given country setting. Specifically, our question is: "Which variables in S and D--that can be influenced by investments in research--have been (and are most likely to be) the principal contributors to technological change?" Alternatively, and as we have pointed out earlier, we can ask: "What are the major constraints to technological change that can be addressed by investments in agricultural research?"

A. Assumptions

We assume that less than US $100,000 and six months will be available for collecting and analyzing data addressed to our questions. Also, we assume that it will not be possible to draw on previous systematic studies of technological change, though in most settings useful secondary data and many unpublished (and uncataloged) sources of information may be available. Finally, we assume that there are several informed nationals genuinely interested in these questions who can assist a small internationally recruited study team by supplementing available information through direct interviews and by guiding the team in ways that will economize its effort and satisfy its time-efficiency imperatives.

An implication of these assumptions is that the model might not be estimated with full statistical precision or that the estimating methods used might require considerable judgment from study team members--at least in a first-round effort.

B. Process

The influences of our model's main determinants are estimated in three stages of analysis.

Stage I leads to a "functional display" of the main institutions, policies, and environments of the Agricultural Technology Management System depicted in Diagram 3. As such, it provides a map of the entire sector to be explored. The specific purposes of Stage I are to identify most elements of the ATMS and to develop working hypotheses concerning the influences on technological change of most all factors in X.

Stage II provides an "institutional analysis" of the Technology Sector, but focuses on institutions in the Technology-Generating Sector and the main determinants of our model associated with those institutions. Thus, the institutional analysis provides conclusions dealing, in the main, with I and

M--the research resource inputs and management of technology-generating institutions.

Stage III brings under close scrutiny the production environment (D), treated in a general way in Stages I and II, through travel and study in field locations that have experienced some technological change. It provides opportunities to "ground-truth" findings and test hypotheses from Stages I and II by observing their impacts in the field on technological change in specific commodities. Stage III is termed the "technological performance analysis."

At all stages, insights are obtained on the rates, directions, and patterns of technological change, as well as on the costs/returns associated with new technologies--the dependent variables of our model. At Stage I, these are of a highly aggregate nature. The Stage II institutional analysis yields insights on the costs of producing technologies and on specific technological outcomes of those institutions engaged in research. At Stage III an analysis is conducted of which technologies have (and have not) "hit the ground," their impacts on production, and their relations to other elements of the Agricultural Technology Management System. Table 2 summarizes the three-stage process just described.

For conceptual purposes, the estimation process can be likened to a funnel with screens at each stage that sift information with increasing detail as the funnel narrows. At Stage I, the study team is looking down on Diagram 3 from the top of the funnel, but focusing attention on the outer ring. At Stage II, it is looking down the funnel from the level of the two middle circles at the Technology Sector, but focusing on the Technology-Generating Sector. At Stage III, the analysis is conducted from the level of the inner most circle and focuses on the Technology-Users Sector, but brings to bear major findings of the two earlier stages.

C. Unifying Tool

The Intervention Opportunities Matrix (IOM) is the unifying tool of our methodology used at all three stages of the analysis to summarize data. Along the top of the IOM are arrayed the main determinants and related variables listed in Table 1. Down the left side are listed quantitative measures of important technological events or outcomes. As the analysis of the study team proceeds, cells of the matrix are filled with descriptors of the impacts of the main determinants on observed technological change.

In a world of complete information, the technological events would be represented by precise quantitative measures. In the real world of limited information, study team members should estimate the increased value of production associated with each event and use it as the sole dependent variable of the model, relating in a single equation (rather than two) the model's major

Table 2 -- Analytical Stages Used in Estimating the Model

Stage	Scope	Focus	Main Variables Independent	Main Variables Dependent
I-Functional Display	ATMS (area inside three outer circles of Diagram 3)	Research Environment (S)	X	$,T
II-Institutional Analysis	Technology Sector (area inside two inner circles of Diagram 3)	Technology Generating Sector (TGS)	I,M	$,T
III-Technological Performance Analysis	Technology Sector	Technology-Users Sector (TUS)	D	$,T

determinants to a measure of technological change. That measure serves as a "proxy" for the returns to technology, previously defined by the symbol $.

Informed observers can be asked to state whether a particular technological change resulted in a small or negligible change in the value of production (0 to 10 percent), a significant change (10 to 25 percent), or a really major production increase (over 25 percent). By this means, the value of the production increase associated with the technological change is obtained on applying the resulting percentage to the base-period value of production (the production that prevailed before the increase took place). Values should be estimated, of course, in constant dollars or units of local currency and related to the average annual, long-term increase in production over the base period.

In order to fill cells of the matrix, it is most practical to simply assign a score of +1 to determinants that are judged to have had a significant positive impact on technological change and a score of -1 to those determinants judged to represent important inhibiting factors. A blank cell can denote "no perceptible influence," or an absence of information. Most any consistently applied scoring scheme is acceptable.

At the conclusion of all three stages of analysis, the IOM should be full; and the information it contains can be used to estimate a simple regression of the single dependent variable on values of the determinants appearing in the cells of the IOM. The recommended statistical approach is to represent each major determinant by "dummy" variables in the regression: one should equal 1.0 when the determinant is inhibiting and 0 otherwise; another should equal 1.0 when the determinant is contributing and 0 otherwise. Determinants with the largest negative regression coefficients on their corresponding "inhibiting dummy variables" should be priority targets for investments in agricultural research.

Results of this regression should shorten the "leaps of faith" by ATM study teams when they conclude that a particular factor has represented a "major constraint."

The next section of this paper describes how the three stages of analysis, summarized earlier, can be used to generate the data required for the Intervention Opportunities Matrix.

D. Stages of Analysis

1. Stage I

This stage of analysis maps the Agricultural Technology Management System of the country and analyzes the roles of major external research support mecharisms in the research environment on technological change. At the conclusion of Stage I, the study team should have at its command:

* **A complete map of the ATMS**--of the institutional configuration of the system and of the roles of every institution.

* **A chronology of major technological events and the parts played by all institutions/groups in those events.**

* **An assessment of key policies,** operating through the research environment, **as well as an assessment of agriculture's structure and performance,** reflecting the production environment.

Three tools are employed to yield these important results:

a. **Responsibility charts.** This first tool arrays all national and international institutions influencing technological change down a single column. A second column assigns each institution to one of the key elements or subsectors included in Diagram 3 of the ATMS, and a third includes a short sentence describing the purposes of each institution. A fourth column of the responsibility chart ties activities of each institution to key determinants in S or D. Institutions that do not influence the availability of, or the costs or returns to, technology are excluded from the responsibility chart and from the ATMS.

The responsibility chart mainly serves to familiarize a study team with the country's ATMS and provides a frame of reference for its early-stage discussions, interviews, and literature searches. Ideally, the institutions hosting the study team will have prepared beforehand a responsibility chart and be able to highlight those institutions/groups that have had a primary influence on, or represented constraints to, technological change in agriculture.

Table 3 illustrates a partial list of key institutions/groups for a hypothetical country.

b. **Technological Change Chronology.** This tool catalogs information obtained through literature reviews, discussions with informed professionals, and field study--guided by the responsibility chart--that bear on significant technological events of (approximately) the past decade. In its final form, each event is briefly described ("introduction of first dwarf variety"); the event is classified by type (for example, as a biological, chemical, or mechanical technology); the commodities affected are identified ("rice"); the year or period involved is specified ("1975"); and the principal institutions/groups of the ATMS are identified ("large rice producers, IRRI, local national research program, public seed producer, and rice mills"). Most importantly, each event is also associated with a contributing or inhibiting determinant of our model--"contributing - public seed company, distribution of seed by private mills; inhibiting - low market price for rice, limited areas of rice irrigated, low resistance to blast disease." If committed to a computerized data-base management system, the chronology can be used to trace

Table 3 -- Partial Responsibility Chart, Hypothetical Country

Institution/Group	ATMS Sub sector	Purpose	Major Determinants Influenced
National Department of Planning	National Policy	Budget/Policy Formulation	X-D, E, SE, F, I
CIAT	International	Provide germplasm	I
Agricultural Credit Bank	National Research Support	Provide Agric. Credit	X-D, R, E, SE
National University	Technology-Generating Sector (TGS)	Education/ Research	I, M
Cattle Producers' Association	Technology-Users Sector (TUS)	Represent/Lobby	SE

major changes occurring in individual commodities; to highlight the roles of particular institutions/groups in technological change; and to identify significant contributing or inhibiting determinants within our model by institution and/or commodity group. The basic data can be committed to 3x5 cards while the study team is in the field. Events can be classified on the cards by commodity, and these basic data can be refined later and summarized in the technological change chronology.

Much of the basic data of the chronology should be developed by interested nationals and host insitutions prior to the arrival of the study team in-country.

c. **Assessments of External Research Support Mechanisms.** Use of this final tool of Stage I requires most time of study team members. It is more judgmental than the previously described tools.

These assessments are intended to describe and evaluate the roles of external research support mechanisms (X) in our model. Though the assessment of the production environment represents a first approximation--aggregate and macroeconomic in its perspective--the assessment of other mechanisms largely ends at this stage and, therefore, must be more thorough going.

The assessment of the production environment reviews broadly agriculture's structure and performance over the most recent decade. It should provide basic factual information concerning the growth of agricultural production and those commodities, regions, and farmer groups that have most contributed to or inhibited that growth. Productivity changes (changes in output per unit of land, labor, or total input) should be highlighted by commodity, region, and production group; and key factors in the production and research environments should be identified as contributing to or inhibiting those changes. To economize on the effort, the assessment should 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. This can help highlight areas of difference and similarity that distinguish the country's agricultural structure and performance.

The policy assessment should be conducted by the same member (members) of the study team performing the sector assessment so that they are integrated and reinforcing. Included are macroeconomic policies affecting the overall economy; policies affecting resource allocations between agriculture and other sectors; and policies influencing resource use and technical change in agriculture, especially technology generation, transfer, and adoption.

At the macroeconomic level, interest should focus on policies affecting exchange rates and relative product and input prices, including regulations affecting taxes, capital costs, interest rates, and real wages.

At the level of intersectoral resource allocations, interest centers on the priority accorded agriculture as reflected in the scale of its budget relative to its contribution to gross domestic product. Efforts should be made to understand whether resource commitments are largely investment-related, consumption-related, or simple transfers. A commitment to investment expenditures signals a policy environment that is potentially supportive of long-term programs of agricultural research.

The assessment of policies influencing resource use and technical change in agriculture itself should examine with care specific programs of technology transfer, public and private input suppliers, and the international community. Two related questions should be addressed: Which institutions have been major contributors to or inhibitors of technological change? Have their programs been reinforcing, at least to the extent that they have focused on similar commodity groups, regions, and/or farm types, i.e., is there policy and program coherence or dispersion? The latter question can be simply answered, for example, with a table of data that arrays resource commitments by commodity and by external research support mechanism (or institution) for selected periods.

By superimposing the policy and sector assessments on the chronology of technological events, and tying together the conclusions of each tool, important inferences can be drawn concerning the determinants of the Agricultural Technology Management System that have contributed to or inhibited technological change over the past decade. Some of these can be affected directly by research investments in the future.

2. Stage II

The institutional analysis focuses on individual organizations within the system concerned with technology generation for agriculture. Its purpose is to identify the roles of two main determinants in the research environment--research resource inputs (I) and research management (M)--on the supply of new technology. The variables describing those determinants, listed earlier in Table 1, are designated as contributing or inhibiting that supply. While insights on these matters will have been gained through the Stage I effort, which should help delimit areas deserving special attention in Stage II, the institutional analysis described in this section is a vital part of the overall methodology.

Basic data on research resource inputs should be generated through the application of the ISNAR/IFARD Questionnaire. This is a simple, three-part survey instrument, designed for ATM Systems in the developing world, that has been utilized successfully in numerous countries inside and outside Latin America to provide comparable data on strategic variables relating to their research resource inputs and some research management practices. In most settings, the survey form has been first filled out by interested locals, and the information submitted has been refined through consultations with ISNAR staff or through consultations with an ATMS country study team. We recommend that it be supplied to all technology-generating institutions in the Technology Sector, after the study team has completed its responsibility chart, and that the study team utilize the draft results at Stage II to guide its interviews and discussions with institutional representatives, refining and supplementing, in the process, the answers provided. Copies of the questionnaire, instructions as to its use, and publications derived from the expanding data base collected through country surveys are available from ISNAR.

Ten useful rules of thumb have been derived from analyses of the survey information to date concerning the ingredients of productive developing country ATM Systems. These can be used as guides by study team members in evaluating the information they obtain:

* Between 1 and 2 percent of agricultural gross domestic product should be devoted annually to agricultural research expenditures in a country.

* About two-thirds of these expenditures should be made by public-sector institutions where annual per capita national incomes are US $2,000 or less and the rewards to technology generation by the private sector are either not clearly revealed or still involve substantial risk.

* If more than a third of total public sector funding for research is provided by external donors, the political base for long-term support of national institutions may be jeopardized.

* No more than 70 percent of public sector research expenditures should be allocated to salaries and wages.

* No more than 70 percent of all external funding should support salary payments.

* A significant share of external funding should be designated for operating capital expenditures of technology-generating institutions.

* Deviations of more than 10 percent between years in total funding for agricultural research reduce system productivity.

* Half or more of all expenditures by public institutions for salaries should support graduate-level (M.S. and Ph.D.) scientific personnel, and 20 percent or more of all personnel costs should be devoted to Ph.D.-level staff.

* The salary scale applicable to graduate-level personnel should provide returns to M.S.-and Ph.D.-level training that fully compensate for the costs of such training, if either the public sector or individual professionals are to utilize national

resources to sustain a long-term process of human capital development and maintenance.

*** The shares of public resources for research invested annually in individual commodities should approximate the shares those commodities produce of agricultural gross domestic product.**

Assessments of the roles of the research management variables will need to go beyond the ISNAR/IFARD Questionnaire to meetings and in-depth interviews with research leaders and administrators in the technology generating institutions of the public and private sectors. In making the management assessment, the study team will need to discipline itself to consider only those variables that have had a potentially significant link to the costs and availability of technology.

Some important questions to be answered for each technology-generating institution in this phase are listed below under the six variables used to describe internal management in Table 1:

*** Problem Identification/Priority Setting.** Are research problems identified mutually by the technology-generating institution, its researchers and administrative staff, and other institutions in the Technology Sector? Are research priorities systematicaly developed by commodity, region, and/or farmer group? Given the problems identified, are priorities set using criteria that should maximize economic returns to research investments? Have priorities been clearly stated in researchable terms ("develop blast-resistant rice varieties")? Are expected results quantified in economic terms ("reduce by 50 percent the economic loss from blast disease")?

*** Planning.** Is planning for the utilization of research resources clearly related to research priorities? Is planning a participatory institutional process? Are few administrative decisions taken at the center of the organization? Is planning a periodic exercise with a sufficiently long time frame of reference? Are plans developed to an acceptable level of detail? Do plans not "over regulate"?

*** Evaluation.** Are evaluations of research clearly related to the achievement of stated plans and priorities? Are ad hoc evaluative criteria eschewed? Are evaluations conducted periodically and on a timely basis so they can be integrated with later problem identification, priority setting, and planning exercises? Are external reviewers occasionally incorporated into the evaluation process? Is there a "methodology" for evaluating research activities? Is the methodology well known by most research personnel?

*** Research Methodologies.** Does the technology generating institution have well developed methodologies for attacking research problems? Is there an appropriate mix of on-farm, on-station, and in-laboratory research? Are research results systematically analyzed? Are the statistical and biometric techniques utilized adequate for the task in most cases?

* **Personnel Management** With 70 percent or more of total research resource input costs being absorbed by personnel, most attention deserves to focus on personnel management and related institutional practices. They can be prime determinants of the supply of technology in most any Latin American setting. Key questions we would expect to be answered affirmatively, if the variables with which they deal have not been importantly inhibiting, are: Can personnel be mobilized efficiently around priority problems? Is there continuity of research personnel devoted to priority problems? Are personnel appropriately trained and experienced for their jobs? Is there adequate leadership assigned to priority areas of research? Is there leadership continuity associated with priority research areas? Is compensation sufficient to attract, retain and motivate graduate-level personnel and staff assigned to field locations? Does compensation reward research productivity? Are there adequate indirect forms of personnel compensation (pension plans and the like)? Are periodic personnel evaluations conducted? Do personnel evaluations coincide with appointment terms of staff? Are most personnel on fixed term contracts of reasonable (adequate) length? Do personnel evaluations stress research productivity? Is there a staff development plan for the institution? Is staff development balanced between long-term and short-term training? Are short-term training activities designed and conducted by the institution? Do they provide new priority skills, or refresh formally acquired skills?

* **Financial Management.** Are resources assigned, in fact, by priority areas of research? Do budgets and budget implementation practices reflect planning and evaluation exercises? Are resources delivered to field locations on a timely basis? Are adequate financial resources set aside annually for contingencies and emerging research opportunities not fully anticipated by the planning process? Are financial reports rendered in ways that facilitate evaluation? Are there strong organizational linkages between the planning function and the administration/financial management functions? Are the external and internal audit functions well developed? Do external auditors issue "management letters"? Are these letters dealt with thoroughly by the governing bodies of the research organizations?

The adequacy of management linkages--the second set of variables in our management determinant (M)--is not difficult to assess; and, therefore, we do not pose at this juncture particular questions for the guidance of the study team. We only mention that these linkages will need to be defined more precisely, depending on circumstance. For example, rather than designating "linkages with national technology-transfer programs" as an inhibiting factor, the study team will want to define the matter more narrowly--for example, as "the availability of extension specialists" in the technology-generating institution.

3. Stage III

The technology performance analysis examines closely the production environment (D) associated with the Technology-Users Sector through travel and study in field locations. Its purpose is to "ground-truth" findings and test hypotheses that have emerged from Stages I and II by observing technologies in specific commodities in field locations. Attention focuses on technologies that "have hit the ground" and their impacts on production. The principal tool for the technology performance analysis is the "commodity case study," and this section of the paper addresses three questions vital to the successful conduct of case studies: What findings/hypotheses are, in fact, tested at this stage? How are the case studies chosen? And what is the content of the case studies?

The first question is best answered by example--by listing those main findings and hypotheses that emerged through the Stage I and II analyses of Panama's Agricultural Technology Management System. Five of those dealt with the roles of external research support mechanisms (X), except those mechanisms in D; one dealt with D itself; three dealt with research resource inputs (I); and one dealt with the management of technology-generating institutions.

* **Exchange Rate Policy (X).** Exchange rate policy in Panama ties the local currency to the U.S. dollar. It imposed a substantial challenge on all technology generating and transfer institutions by setting the productivity of U.S. agriculture as the target level of productivity to be achieved by national farmers producing competing products. While it should have operated as an important factor inhibiting technological change in most grain crops and in beef and milk production, among other commodities, it should also have been a factor contributing to technological change involving such costly imported technologies as tractors, trucks, and machines generally.

* **Input/Product Price Relations (X).** Partially in response to the exchange policy of the Panamanian government, intersectoral and sectoral policies have propped up local farmers with a bewildering array of market interventions affecting input and product prices. In general, significant price distortions in relative commodity and inputs prices have resulted. Farmers and farmer organizations with economic and political power have enjoyed very favorable product/input price relations: for them, these price relations have been factors facilitating technological change.

* **Commitment to Agriculture (X).** The government's commitment to agriculture, as measured by its share of public-sector expenditures, has been large, but this commitment has been oriented toward consumption, in the main. The result has been that productivity gains have been modest, even when program coherence has targeted particular commodities, regions, or farmer groups for major public sector expenditures.

* **Policy Consistency/Coherence (X).** Panama's Agricultural Technology Management System is complex, with crosscutting and overlapping responsibilities having been assigned public-sector institutions. These appear to reflect substantial policy instability, which has produced new institutions at each turn, with limited consolidation or elimination of existing institutions. The result has been that, with few exceptions, government expenditures have been dispersed and less than fully cost-effective. This lack of policy consistency and coherence has represented an inhibiting factor for agriculture's performance.

* **International Community (X).** The weaknesses just described in Panama's ATMS provided donors with a unique opportunity to influence sector planning and coordinate linkages between ATMS institutions through funding mechanisms. Donor contributions played especially significant roles in training, infrastructure and providing technical assistance relating to technology generation. International institutes and universities provided germplasm that when adapted through national breeding programs, successfully addressed important agricultural production constraints relating to product quality, yields, and resistance to local pests and diseases. Where the international donor community has focused its efforts, it has been an important contributing factor in technological change. However, in at least one instance, research strategies urged by external donors may have inhibited technological change.

* **Labor Costs (D).** A consumption-related national policy favoring employment, combined with high wages for labor resulting from salaries fixed institutionally in the Canal Zone, have combined to make labor a scarce factor of production in agriculture. Not surprisingly, it was concluded from the technological events chronology that technical change has occurred where production has not been labor-using or where technological change has been labor-substituting. Mechanical technologies appear to have been highly productive, but returns to biological and chemical technologies were frequently constrained, except where market intervention has occurred and product-input price relations have been more favorable.

* **Research Operating Capital Resources (I).** Operating capital, especially to support field research, was a pervasive constraint on the supply of technology. Small grants from some donors for specific research projects removed this constraint in a few instances. As a result, substantial national resources have been mobilized by these small grants which have involved operating capital resources, and technology generation has been importantly accelerated.

* **Research Program Scale (I).** Because the Panamanian system is poorly articulated, somewhat unstable, and young (the major technology generating institution is just 10 years old), successful commodity research programs appeared to be of below-

average scale, in terms of the research resource inputs they absorbed. Thus, program scale operated as an inhibiting factor where it was large and, perhaps, as a contributing factor in the cases of those commodities and research areas benefiting from more modest levels of research resource inputs.

* **Research Leadership (I).** We concluded that the acquired levels of formal graduate training were low within Panama's Technology-Generating Sector. The result has been that an especially high premium has been placed on high-level, continuous program leadership for research to succeed. Where it has been present, research leadership was an important contributing factor to technological change; conversely, its absence was clearly detrimental.

* **Research Priority Setting (M).** Confused signals from national policy to technology-generating institutions imposed substantial challenges on research management. Though priority-setting and problem identification exercises have been successfully undertaken by the Technology-Generating Sector, several commodity research programs suffered from poorly articulated priorities, with scarce research resource inputs being scattered and dispersed in ways that inhibited their effectiveness.

Therefore, as we entered on Stage III, we sought to observe the contributing and inhibiting influences of these particular determinants, judged through prior study to have been most relevant to technological change in Panama.

The preceding statement partially answers the second question posed above, namely, "How are the case studies chosen?" One choice criterion should be whether particular commodity case studies promise to shed light on the findings and hypotheses emerging from Stages I and II. The second choice criterion is equally simple. We would expect to learn most about the workings of the Agricultural Technology Management System by examining carefully in the field those commodities in which the system has invested most heavily and/or those commodities that were identified as experiencing significant technological change through the analyses of Stages I and II. The Panamanian System generally, and the Technology-Generating Sector in particular, had invested most heavily in rice and maize improvement. Hence, these two grain crops were selected, along with legume crops (cowpeas, beans, and soybeans), onions, and tomatoes, which had experienced very significant changes in technology through research. Seven case studies were ultimately conducted. Within each, numerous technological events, together with their associated determinants, were examined.

Finally, concerning the contents of the case studies, team members should develop, first, a simple table for each commodity--based on the technological events chronology--that summarizes critical technological events and their impacts on the development of the commodity. The table from our case study of rice in Panama is reproduced here in Table 4. These technological events become the basis for the entries in the left-hand column of the Intervention Opportunities Matrix. Other columns, of course, represent (as a minimum) the findings and hypotheses derived from Stages I and II, as well as variables in the production environment (D), which are focal points of the case studies.

The case studies begin with a historical and structural analysis, focusing in some detail on key indicators of production and consumption trends, on trends in technology generation and application, and on the impacts 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. A second section reviews historical developments of the commodity in the Technology-Generating Sector, identifies central institutions, and discusses the most important advances and constraints of the system on technological change in the commodity. A third section analyzes the impact of technological advances on production and productivity in terms of commodity yields, land area harvested, and the value of final output. Comparisons within the region and beyond help set achievements and constraints in perspective.

An important, final section of the study focuses on the major determinants that have influenced the observed technological events. The adequacy of research resource inputs is assessed, as well as their contributions to achievements. An analysis of key management functions follows, indicating how well available resources were manipulated to reach commodity objectives. The roles of important external research support mechanisms (other than D) affecting technological change are identified, and major contributing and inhibiting factors in the farm resource, economic, social, biophysical, and farmer decision sub environments of the production environment are described. Results are summarized in the Intervention Opportunities Matrix.

Each case study draws initially on available secondary data and literature. Visits are then made to interview representatives of key institutions and groups in the Technology Sector concerned with the commodity. Important technological events and their impacts are further identified, and casual determinants pinpointed. An intensive round 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. Additional meetings are held with collaborating nationals to discuss these, and a final round of field trips may be indicated. The case study is then finalized and should be presented in a seminar/workshop with top representatives of all key institutions to achieve some consensus concerning conclusions and to stimulate local actions.

Table 4 -- Panama: Technological Events in Rice

Event	Impact
Introduction of improved varieties	Responsible for yield increase of 40%, valued at $7.9 million in 1983, or 17% of total production value. Yield potential 5-6 t/ha or more, double to triple national average. Used on 40% of rice area.
Development of national seed industry	Complete self-sufficiency for rice seed needs. Certified rice seed market volume was 6800 t in 1982, valued at $4.2-4.5 million, or 10% of total production.
Development of varieties resistant to blast	Yield potential equal to introduced varieties; responsible for 40% yield increase valued at $2.0 million in 1983, or 4% of total production. Adoption of blast-tolerant varieties on 50% of rice area would result in estimated savings of $3.6 million, or 8% of production value. Total potential contribution equal to 12% of production value.
National development of lower cost production practices	None to date. Preliminary results indicate potential to reduce risks, reduce production costs by 8%, and increase yields by 18%. If package adopted on 45% of rice area, production cost savings would be 4%.

The case study information is cast in final form into the Intervention Opportunities Matrix, and a regression is estimated with the increased value of production of the observed technological events as the dependent variable and the influences of major determinants as the independent variables. Results will signal priority factors inhibiting technological change in agriculture, as described earlier.

Chapter 3

Organizing ATMS Reviews

This final chapter provides guidance for organizing a review of a country's Agricultural Technology Management System.

A. Local Advisory Committee

The methodology calls for the constitution of a local advisory committee to provide initial guidance to the study team and to review periodically its findings. Members should be broadly representative of the Technology Sector; 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 the ATMS. Further, it suggests contacts and provides introductions to many of the organizations. It should also play an important role in the selection of case studies.

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 should also serve as the committee's secretary. The local coordinator helps arrange a productive and cost-effective agenda of local interviews and assists 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, for such a person is well positioned to provide information and make contacts, as well as to benefit from the study.

C. 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 ranges from defining the specific purpose of the mission to ensuring that findings are utilized. The main activities of the leader are to:

- **Establish the Purpose of the Analysis.** The ATMS review may be undertaken to provide information on a system that is poorly understood or to target particular organizations for improvement. The attention given to the different parts of the analysis depends on its main purposes.

- **Assemble Existing Information for Team Briefing.** The leader must identify and assemble relevant studies and sector analyses for briefings of team members. Considerable time may be saved if team members have had the opportunity to study basic documents before arriving in the field.

* **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.

* **Select Team Members.** With strong local backstopping and cooperation, the study team can be limited to three members: a political economist/agricultural economist; an ATM System specialist; and a biophysical scientist to lead the case studies.

* **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 team members, meetings with the advisory committee, and periods for integrating the analysis. Final publication and submission of the report rests with the team leader.

* **Organize Final Seminar.** 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 acceptance among participants, members of the local advisory committee could take the lead in promoting improvements in line with the findings of the mission.

D. Costs

The study team of three persons will need a period for pre-study (15 days); another for a first investigative trip to prepare the ground in-country (10 days); periods of intensive fieldwork, plus time for a final seminar (40 days); and time for writing the final report (30 days). Therefore, we estimate a 12 person-month level of effort by a three-person study team, plus up to two person-months by the local coordinator. Total costs for an internationally recruited team to work in Latin America should not exceed US $100,000 (Table 5).

We believe these costs could be reduced by 50 percent or more through local efforts by donor agencies and interested nationals to develop--prior to the arrival of a study team--the responsibility chart, the technology change chronology, and the assessments of external research support mechanisms of Stage I, as well as replies to the ISNAR/IFARD Questionnaire of Stage II, for all institutions in the TGS. There is also the distinct possibility that in some countries the entire review could be conducted by local professionals as part of the planning processes of institutions in the Technology Sector. In this case, only modest costs might be incurred to brief local study

Table 5 -- Estimated ATMS Review Costs

Item	Units	Total	Cost/Unit	Cost
Staff				
Economist	Months	4.0	$4,000	$16,000
ATMS Specialist	"	4.0	4,000	16,000
Biophysical Scientist	"	4.0	4,000	16,000
Local Coordinator	"	2.0	2,000	4,000
Travel				
International	Round trips	12	1,000	12,000
Per diem	Weeks	30	560	17,000
Support Staff				
Research Assistance	Months	2	1,500	3,000
Secretarial	Months	4	2,000	8,000
Communications				1,000
Publication and Distribution				7,000
TOTAL				$100,000

team members on the methodology at the outset of their efforts andto provide an external peer review of their final report.

PART II: PANAMA CASE STUDY

CHAPTER 1

STAGE I - FUNCTIONAL DISPLAY

The functional display of the Panamanian agricultural technology management (ATM) system includes:

* **A survey of institutional functions,** which identifies each institution playing a role in the system, and places the organizations in sectoral perspective.

* **A chronology of major technological events,** the parts played by all institutions/groups in those events, and their association with contributing or inhibiting determinants of the ATMS model.

* **An assessment of key policies** operating through the research environment, based on a review of agriculture's structure and performance.

By superimposing the sector and policy assessments on the chronology of technological events, important inferences can be drawn concerning the determinants of the ATM system which have contributed to or inhibited technological change. Some of these can be affected directly by research investments in the future.

A. Survey of Institutional Functions

Identifying the various organizations of the Panamanian ATM system and the ways in which they relate to its key functions is an important step toward discovering the points of potential intervention in the system. Table A.1 (table and diagram numbers preceded with "A" are in the appendix) is a responsibility chart which arrays down one column all national and international institutions or associations influencing technological change in the Panamanian ATM system. Each has been classified by ATMS subsector in the second column, and by principal purpose in the third. The fourth column ties activities of each institution to key determinants in S and D. The responsibility chart provides a ready frame of reference from which to highlight those institutions/groups that have had a primary influence on, or represented constraints to, technological change in Panamanian agriculture. A second table provides chronological information on major institutional events within the ATMS (Table A.2).

Major features in the complex ATM system were observed as follows: with respect to macroeconomic policy and planning, few agricultural sector organizations participate in decisions on major variables (budget deficit, rate of inflation, exchange rate) with important macroeconomic implications for the sector. A larger number of organizations influence the intersectoral allocation of resources. However, few formal mechanisms exist for setting and influencing agricultural sector goals. The plurality of organizations involved in decisions with respect to given processes and subsectors of the ATM system is indicative of a fragmented decision-making structure resulting from weaknesses in the Ministry of Agricultural Development (MIDA) and the absence of a representative legislative body. Donors currently play the strongest role in generating domestic political support for agricultural research and extension, but there are no formal mechanisms to coordinate activities among them.

Research is executed by specialized institutions in the public sector (principally IDIAP and FAUP), with major input from the international agricultural research centers. Private sector participation in research is limited. There is no absence of mechanisms to influence research strategy, but input from farmer organizations and representatives has been minimal. Technology transfer is formally the task of SENEAGRO (a division of MIDA); however, there was no functioning extension service from 1972 until 1984. Support services are almost always duplicated in both the public and private sectors, suggesting that their clientele is differentiated.

External support to the ATM system is provided directly by a number of donors, principally USAID, the Interamerican Development Bank, and the World Bank. External agencies have played an important role with respect to the training of human resources for the ATM system. Donors also perform a valuable monitoring and evaluation function, since it is not well developed in the Ministry of Planning (MIPPE) and MIDA--the central decision-making and implementing bodies in the agricultural sector.

From the survey of institutional functions within the Panamanian ATM system, we are able to establish the following hypotheses:

* Few formal mechanisms exist for setting/influencing agricultural sector goals

* MIDA has failed to coordinate sector activities, which are highly fragmented

* Political support for research is lacking

* Poor donor coordination exists

* Public extension substitutes have emerged

B. Chronology of Major Technological Events

This section addresses key "events" and provides the technological history of the ATM System. Most importantly, each event is associated with a contributing or inhibiting determinant of the ATMS model. Critical information is obtained about significant technical events through personal interviews or existing literature. Using a data base management program, these events may be categorized later in ways which are not apparent when considered in isolation.

The following information was obtained for each event:

* Commodity to which the event relates
* Date or period over which the event occurred;
* Type of event (agronomic, biological, mechanical, economic, institutional);
* Description of the event;
* Association of the event with a contributing or inhibiting determinant of the ATMS model.

This information is sorted and categorized to yield a chronology of events by commodity and to document the roles of public and private organizations in technology generation and transfer. The data base serves as a valuable record of these events for future reference.

There is a tendency to overlook the importance of the private sector in promoting technological change while concentrating on breeding and other activities of the public sector. An events analysis is useful in correcting this imbalance. The private sector has clearly played a predominant role in the introduction of mechanical and chemical technology. However, there are also several instances where private firms cooperated with public entities in the introduction of improved seed technology (e.g. introduction of "IR-8" rice in 1967, introduction of "1-12" tomato in 1975, and the introduction of Andropogon gayanus pasture in 1979).

A chronology of major technological events is presented for rice, as an example, since rice is a commodity of major national significance affected by numerous technological innovations (Table A.3). Similar chronologies are performed for other key commodities. They provided particularly useful references for Stage III--the Technology Performance Analysis.

C. Assessment of Key Policies Affecting the Production Environment

This section begins with an assessment of the production environment which broadly reviews agriculture's structure and performance over the most recent decade. A second section follows which goes into some depth concerning key policies with important implications for the agricultural production environment.

1. Agriculture's Structure and Performance

Panama is a narrow isthmus 480 miles long and 37 to 110 miles wide, connecting the North and South American continents. A central range of highlands forms a continental divide, and the climate is temperate. Both coasts have narrow plains cut by numerous small rivers running into the sea. With the exception of banana plantations on the Atlantic side near Costa Rica, land used for livestock and crops has been confined largely to the Pacific slopes. Recent road developments into the Atlantic slopes, however, have brought slash-and-burn agriculture and livestock to the region.

Day and nighttime temperature variations are small, rarely exceeding 10° F. Seasons are determined by rainfall rather than changes in temperature. A dry season extends from December to April in parts of the Pacific slope and for shorter periods on the Atlantic slope.

The total land area is not quite four times that of the State of New Jersey. The forested area in 1970 was estimated at 43 percent. Deforestation from commercial logging and agricultural colonization has been extensive during the past decade, estimated at nearly 80,000 ha/yr, and serious erosion is reported.

In 1980 about 2.2 million ha (29 percent of Panama's land area) were used for agricultural purposes of various intensity. About 16 percent of that total is in crops, 57 percent in pasture, and the balance in other uses or fallow. Most of the land is hilly or mountainous (DEC, 1984a). About 22,000 ha were irrigated in 1980 for crop production during the dry season, mainly in the Azuero peninsula. Adequate rainfall precludes the need for irrigation generally.

Panama is a service-oriented economy, exposed to external influences and foreign competition by its easy access through two oceans and the canal. Given Panama's international exposure, a demand-led, dynamic growth of agriculture would be expected. However, potential demand has been shattered by a bewildering array of trade subsidies, taxes, and quotas and by increasing public- and private-sector manipulation of internal markets. Also, the government sought to redress Panama's skewed distribution of landholdings with a land reform during the 1970s. This was followed by a commitment to the reformed sector that may have absorbed 75 percent of public resources devoted to agriculture. The returns on those investments have been low. As a consequence, after turning in a respectable performance in the 1960s, agriculture expanded at below average rates in the past decade, and total productivity gains were negligible.

The agriculture sector includes crops, livestock, forestry, hunting, and fishing. As so defined, agriculture contributed 10.6 percent of total GDP in 1984. The component contributions were: crops, 56 percent; livestock, 33 percent; fishing, 9 percent; and forestry, 2 percent. Livestock and fishing have increased in importance over the past decade. The annual rate of growth of agricultural production during the 1960s averaged 5.6 percent, comparable to the GDP average of nearly 6.0 percent. However, agricultural growth during the 1970s averaged 1.7 percent, while the GDP average was 4.5 percent (BID, 1982).

Nevertheless, agriculture produces a substantial surplus. In the five-year period, 1979-83, exports ranged from $300 to $350 million annually. The agricultural sector contributed 69 percent of all 1983 exports. The major agricultural exports in descending order of value are bananas, shrimp, sugar, coffee, fish meal and beef, accounting for more than 60 percent of total exports. Imported foodstuffs have included food grains, processed food products and fats/oils for consumption. These items, including wheat and temperate climate fruits, cannot be produced in Panama. Food imports have been 50 to 60 percent of agricultural exports for the past decade (Conklin, 1986).

The agricultural sector employed 28 percent of the total labor force in 1982. Some 85 percent of agricultural sector employment was dispersed through the country, with the balance located around areas of urban concentration.

The 1980 Agricultural Census shows 102,169 farm units producing agricultural crops and livestock products on 2.25-million ha of land. More than three-fourths of all farms are highly diversified, producing both annual and permanent crops. Land in annual crops has increased steadily, while land in permanent crops has declined. Land in pasture for livestock has increased over the past three decades. Overall agricultural land use has nearly doubled since 1950.

More than 80 percent of all land is owned by sole proprietors. Only about 3 percent is in collective farms. The collective farms are the result of an ambitious land reform. By 1980 there were 206 such farms on about 70,000 ha. Land in collective farms is owned by the state and was obtained from the public domain, donations, tax default, auction and expropriations. Most of the land was poor quality--less than one-third was suitable for farming or cattle raising.

The size distribution of all farms in 1980, shown in Table A.4, is skewed. Farms with fewer than 10 ha occupy 8 percent of total agricultural land and represent 60 percent of all farms. Ninety percent of all farms are smaller than 50 ha but occupy less than 35 percent of all farmland. Farms of more than 200 ha account for 1.5 percent of the farms, but 34 percent of total agricultural land. Comparisons of data for 1970 and 1980 indicate almost no change in the farm size distribution, if the new collective farms are treated as whole farm units. This indicates that Panama's land reform had limited spillover effects--voluntary divisions of large farms into smaller units.

Two striking problems confront agriculture in Panama. First, the unitary costs of several inputs are high--mainly those of labor and chemical inputs. High labor costs are a fact of life for the entire economy, related largely to the high wages paid in the Canal Zone. Those trickle down to all sectors, including agriculture (Pou, 1984). The high costs of chemical inputs are illustrated in the case of nitrogen in Table A.5 and are the product of tariffs and quotas on their importation (Barrios, 1984).

Second, productivity levels (output per unit of land, in particular) are low. Table A.6 presents yield data on 16 commodities and one commodity aggregate (cereals) for Panama, its two neighboring countries (Costa Rica and Colombia), and all South America. It shows that Panama's yields, at least for a single year (1980), are above those of one of its neighbors and South America in the cases of onions, tobacco, and beef, though yields obtained for cassava, tomatoes, and milk approximate those of at least one neighbor and of South American countries.

These two problems partly explain why Panama is a high-cost producer of agricultural commodities and why the prices farmers receive, except for tobacco and beef (Table A.7) are high.

2. Key Policies

This section provides an overview of principal economic policies, the institutions involved, and the ways in which these policies affect the process of agricultural technology generation and transfer. Included are macroeconomic policies affecting the overall economy, policies affecting resource allocations between agriculture and other sectors; and policies influencing resource use and technical change in agriculture, especially technology generation, transfer and adoption. Table A.8 summarizes key policies and their implications.

a. Macroeconomic Policies

i. Exchange Rate Policy

The use of the U.S. dollar as the Panamanian currency has facilitated the growth of the country as an international service economy and provided stability in the exchange rate which encouraged international investment. However, the fixed exchange between the Panamanian balboa and the U.S. dollar has also led to the establishment of compensatory policies managed by autonomous agencies dealing separately with quota restrictions, price supports, credit, distribution, and input supply. Being part of the dollar economy, Panama foregoes the option of devaluation as one of its policy instruments. Thus, Panamanian producers must compete directly with American farmers who benefit from scale and technological advantages and (in some cases) government intervention in the marketing system. Panamanian agriculture must attain U.S. levels of efficiency in order to remain viable. Productive agricultural research is a sine qua non for this to come about.

ii. 1983 Policy Changes

The government has consistently focussed its efforts on the development of a service economy through investments in Canal Zone infrastructure and the banking sector. With the exception of the collective farms, which absorbed most of the funds devoted to agriculture over the period 1970-80, government efforts in agriculture have taken the form of market interventions in support of certain commodities. Major investments in rural engineering, agricultural research, and extension have historically been neglected.

Following the oil crisis in 1973, the Panamanian economy began to lag, reflecting the slowdown in international trade. Indebtedness increased, and borrowing abroad became necessary to meet interest payments on a debt that became one of the highest in the world, relative to GNP (Harberger, 1984). The government adopted policies to decrease spending and expand export earnings in response to conditions attached to IMF and World Bank loans of 1983.

To meet the IMF's conditions, the government agreed to reduce the fiscal deficit, to reduce capital expenditures, to decrease borrowing and finance the deficit without recourse to commercial credits, and to adopt other measures to increase public sector saving and stimulate private investment (Green et al., 1983). These measures included liquidation or divestiture of money-losing state enterprises; reductions in subsidies to private activities and businesses; increased efficiency in the public sector; and revision of the tax structure. The implications of these agreements for the agricultural sector are very significant:

* a turn away from heavy investment in the collective farms

* a withdrawal of the government from sugar production in high cost mills and possibly a divestiture of <u>Citricos de Chiriqui</u>

* austerity management of the operating budgets of the Ministry of Agriculture and its autonomous agencies

* a reorientation of agricultural policies from import substitution to export promotion

iii. Relative Prices and Real Wages

Throughout the 1970s, Panama followed a social policy aimed at the redistribution of incomes to marginal farmers through colonization schemes, protection of workers by strong unions, and legislation favoring laborers. Real wages fell significantly over the 1970-82 period, with the largest decreases experienced by professionals with post-secondary training and by public sector employees (Pou, 1984). Because the government was generating employment through capital-intensive projects, it lacked the financial resources to raise salaries. The resulting compression of wage scales made difficult the attraction, retention, and motivation of public sector agricultural research and extension personnel.

In spite of this real wage picture, the cost of labor to employers has been high because of job security and antidiscrimination measures, work rules, and occupational training provisions (Spinanger, 1984). The management of a decrease in real wages and more flexible labor codes is one of the current policy challenges of the government (Harberger, 1984).

In the agricultural sector, minimum wages are fixed uniformly throughout the country. More important than the actual level of minimum wages has been the influence of labor unions in agricultural processing industries. In milk processing, the cost of operating dairies on Sundays has been the justification for most processors to base their activity on imported powder. In bananas, extended strikes led to the withdrawal of United Brands from the producing sector and its concentration on marketing. These examples suggest that the labor codes have held back development of jobs in agricultural industries.

In the cases of sugarcane and rice, the International Labor Organization (ILO) has concluded that the type of technology introduced has had a positive impact on production, negative impacts on income distribution, and a mixed impact on employment. The ILO argues that the lower cost of capital-intensive techniques results from policies artificially reducing the cost of capital and increases in minimum wages. The labor code and unionization of agriculture have led farmers to employ very sophisticated machinery to reduce the number of workers without necessarily reducing costs of production (OIT, 1976).

b. Intersectoral Allocation of Resources

i. Science and Technology Policy

On the whole, MIPPE's strategy for science and technology favors Panama's development as a technologically advanced international service economy. In a functional breakdown of the national budget, 30 percent of total science and technology funding is allocated broadly to the agricultural sector, which also includes forestry and agribusiness (MIPPE, 1983). Moreover, less than 40 percent of these funds are for research and development; most underwrite administrative and service functions (MIPPE, 1985). Agriculture, forestry, and agriculturally related industries account for only one-third of all proposed investments in a 1982 projection (Tal, 1982).

ii. Share of Budget for Agriculture

Expenditure by the Panamanian government on the agricultural sector reached almost 30 percent of agricultural gross domestic product in the late 1970s. Table 6 compares selected Central American and Caribbean countries with respect to key ratios that explain this high percentage (IBRD, 1983). It is concluded that the high ratio of agricultural expenditures in relation to agricultural GDP is a function of the large role of the government in the economy, a small agricultural sector, and an average commitment of budgetary resources to agriculture.

c. Policies Influencing Resource Use in the Agricultural Sector

i. Institutional Resource Commitments by Commodity

Agricultural sector policies are most clearly defined by institutional resource commitments to individual commodities. We have analyzed the degree of congruence between public-sector interventions in selected crops and the importance of those crops in the value of production (Table 7). The data are estimates calculated from different sources, but the orders of magnitude are sufficiently clear to draw preliminary conclusions.

Rice is clearly a priority crop receiving a disproportionate share of credit, guaranteed purchases, and seed production efforts. A recent reduction in research expenditures on this commodity signals a change in policy that is expected to bring about changes in other support policies. Maize is the second most important grain crop, but looms much larger in research than in other forms of intervention. This divergence from congruence may indicate that the appropriate research package that would justify other interventions has yet to be developed, or that other factors are negatively influencing the policy environment. The disparities between public sector interventions in these two crops are reflected in private sector investment patterns, as seen in the commodity case studies.

In the cases of tomato and coffee, production value is high, but public sector commitments are reduced due to significant activity in the private sector. In cases where there is a desire to promote production, research investments are disproportionately large in comparison with production value and credit, as in beans and onion. In contrast, cowpea is virtually neglected by all institutions.

Table 6 -- Central America: Comparison of National Expenditure on Agriculture, (1979-80)

Country	AGEXPEND / AGDP	AGEXPEND / GOVEXPEND	GOVEXPEND / GDP	AGGDP / GDP
Panama (1979)	0.295	0.085	0.375	0.108
El Salvador (1980)	0.035	0.056	0.175	0.276
Nicaragua (1980)	0.114	0.089	0.289	0.225
Honduras (1979)	0.073	0.096	0.198	0.259
Costa Rica (1980)	0.047	0.0339	0.250	0.178
Guatemala (1980)	NA	0.040	0.130	NA
Dominican Rep. (1980)	0.115	0.142	0.1691	0.2090

Source: IBRD, 1983.

Footnote: The ratio of expenditure on agriculture relative to agricultural GDP may be broken down as follows:

$$\frac{AGEXPEND}{AGGDP} = \frac{\frac{AGEXPEND}{GOVEXPEND} \times \frac{GOVEXPEND}{GDP}}{\frac{AGGDP}{GDP}}$$

where:

AGEXPEND = Total public expenditure on agriculture, including current subsidies and expenditures on irrigation schemes or other investments included in current budgets;

AGGDP = Agricultural value added in the economy;

GOVEXPEND = The government's budget for the year in question; and

GDP = The gross domestic product of the country

The ratio on the left-hand side of the equation (AGEXPEND/AGGDP) is found in Column 1 and is often used as a measure of the priority accorded to agriculture. This ratio is related to agriculture's claim on government revenues (AGEXPEND/GOVEXPEND), as shown in Column 2; the government's share in the economy (GOVEXPEND/GDP) as shown in Column 3; and the share of agriculture in the economy (AGGDP/GDP) shown in Column 4.

Table 7 -- Panama: Congruence of Support Policies for Selected Crops*

Crops	A. Value of Production 1979-80 (1000 US $)	% A	B. Research Expd. 1984 (1000 US $)	% B	C. IMA Purchases 1979-80 (1000 US $)	% C	D. BDA Credit 1980 (1000 US $)	% D	E. Enasem Seed Production (t) 1982	% E
Rice	35,890.0	38.8	424.9	31.0	3,641.6	67.0	11,305.5	51.5	1,362.0	93.6
Maize	14,560.0	15.8	385.7	28.2	1,048.8	19.3	2,502.4	11.4	38.6	2.7
Sorphum	9,355.0	10.1	153.3	11.1	106.0	2.0	2,469.2	11.3	45.4	3.1
Potato	5,145.0	5.6	105.9	7.7	37.0	0.7	1,148.0	5.2	-	-
Tomato	12,875.0	13.9	102.6	7.5	-	-	1,730.9	7.9	-	-
Onion	2,374.0	1.5	99.5	7.3	314.3	5.8	606.0	2.8	-	-
Bean	465.0	0.5	76.1	5.6	266.2	4.9	240.6	1.1	-	-
Cowpea	2,007.0	2.2	20.9	1.5	18.4	0.3	27.3	0.1	9.1	0.6
Coffee	10,713.0	11.6	-	-	-	-	1,914.6	8.7	-	-
TOTAL	92,384.0	100.0	1,369.0	100.0	5,432.3	100.0	21,944.5	100.0	1,455.1	100.0

* Data are estimated from various sources

Sources: IDIAP, 1984c.
IDIAP, 1985d.
IMA, 1983.
Amon., 1984.
Pray, 1984.

That the share that the two major grains, rice and corn, represents of public sector budgets exceeds their share of production, is an unanticipated indication of sectoral priorities, the reasons for which will be described in later sections of this Part.

ii. Market Intervention

(a) Institute of Agricultural Marketing

The Institute of Agricultural Marketing (IMA) was created in 1975 out of the former Marketing Office of MIDA. It was charged with ensuring the national supply of basic agricultural products, controlling exports and imports, and administering price supports established by the Ministry of Agriculture. The institute has at its disposal a number of market intervention instruments: support prices, regulation of imports through quotas, control of exports, and provision of storage and drying facilities. IMA concentrates its interventions on a few priority crops. Rice and maize purchases account for more than half of IMA's intervention in domestic production and sales (IMA, 1983). Maize is the largest import item. IMA does not itself import directly, but issues import quotas to private firms. IMA is expected to be self-financing, and it currently covers about 90 percent of its operations.

Support prices are established in a crop-specific manner influenced by different pressure groups, rather than in a general policy framework. The support price is ostensibly based on production costs; however, these are "negotiated." Since support prices are used to establish consumer prices, large marketing margins and high consumer prices have resulted. There is clearly a need for improvement in support price- and consumer price-setting procedures.

Market interventions by IMA have a major impact on the structure of the production environment. IMA's support price for rice is far in excess of the price needed for large producers to stay in business and keeps many marginal producers in the market. In addition, the high price of rice is an impediment to the expansion of maize production, since it drives rice production onto land that could be put into maize production. Because increasing the price of maize would further raise swine and poultry production costs, a reduction in the price of rice is considered an important step toward establishing equilibrium prices for both crops. IMA fixes support prices for beans at levels double those for cowpeas, due to strong consumer demand for kidney beans. Despite the government's interest in promoting cowpeas as a substitute for bean imports, a realignment of bean and cowpea prices is unlikely without a change in the ways IMA finances its operations.

(b) The Office of Price Regulation

The Office of Price Regulation (ORP) was created by cabinet decree in 1969 and charged with fixing prices for essential products (Gabinete, 1969), ostensibly operating to protect the consumer. The ORP lost its authority to fix prices and establish import quotas for agricultural products when IMA was created in 1975. The ORP uses crop support prices established by IMA and adds storage, financial, milling, and administrative costs incurred throughout the chain of processing and distribution in order to arrive at a wholesale price. Since it carries out no cost studies to establish margins, it negotiates them through a Board of Adjustments on which members of interested groups are represented. This clearly provides an opportunity for price distortions, for consumer groups are unlikely to be as influential as producer groups.

(c) Crop Commissions

A number of crop commissions have been set up as advisory bodies to the Ministry of Agriculture. They are made up of representatives of MIDA technical agencies, private traders and input suppliers, users, and growers. Commodity commissions exist for maize and sorghum, rice, onions, legumes, meat and milk, potatoes, and for coffee, cocoa, and plaintains. Great variation exists in the political and economic importance of the different commissions, which is related to the degree of organization of its members.

The commodity-by-commodity approach to price intervention makes it difficult to coordinate price policy. Nevertheless, the establishment of the commissions was a positive development in that it provided a focus of responsibility and a procedure for price-setting. Further progress could be made by designating members of each commission to serve on a council that would coordinate price-setting for all crops.

iii. Technology Transfer

The 1950s were a period of extension without a solid basis in national research. The 1960s were a decade of mass public extension based on farmer organizations, education, and home economics. Technology transfer was limited to knowledge embodied in the extension worker. The 1970s, however, were a decade of research without extension. Public extension served only the collective farms, which had become the focus of the government's agricultural strategy. Research results became available first from the Faculty of Agronomy and, later, from IDIAP. In the absence of an extension service for individual farmers, the private sector attended to input distribution. This was a period of increasing intervention in price and marketing structures by the public sector. The 1980s are characterized by the search for a model to integrate research and extension.

Currently, extension activities are the responsibility of the National Service for Agricultural Extension (SENEAGRO), organized in 1984 as one of four technical authorities within MIDA. SENEAGRO's mandate includes traditional extension activities, as well as development and dissemination of technical information packages, training, studies of agricultural marketing and resource use, as well as other responsibilities (MIDA, 1984).

SENEAGRO began operations as a pilot project in the province of Chiriqui, where IDIAP already had significant experience in farming systems. The project works in defined areas and defined crops, specifically maize, beans, onions, and cocoa. The first three are priority crops for import substitution and the last is for generating export receipts. Maize, beans, and onions all benefit from IDIAP's research.

The extension model used is a modified "training and visit model." The pilot project, borrowed from the U.S. extension model, involves the establishment of local offices, the continuous training of field personnel, the use of demonstration plots, farmer group meetings, field days, and mass communication methods. From other systems it borrowed periodic on-farm visits, coordination of farm support services, and delineation of microareas. However, the project proposes to go one step beyond other models by introducing intensive training of farmers. Weaknesses have been identified in all of the following: transfer agents, trainers, subject specialists, and administrators; training materials and communications; inter-institutional coordination; and logistical support to technology transfer (Traywick, 1985; USAID, 1984).

Complementing this structure are local, regional and national agricultural councils (CALs, CARs, and CANs) which bring together various combinations of public and private sector representatives. Organization of the councils was proposed less than two years ago, and as yet very few have been constituted. While the intent is laudable, it is unlikely that the councils will ever function effectively, for they have no authority over budgets.

Because SENEAGRO was created out of existing departments of the Ministry of Agricultural Development, it was not at liberty to choose all its personnel. Thus, one of the important tasks of the program will be to retrain much of the staff to serve as extension agents. The need for major personnel changes and staff development is a precondition for the establishment of a successful national program.

Like other public-sector institutions, MIDA has experienced delays in the approval of its budget. Extension projects, which depend on fuel for vehicles and per diems for staff, cannot function when they do not arrive. A major additional commitment of funds from the government is essential for success.

iv. Agricultural Sector Credit

Agricultural credit has represented less than two percent of all credit from the banking sector (public and private) over the last 10 years (Table A.9). Public sector credit has represented only 10 to 15 percent of crop credit and 20 to 25 percent of livestock credit (Table A.10). Given the limited amount of public credit for agriculture, public credit policy has not influenced greatly the allocation of resources within the banking sector. However, it has played a modest role in serving small and medium farmers.

In July of 1980, the government created a Special Fund for Interest Compensation (FECI) which collects tax receipts on banking operations in the commercial sector and uses them to subsidize credit to the agricultural sector. In spite of the special measures taken to direct loans to the agricultural sector, private banks have been withdrawing from the countryside in recent years, citing high overhead costs.

The public sector bank, BDA, maintains agencies throughout the country. It provides credit to small- and medium-sized farmers below prevailing market rates, by drawing on the FECI fund. Its agricultural agents enforce technical recommendations as a condition of credit and perform a valuable technology transfer role in the absence of an official extension agency. As the private banking system withdraws from the rural market, mechanisms should be created that make it possible for BDA to maintain its services to farmers not reached by other sources. The BDA has suggested that it function as a full commercial bank. This would not seem to pose a threat to the private banking sector and might lower the overhead costs of agricultural development banking.

v. Public and Private Input Suppliers

(a) The Private Commercial Sector

The private commercial sector is made up of approximately 127 firms involved in the sale of agricultural machinery, fertilizer, seeds, herbicides, fungicides and veterinary products. Thirty-one firms (controlling approximately 85 percent of the total sales) joined together to form the National Association of Agricultural Input Distributors (ANDIA) in 1976. (Cuellar, 1985).

The private commercial sector had sales of approximately $47 million in 1982. National consumption of fertilizer was valued at $18.4 million, of which 60 percent was supplied from domestic mixing plants. Sales of agricultural chemicals were $19.6 million. In agricultural machinery, sales reached $8.6 million, including machines, implements and spare parts. Veterinary product sales were approximately $300,000 (Cuellar, 1985).

The high cost of inputs is frequently cited as one of the major factors in high production costs. A commercial sector representative confirmed that imported inputs were more costly in Panama relative to regional countries, due to the parity of Panama's currency with the U.S. dollar. However, the situation has reversed in recent years due to the strength of the dollar (Gordon, 1985).

The private commercial sector has played a predominant role in the transfer of chemical and mechanical technology imported from developed countries. It cites the inconsistency and lack of continuity in agricultural policies, the Labor Code, the transfer tax on fixed property, and delays in approval of introductions of agricultural chemicals as public sector influences currently hampering operations. Concern has also been voiced about the reduction of credit to the agricultural sector by the private banks.

(b) ENASEM and Public Regulation of the Seed Sector

The National Seed Company (ENASEM) was created in 1975 out of a seed production service that previously existed within the Ministry of Agricultural Development. Its purpose is to provide farmers with high-quality, disease-free, and low-cost seeds. A national capacity to produce seed is considered essential to speed the introduction of new seed varieties and ensure rapid adjustment to new disease or pest problems.

Through agreements with the Faculty of Agronomy and IDIAP, ENASEM buys basic and registered seed that it then multiplies on its own fields and sells. ENASEM also purchases and redistributes seed coming from private seed companies. By providing a guaranteed market and some technical assistance to private seed growers, ENASEM has encouraged the growth of private seed production.

ENASEM's capacity will be greatly increased upon completion of a five-year $9 million project financed by the Inter-American Development Bank. ENASEM's new facilities should be adequate to meet national needs for improved seed. The company is already expanding its activities into maize and improved bean varieties and eventually will expand into pastures. This represents an important addition to agricultural sector infrastructure that should improve productivity.

The National Seed Commission (CNS) was created somewhat later than ENASEM with the objective of making recommendations to the MIDA on seed production, marketing, and development. It incorporates within its board representatives of the seed producers, seed importers, and seed users, as well as technical representatives from interested public-sector agricultural agencies (IDIAP, FAUP, ENASEM, MIDA, ISA, and BDA). After inspecting fields three times during the growing season (at planting, flowering, and harvest), it can issue seed certificates, approving sales. No seed can be sold through public channels without a certificate from the CNA, and it must approve all seed imports. This provision is of major importance for a crop such as maize, where all hybrid seed is imported.

CHAPTER 2

STAGE II - INSTITUTIONAL ANALYSIS

The institutional analysis focusses on individual organizations within the ATM System concerned with technology generation for agriculture. Its purpose is to identify the roles of two main determinants in the research environment--research resource inputs (I) and research management (M)--on the supply of new technology. Basic data on research resource inputs were generated through the ISNAR/IFARD Survey (ISNAR/IFARD, 1984) with respect to human, fixed, and operating capital resources. Assessments of research management variables were based on in-depth interviews with research leaders and administrators in the technology generating institutions of the public and private sectors. Important variables considered here are problem identification/priority setting, planning, evaluation, personnel management, and the management of linkages with national institutions and the international community.

A. Institute for Agricultural Research of Panama (IDIAP)

1. Origin and Evolution

The Institute for Agricultural Research of Panama (IDIAP) was created in 1975 to integrate agricultural research and technology transfer within a single organization for the benefit of small and medium-scale farmers (CNL, 1975). Before that time, research had been carried out within MIDA's Department of Agricultural Research, in the Faculty of Agronomy, and in a few private entities. IDIAP was given the authority to govern crop and livestock research in the public sector, execute research by itself or through other organisms, and orient research activities of the private sector.

As in other Latin American countries of the day, the national research institute--integrating research and extension--was seen as the model to free research from the weight of bureaucracy. (The idea of integrating research and extension in one agency recurs in the continuing debate over the appropriate relationship between IDIAP and SENEAGRO.) A study group constituted in 1976 recommended that IDIAP concentrate activities in a few areas, expanding to others as resources permitted, and on applied and adaptive research on key crops (rice, maize, beans, potatoes, tomatoes, onions, and dairy and beef cattle). Later, additional objectives were introduced--import substitution, export promotion, service to national industries, etc. (IDIAP, 1979). The Faculty of Agronomy was to concentrate on training agricultural professionals, and its research was to be oriented to didactic activities. IDIAP's first efforts were concentrated in Chiriqui province, where small- and medium-scale farmers are well represented.

2. Structure and Governance

A Board of Directors, composed of the Minister of Agricultural Development, the Dean of the Faculty of Agronomy of the University of Panama, and the General Manager of the Agricultural Development Bank, was constituted to govern IDIAP. However, frequent changes of ministers and competition between FAUP and IDIAP have prevented the governance structure from being a force for integrating research, teaching, and extension.

Additional circumstances have impinged on the effectiveness of IDIAP's structure and governance, depicted in Diagram A.1 (IDIAP, 1985a). IDIAP has been decentralizing progressively, with increasing importance being attributed to regional directors. However, mechanisms for apportioning budgets by region and program have not been worked out.

In response to a 1982 decision to put all technology transfer in the Ministry of Agricultural Development, the Technology Transfer Directorate of IDIAP was converted into a support unit called "Technical Information and Training." However, confusion still exists concerning the relationship between this unit and SENEAGRO, the ministry's extension agency.

IDIAP was initially organized by commodity programs and regions. However, Directorates of Planning and Socioeconomic Studies and of Plant and Environmental Protection were created in 1985. While the latter was recently dissolved, care must be taken to ensure the full integration of the former with the commodity programs.

3. Human Resources and Personnel Management

The development and retention of qualified staff is a key management function. Three issues merit particular attention: the growth of human resources; conditions of service that motivate and retain staff; and programs of staff development, including long-term and short-term training.

In IDIAP, administrative data were readily available on disciplines and salaries of individual scientists. IDIAP also agreed to administer a human resource inventory of senior staff, permitting an analysis of the relationship between salaries and personal and professional characteristics.

a. Growth of Human Resources

IDIAP's initial expansion was slow because it did not receive the budgetary support that should have accompanied its creation. However, its staff increased more rapidly following a USAID loan of $6 million in 1980. Not until 1982 did IDIAP begin to recruit larger numbers of staff with advanced degrees.

Panama ranks reasonably well when compared to other Central American and Caribbean countries on the basis of its ratio of Ph.D. and M.S. scientists to total scientists. Table 8 reports data from the survey of national agricultural research systems (ISNAR/IFARD, 1984). Panama scores slightly higher than other Central American countries in the Ph.D. to B.S. ratio and somewhat lower on the M.S. to B.S. ratio, signaling opportunities for the University of Panama in graduate education at the M.S. level.

A breakdown of senior scientists by discipline (Table A.11) shows that no major discipline is currently missing. However, given the importance of livestock research in IDIAP's portfolio, more senior scientists with advanced degrees (M.S., Ph.D.) are needed in the animal sciences. Plant and environmental protection is also underrepresented. Extension specialists are also needed to link research and technology transfer. Senior management is in the hands of people with advanced degrees, but the number diverted to administrative functions is not excessive (Table A.12).

b. Conditions of Service

Staff salaries were cross-tabulated by level of formal training, sex, and location (IDIAP, 1985c). Data from the human resource inventory were added to estimate an earnings function that identifies the separate effects on salary of degree earned, short courses taken, location of work, sex, and position. A detailed discussion of this study is presented elsewhere (Elliott, et al., 1985).

The earnings function analysis confirms that IDIAP is credential-based: salary increases with level of formal education, but does not rise significantly with experience. Short-term training does not improve salary. The rate of return to earning advanced degrees is high, but diminishing, since the return to the M.S. degree is higher than that to a PhD. Holding a position of authority has a very positive and independent effect on salary. Finally, salaries outside Panama City are significantly lower than in the city, and salaries for female staff members are lower than those for comparable males.

In short, conditions of service in IDIAP are largely in line with those of comparable institutions elsewhere in Latin America. Concern must be expressed, nonetheless, about the effects of gender and location on earnings. The location effect has particularly troublesome implications for a field-based research program.

c. Staff Development

IDIAP should examine the balance between short-term training

Table 8 -- Central America and the Caribbean: Comparison of Human Resources of Agricultural Research Insitute, 1983-84

	Ph.D	M.S	B.S.	Expat.	Total	PhD B.S.	M.S. B.S.	Expat. Total
PANAMA								
Instituto de Investigacion Agropecuaria de Panama (IDIAP) (Part C)	8	32	89	6	135	0.09	0.36	0.04
United Fruit Co. de United Brands Co. (Part C)	-	-	3	4	7	-	-	0.57
Facultad de Agronomia (Part C)	6	12	11	3	31	0.55	1.09	0.10
BARBADOS								
Ministry of Agriculture, Food and Consumer Affairs (Part A)	5	10	28	10	53	0.18	0.36	0.19
" " " " " " (Part C)	2	4	19	6	31	0.11	0.21	0.19
BELIZE								
Ministry of Natural Resources (Part A)	3	12	6	10	31	0.5	2	0.32
Caricom Farms Ltd. (Part C)	-	1	-	-	1	-	-	-
Sugarcane Research Station (Part C)	-	1	1	1	3	-	1	0.33
Carribean Agr. Res. Dev. Institute (ARCI) (Part C)	1	2	-	-	3	-	-	-
COSTA RICA								
Direccion de Investigaciones Agricolas (Part C)	1	11	69	1	82	0.01	0.16	0.01
DOMINICAN REPUBLIC								
National Level (Part A)	7	47	153	8	215	0.05	0.31	0.04
Departmento Investigaciones Agropecuarias (DIA) (Part C)	3	21	72	6	102	0.04	0.29	0.06
U.A.S.D. (Departmento de Ing. Agronomica (Part C) includes part-time staff	3	21	75	1	100	0.04	0.28	0.01
ECUADOR								
National Level (Part A)	6	70	155	8	239	0.04	0.45	0.03
Instituto Nacional de Investigaciones Agropecuarias (INIA) (Part C)	6	70	155	8	239	0.04	0.45	0.03
EL SALVADOR								
National Level (Part A)	-	5	80	-	85	-	0.06	-
Centro de Tecnologia Agricola (Part C)	-	5	80	-	85	-	0.06	-
GUATEMALA								
National Level (Part A)	3	29	53	20	89	0.06	0.55	0.22
National Level Feb. 1985 (Part A, table added)	2	25	101	13	141	0.02	0.25	0.09
Comision Moscamed (Part C)	-	1	19	-	20	-	0.05	-
Comision Mexico-Guatamala para el Control de la Roya del Cafero (Part C)	-	1	18	1	20	-	0.06	0.05
Instituto Nacional Forestal (Part C)	-	1	2	1	4	-	0.50	0.25
Institute of Science and Technology (Part C)	2	21	146	3	172	0.01	0.14	0.02
HONDURAS								
National Level (Part A)	6	15	120	12	153	0.05	0.13	0.08
TRINIDAD & TOBAGO								
National Level (Part A)	31	35	17	20	103	1.82	2.06	0.19

Source: ISNAR/IFARD, 1984

and formal degree training. Because long-term training enhances the productivity of staff, as perceived by the institute's salary scale, more formal degree training is clearly indicated. Problems experienced in the long-term training program (selection of candidates, choice of universities, monitoring student progress, and administration by USDA) need to be resolved before the program is expanded (IDIAP, 1985c). Where IDIAP has the opportunity to participate in the planning of short-term training (as with CATIE), it should influence the choice of subject matter.

4. Fixed Capital and Operating Capital Resources

IDIAP has committed a large portion of its budget to capital investment (Table A.13) in the USAID-financed Agricultural Technology Development Project, which includes both the creation of laboratories and research stations (ISNAR/IFARD, 1984). However, many research personnel have been funded out of the investment budget. Eventually these people will have to be transferred to the operating budget, implying the need for a substantial increase in future government financing of agricultural research in Panama.

As long as IDIAP's strategy has been primarily one of on-farm research, the infrastructure has been adequate to the task. However, the high operating costs of on-farm research may drive IDIAP to do more on-station research in the future. Furthermore, scientists now feel the need to have more controlled environments for their work.

In general, laboratory facilities appear to be weak, with the exception of a small chemistry laboratory at Gualaca. Facilities in the Soils Laboratory at Divisa are currently inadequate to handle demand, but a new laboratory is being constructed there with the help of USAID. Another soils laboratory is located at the Faculty of Agronomy in Chiriqui. Plans are also being drawn up for a tissue culture laboratory in Panama City in association with the Faculty of Sciences at the University of Panama.

Staff costs claim an unusually large share (89 percent) of IDIAP's budget (Table A.14). These include the costs of national researchers and fixed costs of maintaining the national directorates, administration, and planning (largely personnel and travel). Operating funds are severely limited as a result (IDIAP, 1985d).

The ISNAR/IFARD Survey of National Agricultural Research Systems facilitates a comparison of IDIAP's funding with other Central American and Caribbean institutes (Table 9). IDIAP's operating budget, when expressed as a percentage of total budget in local currency and in terms of U.S. dollars per scientist, appears significantly lower than that of other institutes in the region. This is due to the high proportion of its budget

Table 9 -- Central America and Caribbean: Budgetary Resources for Scientists, 1983-84

	Total Number Sc. 1	No. of Nat. Sc. 2	Total Research Budget LCU 3	Operating Budget LCU 4	Exchange Rate 5	Total Research Budget US$ 3 x 5 6	Operating Budget US$ 4 x 5 7	Total Research Budget / Total Sc. 6/1 8	Total Research Budget / Nat. Sc. 6/2 9	Operating Budget / Total Sc. 7/1 10	Operating Budget / Nat. Sc. 7/2 11	Expenditure Resources Dom. (%)	Ext. (%)
PANAMA													
Instituto de Investigacion Agropecuaria de Panama, IDIAP (Part C)	135	129	5,499,000	579,000	1.000	5,499,000	579,000	40,733	42,628	4,289	4,488	62	38
United Fruit Co. (Part C)	7	3	-	-	-	500,000	50,000	71,429	166,667	7,143	16,667	-	-
Facultad de Agronomia (Part C)	31	28	-	-	-	600,000	240,000	19,355	21,429	8,571	7,742	75	11-25
BARBADOS													
National Level Part A	53	43	4,195,823	865,787	0.497	2,086,125	430,461	39,361	48,515	8,122	10,011	100	-
Min. of Agriculture, Food & Consumers Affairs (Part C)	31	25	5,290,000	3,015,677	0.497	2,630,140	1,499,367	84,843	105,206	48,367	59,975	100	-
BELIZE													
Carribean Agr. Res. Dev. Inst., CARDI (Part C)	3	3	300,000	100,000	0.500	150,000	50,000	50,000	50,000	16,667	16,667	-	100
Sugar Cane Research Station (Part C)	3	2	1,805,000	1,640,000	0.500	902,500	820,000	300,833	451,250	273,333	410,000	51-75	26-50
Caricom Farms Ltd. (Part C)	1	1	124,000	56,000	0.500	62,000	28,000	62,000	62,000	28,000	28,000	-	100
National Level (Part A)	31	21	1,001,430	260,000	0.500	500,715	130,000	16,152	23,818	4,333	6,190	90*	10*
COSTA RICA													
Direccion de Investigaciones Agricolas (Part C)	82	81	91,046,095	41,270,504	0.0243	2,215,557	1,004,295	27,019	27,353	12,248	12,399	90-100	1-10
DOMINICAN REPUBLIC													
National Level (Part A)	215	207	3,689,775	611,180	1.000	3,689,775	611,180	17,162	17,825	2,843	2,953	60	40
Departamento Investigaciones Agropecuarias (Part C)	102	96	3,574,775	559,000	1.000	3,574,775	559,000	35,047	37,237	5,480	5,823	51-75	26-50
ECUADOR													
National Level/INIA (Part A/C)	239	231	382,900,000	124,100,000	0.0226	8,679,587	2,813,102	36,316	37,574	11,770	12,178	70*	30*

Table 9 -- (Continuation)

	Total Number Sc. 1	No. of Nat. Sc. 2	Total Research Budget LCU 3	Operating Budget LCU 4	Exchange Rate 5	Total Research Budget US$ 3 x 5 6	Operating Budget US$ 4 x 5 7	Total Research Budget / Total Sc. 6/1 8	Total Research Budget / Nat. Sc. 6/2 9	Operating Budget / Total Sc. 7/1 10	Operating Budget / Nat. Sc. 7/1 11	Expenditure Resources Dom. (%)	Expenditure Resources Ext. (%)
EL SALVADOR													
National Level/CENTA (Part A/C)	85	85	3,281,962	177,712	0.400	1,312,785	71,085	15,445	15,445	836	836	45*	55*
GUATEMALA													
National Level (Part A)	89	69	8,978,555	1,739,270	1.000	8,978,555	1,739,270	100,883	130,124	19,542	25,207	95*	5*
Institute of Science & Technology (Part C)	172	169	5,008,664	1,464,301	-	5,008,664	1,464,301	29,120	29,637	8,513	8,665	87.5	12.5
Comision Moscamed (Part C)	20	20	3,400,000	400,000	-	3,400,000	400,000	170,000	170,000	20,000	20,000	-	100
Comision Mexico-Guatemala para el Control de la Roya del Cafeto (Part C)	20	19	1,200,000	435,000	-	1,200,000	435,000	60,000	63,158	21,750	22,895	100	-
Instituto Nacional Forestal (Part C)	4	3	219,468	29,765	-	219,468	29,765	54,867	73,156	7,441	9,922	100	-
ANACAFE (Part C)	15	15	230,000	-	-	230,000	-	15,333	15,333	-	-	100	-
HONDURAS													
National Level (Part A)	153	141	-	-	0.500							30*	70*
TRINIDAD & TOBAGO													
National Level (Part A)	103	83	37,550,000	12,250,000	0.4166	15,645,833	5,104,167	151,901	188,504	49,550	61,496	94.7	5.3

*Percentages for Operating Costs Only

Source: ISNAR/IFARD, 1984

absorbed by personnel costs. Even more serious is the fact that budget cuts during the course of the year fall almost entirely on the already-inadequate operating budget. Delays in receiving approved funding from the national government have been a serious impediment to field research. This is best illustrated by the fact that, as of October 1985, only about one-fifth of the operating budget for the year had been released (Sands et al., 1985). Even in externally funded projects, gas and travel are generally funded out of the national budget.

IDIAP shows a slightly higher degree of dependence on external funding sources than most other Latin American and Caribbean countries. This is a concern since dependence on foreign funding and unstable local funding make the maintenance of a research program more difficult (IDIAP, 1985d). IDIAP earns $100,000 from farm production, and has resisted going more deeply into commercial production.

5. Problem Identification/Priority Setting

Problem identification and priority setting for the agricultural sector are complicated by the fragmented decision process in the Panamanian ATM System. In July 1981, IDIAP and the Faculty of Agronomy held a technical advisory meeting to define priorities for agricultural and livestock research (IDIAP/FAUP, 1981). This exercise compensated for the absence of a national agricultural plan that could serve as a guide to commodity selection and research strategy. First, commodities were selected on economic and social criteria. Second, the expected impact of research on production was assessed. Finally, the probability of research success was evaluated. Too many criteria were introduced for project selection, and every project was accorded high priority.

Significant effort was devoted to the choice of priority areas in which to focus IDIAP's work, initially by the 1976 study group and subsequently by IDIAP and CATIE. The criteria ultimately adopted for choosing subregions were: priority attached by the government to the region, technological level of farmers, quantity and quality of physical and technological resources, incentives for production, availability of support services and transport, availability of information, and the representativeness of the area (IDIAP/CATIE, 1984). The selection process involved a survey of over 700 farmers and proved to be an important exercise that integrated agricultural and social scientists, and extensionists and farmers.

These sporadic efforts at problem identification and priority setting need to be institutionalized and conducted periodically.

6. Planning

Annual planning begins with a meeting between the director general of IDIAP, the directors of the regional centers, and the national program directors. At the field level, individual researchers present their projects through regional supervisors to regional directors and the regional planner. The regional director then takes the proposals to the directors of the national programs and the director general of IDIAP. Serious delays of up to eight months in completion of the annual plan have been experienced. The Planning Directorate is attempting to ameliorate the situation by initiating the process at an earlier date (IDIAP, 1985b).

For some scientists, planning has been a bureaucratic exercise with little relation to resource allocation. There is need for more vetting of projects at the local and regional levels, for evaluation at the regional level before submission to national headquarters, and for mechanisms to make national and regional objectives compatible. We recommend an iterative process, with a tentative budget sent to the regions for allocation among programs, a preliminary reconciliation at the national level, and then the returning of revised budgets to the regions for modification. In the first round, each region should have a "forward" and a "fallback" position, showing what it would do with 10 percent more and 10 percent less money.

7. Evaluation

Evaluation is not adequately institutionalized within IDIAP. The division of responsibility between national directors, regional directors, and regional supervisors is unclear. In 1982, only 53 percent of all resources went to experiments that were planned, with the remainder diverted to unplanned projects as a result of delays in the receipt of equipment and funds (IDIAP, 1982). This clearly illustrates the negative impact of budget instability on the planning process. The Planning Directorate has no comparative advantage at present in the scientific supervision of the research program. However, it is strengthening financial and administrative control of project execution through the use of "management audits."

The Livestock Research Directorate has taken some leadership for evaluation. Its experience indicates a tendency to blur the line between research and development in all on-farm research (IDIAP, 1983f). The Livestock Directorate has recommended the creation of committees for each line of research within the directorate, and a committee cutting across research lines to review the overall research plan for the institute.

8. Management of Linkages

IDIAP maintains formal agreements with over 20 international, regional, and national organizations in order to facilitate its technology-generating role and the transfer of its technology (IDIAP, 1985e). The agreements with CATIE and the IARCs have been the most fruitful and have provided the most enduring collaboration. In addition, collaboration with the IARCs has tended to strengthen the research methodologies employed by the Institute.

9. Recommendations

a. IDIAP's clients should have a more active role in decision-making. The Board should include representatives of producers, and not just public sector authorities.

b. The institutional support role played by the planning unit should be distinguished from the scientific input of economists to the commodity programs. One option would be to appoint some economists jointly to the socioeconomic unit and other research units.

c. Extension specialists should be hired, integrated into the regional on-farm research and technology-transfer programs, and called on to assist IDIAP in strengthening its linkages with MIDA's extension efforts.

d. Administrative decisions should be taken to establish conditions of service and motivation factors within IDIAP that will ensure the retention of highly trained scientists. The flat income profile of the present salary scale does not offer incentives for a research career. A special scale for researchers would involve step increases for length of service, along with merit increases for productivity. Also, incentives for service outside Panama City should be considered.

e. Upgrading of staff to the M.S. and Ph.D. levels, with increased emphasis especially on the animal sciences, is urged.

f. While continuing short-term training, greater attention should be given by IDIAP to its relevance for the job needs of staff.

g. A new support group might be created to deal with the development of new infrastructure and special projects. This would come under the director general's office, but day-to-day responsibility could reside with the subdirector general in order to leave the director general free for general policy leadership and for developing political and financial support for the institute.

h. A major increase in government funding for operating budgets is necessary.

i. Since budgetary instability has been a severe problem, IDIAP should be encouraged to create a "contingency fund" equal to 10 to 15 percent of its annual budget. This will allow it to carry out critical operations while waiting for the government budget to be voted. The board of directors should guard against the use of this fund for salaries.

j. Donors and the private sector should be approached to guarantee loans by private banks to support the contingency fund.

k. Donor support, which is currently generous on investment costs, should be sought for some operating costs.

l. Collaboration between planning units in the public agricultural sector should be strengthened.

m. Budget planning and priority setting exercises should be made more compatible. The annual planning process must become an important tool of policy, and researchers must relate the funds they receive to the proposals they present.

n. The on-farm focus of the research program at IDIAP requires a decentralized operation. Annual planning and programming make the regional director an important decision-making component.

o. Projects and proposals should be evaluated more thoroughly, especially at the regional level.

p. Formal monitoring and evaluation procedures should be established with the assistance of the Planning Directorate, which make program directors responsible for their implementation.

q. Evaluation should precede the preparation of proposals for the coming year. Technology users should have an input into the evaluation procedure, which is at least equal to their involvement in planning.

r. Regional directors and regional supervisors should have a strong role in ensuring that research continues to meet the needs of clients.

B. Faculty of Agronomy of the University of Panama (FAUP)

1. Origin and Evolution

The Faculty of Agronomy of the University of Panama has been an important actor in the agricultural technology-generating sector. Created in 1959, the faculty's research program in basic grains (rice, maize) preceded that of IDIAP. In fact, IDIAP's research program was initiated by researchers who transferred from the faculty. FAUP continues to interact with IDIAP through members of the faculty who work at the Institute and researchers at IDIAP who teach courses or direct student research at FAUP. The two institutions jointly maintain facilities at Rio Hato, and IDIAP will install its new headquarters on faculty-owned land at the Tocumen Center near Panama City.

FAUP was originally centered at Tocumen, approximately 25 kilometers from Panama City near the international airport. The Tocumen Center is one of the best equipped agricultural research sites in the country. However, in recognition of the agricultural importance of the western region, the government sought (and obtained) $3.5 million from the Interamerican Development Bank for a new headquarters at David in Chiriqui Province (FAUP, 1982).

In 1982, the faculty decided to increase its geographic representation through the creation of new centers to serve the central provinces and the eastern region, as part of an aggressive strategy to establish centers in all agroecological zones of the country not served by IDIAP (ISNAR/IFARD, 1984; Neyra, 1983). There are some who feel this expansion is not desirable, since the faculty is not financially in a position to establish a presence throughout the country. Moreover, such an expansion is not needed for purely didactic purposes. The decision to expand is one that should be taken in a national rather than institutional context, for it will involve commitments of public funds that might serve research better in other ways.

2. Structure and Governance

Within the university, research is administered by the Vice-Rectorate for Research and Postgraduate Studies. A director is named by the vice-rector for the three separate divisions of research, technical assistance, and postgraduate studies. The vice-rectorate supervises the research centers and serves as the authority that transmits research proposals to international agencies and other donors. Directors of centers and coordinators of programs within various facilities are responsible for the execution of projects.

3. Human Resources and Personnel Management

The Faculty of Agronomy includes 65 professors and 20 assistants. Not all professors are full-time, for many hold positions in other institutions. With the move of the faculty to its present location in David, it is increasingly difficult for FAUP to attract and retain staff. Nevertheless, the faculty has managed to carry out its teaching and research functions with a mixture of permanent and visiting professors (FAUP, 1984a).

FAUP is the only unit in the university that counts full-time researchers among its permanent staff. These researchers were originally hired on externally funded projects and later were absorbed by the University. Senior professors working on such crops as maize and rice have assistants permanently attached to their programs. Table A.15 illustrates the composition of researchers in the Faculty of Agronomy in 1985 (ISNAR/IFARD, 1984). The presence of competent research assistance is an important factor in the continued productivity of FAUP's senior faculty.

A study over the period 1968-79 shows a fairly constant 1:1 ratio of research personnel to research assistants (Atencion and Calderon, 1980). This is a lower ratio than in IDIAP, using similar definitions of research and support personnel. FAUP, however, shows a higher ratio of Ph.D. to M.S. scientists. This reflects the higher academic requirements of a university appointment and the greater difficulty the faculty has in hiring and retaining young staff members with M.S. degrees.

The University's salary structure has been a problem in retaining personnel. Appropriate mechanisms do not exist to stimulate outstanding research personnel and salaries are not sufficiently attractive to retain them. Between 1976 and 1982, 12 professionals with Ph.D.s or M.S.s went to other institutions where they were offered better salaries (FAUP, 1982).

Our survey of FAUP human resources revealed that the staff is predominantly male and young: 84 percent of the respondents are under 36 years of age. The mean years of experience since graduation is 6.5. Salary is significantly related to degree level and years of experience. These relationships were tested in a multivariate framework (reported fully in Elliott et al., 1985). The equation describes an earnings profile for FAUP researchers in which salary rises at a decreasing rate with years of experience.

4. Fixed Capital and Operating Capital Resources

FAUP currently maintains three experimental centers totaling 1400 ha. Four additional sites totaling 615 ha are projected or under development (ISNAR/IFARD, 1984; Neyra, 1983). In addition to facilitating research, the faculty's infrastructure also enables it to provide laboratory analyses and improved seeds. A soils analysis laboratory is nearing completion in David that will conduct soil, nematode and leaf-tissue analyses for farmers.

The overall budget of the University of Panama for 1983 was $29.3 million, of which $1.4 million (4.9 percent) was assigned to research in all facilities (Adames et al., 1984). Clearly, research represents a minor part of the university's activity.

The faculty has a regular source of income from the university, from which it pays its personnel. It also receives a subsidy from MIDA. In addition, it earns about $100,000 per year from multiplying basic rice and maize seed, which it sells to ENASEM and private firms.

The research budget of the faculty (Table A.16) though considerably smaller than IDIAP's, is more stable, primarily due to earmarking of university resources for research. FAUP does not experience serious problems in the flow of funds, but has signaled problems with year-to-year fluctuations in budget. Because most of the faculty's research is done on-station, its operating expenses are modest. Relevant comparisons of operating resources for IDIAP and FAUP show the faculty to be seriously lacking support for field work (Table A.17).

5. Problem Identification/Priority Setting

FAUP is like most universities in that individual professors are free to carry out research on subjects they find professionally interesting. Professors submit proposals to the director of research for consideration by a project evaluation committee. Difficulty in the establishment of institutional research priorities, however, is attributed to the absence of a national agricultural research strategy. Officials of the faculty stress the need for a national research plan in which the roles of IDIAP and FAUP are integrated.

In the absence of such a national plan, the committee judges projects on the basis of the importance of the problem, the applicability of the research to other areas, and the availability of resources (economic, physical, and human) to undertake the research. Such criteria place major importance on the faculty's role as generator of technology, but do not adequately stress the faculty's comparative advantage in teaching. Further, FAUP appears to be in competition with IDIAP at the adaptive end of the research scale. The faculty should have a comparative advantage in discipline-based research for didactic and applied purposes, rather than adaptive research for development purposes. Nevertheless, the Faculty shows a tendency to take on significant adaptive research (FAUP, 1983; 1984b; 1984c).

Current research priorities outlined by the faculty include maize and rice, highland vegetables, improved pastures, soil fertility, plant protection, and low-cost agricultural technologies. It is clear that these research areas are aimed at placing the faculty in the front lines of development (FAUP, 1982). However, the topics are so numerous and diverse and resources so limited as to preclude major advances. This dispersion of effort is characteristic of universities everywhere.

A study of student theses over the period 1963-76 shows a strong emphasis on cereals. By 1982, however, new topics, like agricultural development, began to assume significant importance (Atencion and Calderon, 1980; Neyra, 1983). Students in other faculties are also involved in research related to agricultural topics. Several studies on economics and pricing policies in the agricultural sector have been done in the Faculty of Public and Business Administration. Nitrogen fixation and tissue culture research is located in the Faculty of Sciences. Collaboration between the Faculty of Sciences, FAUP, and IDIAP should increase when the new tissue culture laboratory is completed at the Tocumen center.

6. Planning

As noted above, research planning is an informal process carried out on a project-by-project basis in the absence of an overall plan. The faculty seems more concerned with long-term planning relating to student enrollments, and curriculum development.

The priority assigned by the government to undergraduate agricultural education is decreasing, since the number of unemployed agronomists is currently estimated at 400. Declining enrollments experienced by the faculty (down from 200-250 per year in the 1970's to 20-30 in the mid-1980's) were partly intentional, but the move to Chiriqui has reduced admissions below the annual target of 40 (Rodriguez, 1985). The faculty maintains that there is not an overproduction of agronomists, but rather a need to tailor the output of the faculty more to the needs of the country. Following the move to Chiriqui province, the faculty has increased the number of production courses.

Geographical expansion and increased research are seen as means for compensating declining undergraduate enrollments. However, it is unlikely that the faculty could develop a good research program without a strong postgraduate curriculum. To date FAUP has hardly begun to explore the potential for postgraduate education. It offers only one M.S. program in entomology, which was set up to serve the Medical Faculty as much as the Faculty of Agronomy.

7. Evaluation

The faculty has a project evaluation commission for approving research proposals, but little peer evaluation of research proposals and no formal monitoring or ex-post evaluation. However, the faculty points to the following as progress in the area of research in recent years: release of improved varieties of rice, maize and pastures; new research programs in non-traditional areas (medicinal plants, yams, and phytopathology in coffee and fruit crops); international funding for new research programs totaling $187,000; and the restructuring of research administration (FAUP, 1984a).

8. Recommendations

a. The faculty should not compete with IDIAP in adaptive research.

b. The faculty does not require its own experimental fields in all ecological zones of the country, so there is no compelling reason to decentralize further. Didactic needs for field work can be met through collaboration with IDIAP.

c. The faculty should prepare to meet the demand for postgraduate professionals by opening new M.S.-level programs.

d. Donors and interested national agencies should prepare a human resource development plan for the agricultural sector that specifies a role for FAUP in preparing professionals at the M.S. level.

CHAPTER 3

STAGE III. TECHNOLOGICAL PERFORMANCE ANALYSIS

A. Introduction

The technology performance analysis examines closely the production environment (D) associated with the Technology Users Sector through travel and study in field locations. Its purpose is to "ground-truth" findings and test hypotheses that have emerged from Stages I and II by observing technologies and their impacts on production of specific commodities in field locations. The principal tool for the technology performance analysis is the "commodity case study." This section of the paper addresses four questions which are vital to the successful conduct of case studies: What hypotheses are tested at this stage? How are the case studies chosen? What is the content of the case studies? And finally, how are conclusions drawn from the case studies?

1. Hypotheses

Ten principal hypotheses emerged from the Stage I and II analyses of Panama's ATM System dealing with the roles of external support mechanisms (X), with the farm production environment itself (D), with research resource inputs (I), and with the management of technology generating institutions (M). Earlier presented in Part I, they are once again summarized below.

a. **Exchange Rate Policy (X).** Exchange rate policy ties Panamanian currency to the U.S. dollar, thus setting the productivity of U.S. agriculture as the target level for national farmers producing competing products. This policy inhibited technological change in grain crops, beef and milk production, while contributing to technological change dependent on costly imported technologies--mostly mechanical and chemical.

b. **Input/Product Price Relations (X).** Market interventions have resulted in significant price distortions in relative input and commodity prices. These factors have facilitated technological change for farmers and farm organizations with political power, but have constrained technological change in commodities with less powerful groups.

c. **Commitment to Agriculture (X).** National commitment to agriculture has been oriented toward consumption and has failed to facilitate signficant productivity increases in most cases.

d. **Policy Consistency and Coherence (X).** Substantial instability exists in public institutions and policies within the Panamanian ATM. Government expenditures have not been fully cost-effective, thereby inhibiting agriculture's performance.

e. **International Community (X).** Weaknesses in the national ATMS provided international organizations with unique opportunities to positively influence technological change, particularly in training, infrastructure development and provision of technical assistance.

f. **Labor Costs (D).** High labor costs have constrained labor-using technological change. Those technologies which reduce or substitute for labor (e.g. mechanical and chemical technologies) have been most productive, while returns to biological technologies were constrained, except where market intervention resulted in more favorable product-input price relations.

g. **Research Operating Capital Resources (I).** Limited operating capital, especially to support field research, has been a pervasive constraint to the development of new technology.

h. **Research Program Scale (I).** Due to instability in the Panamanian ATMS and the youth of the major technology generating institution, use of research resource inputs was relatively less effective in large commodity research programs and more effective in more modest programs.

i. **Research Leadership (I).** Where present, high-level, continuous program leadership was an important contributing factor to technological change; its absence was detrimental.

j. **Research Priority Setting (M).** Despite occasional priority-setting exercises by the Technology Generating Sector, and some priority assigned resource use in two base gains, rice and maize, the absence of clearly articulated national agricultural priorities has inhibited the effectiveress of commodity research programs.

2. Selection of Commodity Case Studies

Commodity case studies were selected on the basis of a few simple criteria, the first being whether the case shed light on the hypotheses emerging from Stages I and II. Commodity cases were chosen which illustrate variation among institutional priorities and policies and which reveal strengths and weaknesses of the system.

The second criterion relates to the degree of importance attached to the commodity, as reflected in significant investments by the ATM System. The Panamanian ATMS, and the Technology Generating Sector, have invested most heavily in rice and maize. These two grains crops are major commodities in terms of dietary importance, monetary value, and employment generation, while exhibiting contrasting (commercial versus subsistence) market orientations. Hence, rice and maize were selected as case studies.

Finally, commodities were selected which had been identified as experiencing considerable technological change through research--legumes (beans, cowpeas, and soybeans), onion, and tomato. The issues highlighted in the legume cases relate to market demand and incentives for private sector investment. The onion and tomato cases illustrate the impact of different types of private sector organizations on the TGS.

3. Content of Case Studies

A simple table was developed for each commodity which summarizes key critical technological events and their impacts on the development of the commodity. These technological events became the basis for entries in the Intervention Opportunities Matrix (IOM) and provided the focus for the development of the technological performance analysis.

The case studies begin with an historical and structural analysis, focussing on key indicators of production and consumption trends, on trends in technology generation and application, and on the impacts of technological advances. A second section reviews historical developments in the Technology Generating Sector, and discusses the most important advances and constraints to technological change in the commodity. A third section analyzes the impact of technological advances on production and productivity. The final section focusses on the major determinants which have influenced the observed technological events. An assessment is made of the adequacy of research resource inputs, key management functions, the roles of external research support mechanisms, and contributing and inhibiting factors in the farm production environment itself. Results are summarized in the Intervention Opportunities Matrix.

4. Drawing Conclusions from the Case Studies

Case study information is summarized and quantified in the Intervention Opportunties Matrix. Individual determinants were assigned positive, negative or neutral values according to their impact on production. These values were entered into the IOM. The increased value of production resulting from the observed technological events was calculated. A regression was then estimated using increased production value as the dependent variable and the values of the major determinants as the independent variables for each technological event. Results signaled those factors most critical in inhibiting or contributing to technological change.

B. Rice

1. Historical Analysis

a. Production and Consumption Trends

Rice is the most important food crop in Panama, accounting for roughly 20 percent of the national agricultural product (IDIAP, 1983a) and second only to bananas in value (Anon., 1984). Per capita consumption is one of the highest in the region (DEC, 1984b; Lasso, 1985).

Currently, the production area is slightly greater than 100,000 ha. Rain fed rice predominates; only five percent 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, 1985).

Production volume was roughly 200,000 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, though mechanized farmers reap 3.5 t/ha, and yields of 5 - 6 t/ha have been achieved in rainfed rice (Lasso, 1985). National yields are low in comparison with other countries in the region--10 countries have higher yields and only two have lower yields (FAO, 1985).

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 1 ha, accounting for 57 percent of total rice area but only 32 per cent of production. At the other end of the scale, 1.6 percent of the rice farms account for 30 percent of total rice area (averaging 33 ha), but 51 percent 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, 1984a; Lasso, 1985; Watts, 1985). Costs of fertilizer and other chemical inputs are as much as three times higher than in the United States (Anon., 1984). These costs have also been higher than in other countries until recently, when regional prices rose to comparable levels due to the strong U.S. dollar (Gordon, 1985).

Panama achieved self-sufficiency in rice for the first time in 1955 (IDIAP, 1983a). Virtually the only rice now 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. Surpluses have 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. The national Agricultural Marketing Institute (IMA) purchases and stores 10 to 20 percent of the production at guaranteed prices.

b. Trends in Technology Generation and Application

From the mid-1940s to the mid-1970s, the principal constraints to rice production in Panama were the need for improved varieties and production practices, including mechanization. Skilled human resources and physical infrastructure were also lacking. When technologies and expertise became available from external sources, public policy was focused on the development of the rice-producing sector, credit and physical infrastructure, human resources for technology adoption and transfer, and market incentives.

The TGS developed with imported technologies. Skilled human resources were fostered through daily interactions with expatriate scientists and through formal training programs abroad. The 1950s saw a spurt of technological advances in agronomic practices and plant protection, as well as the importation of improved, higher-yielding varieties. Late in the decade, the Faculty of Agronomy was created at the University of Panama (FAUP), which played an important role in research and technology generation in the 1960s and 1970s.

The 1960s saw a major expansion in land area devoted to rice production and the increased use of mechanization. Production jumped almost 50 percent (DEC, 1985), due as much to area expansion as to higher yields. The private sector strengthened its role throughout the decade by developing comprehensive extension programs, including technical assistance and credit for inputs. Collaboration with the international community continued at FAUP and INA on improved agronomic practices (IDIAP, 1983a).

Adoption of mechanization was largely completed by the start of the 1970s, and widespread adoption of the new dwarf varieties was principally responsible for yield and production gains over the decade. However, the new varieties were susceptible to rice blast. A national hybridization program, begun at the end of the 1960's, resulted scarcely a decade later in blast-tolerant dwarf varieties (IDIAP, 1983a; Lasso, 1985).

The regular achievement of surplus rice production in the 1970's signalled the realization of national goals with respect to rice production and the need to reorient agricultural-sector priorities. Policies and institutions were still oriented toward encouraging rice production, and those who had benefited (producers, intermediaries) had the political strength to oppose changes. By the mid-1980s, however, national economic constraints began to result in credit restrictions and a slight decrease in the rice support price.

c. FAUP and IDIAP Rice Programs

FAUP and IDIAP are the principal rice technology-generating institutions, with inputs from the international agricultural research organizations and, to a limited extent, from private firms. As the major national cereal crop, rice has received high priority in research at FAUP and at IDIAP. The orientation of rice research at FAUP placed increasing emphasis on genetic improvement during the 1970s. Collaboration with international agricultural institutions, like 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, 1985) Major efforts were also devoted to the production and processing of improved rice seed to reduce dependence on imported supplies.

With the creation of IDIAP in 1975, 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, 1985). The first blast-tolerant varieties still maintain their tolerance today with yields comparable to those of introduced varieties (IDIAP, 1983a; Lasso, 1985). In 1982, IDIAP entered into close collaboration with CIAT, which provided over $10,000 for the collaborative program in 1984 (IDIAP, 1984c). 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, 1985).

Results from agronomic studies indicate that weed control, inadequate fertilization, and insect control are currently the most important production constraints. Improved agronomic packages have been available since 1981 and are continually refined (IDIAP, 1983b). The international community is still an important resource for agronomic technology--CATIE has provided roughly $100,000 for research on farming systems, including lower-cost rice production (Bejarano, 1985; IDIAP, 1984c).

IDIAP's 1984 budget provided $425,000 for the rice program, roughly 20 percent of the total budget and the largest of any crop (IDIAP, 1984c). Human resources include one Ph.D. scientist, five technicians, and five part-time specialists. 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, 1985). FAUP maintains a rice germplasm collection at seed storage facilities in Tocumen (Panama province) and Alanje (Chiriqui province).

2. Impact of Rice Technological Advances

National rice yields have increased roughly 60 percent since 1950 (DEC, 1985), while the yields of available varieties rose 150 percent (IDIAP, 1983a). The slow gains imply a stagnation in yields among most traditional farmers, offsetting gains achieved by mechanized farmers. National yields are 30to 50 percent lower than yields obtained in other Central American countries (FAO, 1985).

Of the varieties themselves, 80 percent of those planted on mechanized lands are introduced, but a nationally produced variety ranks first in yield and second in area (Table A.18). National varieties are more widely used on traditional farms due to their lower demand for chemical inputs, particularly for blast control (Lasso, 1985). IDIAP estimates annual savings of $3.6 million in chemical control costs if blast-tolerant varieties were used on 50 percent of the rice area (IDIAP, 1984d).

Efforts by FAUP, IDIAP, ENASEM, and precursor organizations, as well as the recent addition of private firms, 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.

Research on agronomic practices has been particularly influenced by external technologies using chemical inputs. 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. IDIAP, in collaboration with CATIE, is completing the development of a lower cost, higher return production package in Chiriqui province (Bejarano, 1985). However, these efforts 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 10. Major determinants of those events are presented in Table A.19, and identified as I, M, X or D variables for entry in the intervention opportunities matrix (IOM), which appears in Table A.20.

3. Analysis of Key Variables

a. Research Resource Input Variables (I)

Of the three major resource variables, human and operating capital resources have been dominant, while fixed capital resources have played a lesser role in contributing to technological change. Scholarship programs dating back to the late 1920s placed professionally competent people in positions to lead technological development in the public and private

Table 10 -- Panama: Technological Events in Rice

Event	Impact
Introduction of improved varieties	Responsible for yield increase of 40%, valued at $7.9 million in 1983, or 17% of total production value. Yield potential 5-6 t/ha or more, double to triple national average. Used on 40% of rice area.
Development of national seed industry	Complete self-sufficiency for rice seed needs. Certified rice seed market volume was 6800 t in 1982, valued at $4.2-4.5 million, or 10% of total production.
Development of varieties resistant to blast	Yield potential equal to introduced varieties; responsible for 40% yield increase valued at $2.0 million in 1983, or 4% of total production. Adoption of blast-tolerant varieties on 50% of rice area would result in estimated savings of $3.6 million, or 8% of production value. Total potential contribution equal to 12% of production value.
National development of lower cost production practices	None to date. Preliminary results indicate potential to reduce risks, reduce production costs by 8%, and increase yields by 18%. If package were adopted on 45% of rice area, production cost savings would be 4%.

to lead technological development in the public and private sectors and to assimilate technical assistance provided from abroad (IDIAP, 1983a). Senior leadership in the TGS benefitted from participation in the Servicio Internacional Cientifico Agropecuario (SICAP), as well as from formal training abroad. Continuity of leadership has been a stabilizing factor in the TGS.

Rice has received the highest priority nationally of any crop 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. Therefore, operating capital resources have had a greater positive impact on technological change than in other commodities. However, current policy calls for reductions in the support price, credit, and area planted. These adjustments are warranted to curb production surpluses to promote other commodities in the agricultural sector.

Fixed capital resources for rice technology development have been adequate to support the achievement of self-sufficiency in rice production. Physical infrastructure for technology development in the public sector is limited to modest experimental centers and grain storage facilities. Laboratory facilities are extremely limited; however, plans are under way to expand these on FAUP land at Tocumen.

b. Management Variables (M)

A broad array of human and capital resources was successfully brought to bear on rice production in the 1950's and 1960's, resulting in the creation of infrastructure (credit, marketing, insurance, research, training) needed for development on a large scale. Priority-setting was facilitated by coherent national policies. With the achievement of self-sufficiency in rice, this coherence was undermined. The key management issue in the TGS is now the need to reduce rice production costs. Critical policy issues include limiting of government intervention in the market, collaboration in setting sector priorities, and greater commitment to strengthening the agricultural sector.

Management of research methodologies has been good. Astute research coordinators have successfully used crises, such as rice blast, to focus attention and resources on the problem. Research to reduce production costs will require a significant input of management skills to coordinate biological and socioeconomic inputs.

The effective deployment of human resources has had a positive impact on technological change, particularly in the assignment of highly trained professionals to research activities. The assignment of extension agents solely to collective farms during the 1970's reduced the impact of human resources in technology transfer. Linkages between research and extension currently need strengthening, particularly with regard to the transfer of lower-cost rice production practices. Linkages with the international community have been successully exploited.

c. External Resource Support Variables (X, Including D)

Variables external to the TGS have played pivotal roles in promoting the development of rice technology in Panama over the last three decades. 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. National institutions have been equally supportive. The National Rice Commission--established in 1983--has helped bring diverse entities of the ATMS together to coordinate policies on rice and improve procedures for setting prices (Lasso, 1985). Both IDIAP and FAUP have representatives on the commission.

Rice producer organizations are strong and have consistently promoted technological development. Recognizing the value of the TGS, the largest association has recently instituted a modest tax on rice produced by its members to support a research fund (Watts, 1985).

The current need for clearer signals on rice policy from the sociopolitical environment to the TGS is apparent. This cannot be achieved without greater government participation in setting priorities for the ATMS and adjustment of policies in accordance with those priorities. 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

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

ii. Costly and inefficient agronomic practices constitute the principal technological constraint.

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

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

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

b. Recommendations

i. Commission rigorous studies of the causes of the low productivity and high production costs. The TGS socioeconomic capability should be strengthened to permit this.

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

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

C. Maize

1. Historical Analysis

a. Production and Consumption Trends

Maize is an important traditional crop in Panama, second to rice in production volume, and second to wheat in imports. Total national consumption is nearly 100,000 t, of which one-third is imported (DEC, 1985). An estimated 40 percent is consumed by humans; the remaining 60 percent is fed to animals.

Maize is produced in every province of Panama by farmers using traditional methods. Total production area was just over 75,000 ha in 1983. Mechanized farming is concentrated on the Azuero Peninsula of central Panama in Los Santos and Veraguas provinces. Estimates of the area mechanized vary from eight percent (DEC, 1985) to 12-15 percent (Alvarado, 1985). Total national production was roughly 70,000 t in 1983-84, with average yields of just under 1 t/ha. National yields have stagnated since the 1950's, despite average yields of 2-3 t/ha realized by mechanized producers. The impact of mechanized yields on the national average is minimal due to the small area involved.

Maize production costs are approximately $400-600/ha on mechanized farms and $200/ha on traditional farms (Alvarado, 1982; 1985). Chemical inputs account for up to one-third of total costs (ISA, 1984a). The most expensive operations are soil preparation, weed control and harvesting. Harvesting is usually done by hand even on many mechanized farms. The support price for maize, guaranteed by IMA, is currently $220-250/t. However, producers commonly receive $175/t locally. Profits range from $50-300/ha, depending on production costs (Alvarado, 1985).

IMA imports maize at world prices of approximately $130/t and sells at support price levels. The volume of imports has fluctuated between 25,000 and 30,000 t in recent years. Current imports are valued at almost $6 million (Alvarado, 1985). IMA uses profits gained on the sale of maize to subsidize production of maize and other crops.

b. Trends in Technology Generation and Application

Systematic research on maize got under way in 1952 at INA with the arrival of the Arkansas mission. Trials were carried out on improved varieties and hybrids adapted to the tropical lowlands (Gavidia and Samaniego, 1980). Maize research was centered at INA during the 1950s and 1960s, largely based on guidelines provided by the Central American Cooperative Program for Maize Improvement (PCCMM, later PCCMCA), which has played an important role in fostering regional cooperation and the distribution of maize germplasm (ibid.).

The focus of maize research shifted away from INA in the late 1960s with the development of other agricultural institutions. Maize research was relocated in the new Ministry of Agriculture Office for Research and Extension and made to include research on agronomic practices, as well as varietal improvement. However, research leadership soon passed to FAUP, and then to IDIAP--still the dominant research institutions today.

c. FAUP and IDIAP Maize Programs

Maize research got underway at FAUP in 1968, and in 1970 FAUP received its first funds from the government specifically for research. FAUP played the predominant role in maize research throughout the 1970s, becoming the headquarters for international experiments with the PCCMCA and, beginning in 1974, with CIMMYT (Gavidia and Samaniego, 1980).

Initially, the major varietal constraints were low yield and excessive plant height. Early efforts focused on the development of high-yielding open-pollinated varieties with shorter stature through selection, evaluation and hybridization. FAUP was responsible for a number of improved open-pollinated varieties developed since 1970, at first independently, and later in collaboration with CIMMYT (Alvarado, 1985).

FAUP continues to be involved in maize research and in the production of certified seed. However, the focus of maize research switched from FAUP to IDIAP in the late 1970s. IDIAP currently has six full-time professionals working on maize, compared to two in FAUP. Because IDIAP's scientists were drawn largely from FAUP, research efforts initiated in FAUP were continued in IDIAP.

Maize improvement continued under IDIAP with the release of three new varieties developed collaboratively with CIMMYT. These have a yield potential of 5 t/ha and perform as well as imported hybrids currently planted. Varieties with a shorter growing season and earlier maturity are being readied for release. Improvement efforts are now focused on disease resistance, particularly to bushy stunt disease (Alvarado, 1985).

Research on agronomic practices began in the 1970s, but was not accorded high priority until the end of the decade. Early agronomic studies applied a farming systems approach which was not as effective as the single commodity focus on maize subsequently implemented in collaboration with CIMMYT in the late 1970s (Arauz, 1985). A package of appropriate technologies developed in Caisan through a joint IDIAP/CIMMYT research project resulted in savings of 20 percent on production costs (Arauz, 1985; IDIAP, 1983c; IDIAP/CIMMYT, 1983).

The influence of CIMMYT's program is reflected in FAUP's and IDIAP's exclusive focus on open-pollinated varieties, in spite of the widespread use of imported hybrids among mechanized farmers. The current rationale is based on the somewhat erratic performance of the hybrids, which generally outyield open-pollinated varieties under good conditions, but do not yield as well under adverse conditions (Alvarado, 1985). In principal, hybrids developed specifically for a particular region should outyield improved open-pollinated varieties by as much as 20 percent. However, it is not attractive for international companies to develop hybrid varieties specifically for Panama because the market is too small (ibid.). Higher program costs and an orientation toward traditional farmers are factors in IDIAP's decision to forego hybrid development.

Currently FAUP and IDIAP produce basic seed for sale to ENASEM, which contracts with private growers to produce certified seed. There are no private companies producing maize seed in Panama. Maize seed accounts for 12 percent of ENASEM's production, and that share is increasing rapidly (Guzman, 1985). National varieties now account for 30 to 40 percent of marketed maize seed (ibid.) and imported hybrids for the remaining portion. However, a large proportion of maize used for seed never enters the market. Most of this seed can be assumed to be unimproved native varieties.

The private sector has not played as great a role in the development of maize technologies as it has with rice, due to the predominantly traditional orientation of maize farmers. Nevertheless, the private sector maintains an important distribution network for imported hybrid seed and chemical inputs.

2. Impact of Maize Technological Advances

Improved maize varieties and more efficient agronomic practices are significant achievements of the TGS. However, yields and production volume have remained largely unchanged over the past 35 years, indicating that these advances have had little impact on national maize production (Table 11). Dramatic increases could be achieved in maize productivity, if improved varieties and agronomic practices were more widely adopted.

Adoption of improved varieties is a critical factor in modernizing Panamanian maize production. Increased yields possible with improved open-pollinated and hybrid varieties have been realized on a very limited area, contributing less than 10 percent to maize production when much larger increases could be realized (Table 11). Hybrid varieties developed specifically for Panama could boost yields an additional 20 percent under ideal conditions. Local production of hybrid varieties would also strengthen the national seed industry.

The impact of improved, lower-cost agronomic practices is currently restricted to the Caisan area of Chiriqui province, where they resulted in increased yields and a 20 percent reduction in production costs (IDIAP, 1983c; IDIAP/CIMMYT, 1983).

If more widely adopted where improved practices are already being used (roughly 45 percent of maize areas), savings could reach nine percent of total production costs (Table 11). IDIAP will need to test its technology under a wider range of conditions, and to push for greater support from a strengthened extension service for this to occur.

Key events in the development of technology for maize production and their impact are summarized in Table 11. Major determinants of these events are presented in Table A.21, and identified as I, M, X or D variables for entry in the Intervention Opportunities Matrix (IOM), which appears in Table A.22.

3. Analysis of Key Variables

Adoption of new technologies has been inhibited principally by the highly traditional nature of the production environment and the unfavorable policy environment. The lack of a functioning extension service limits the impact of the TGS, which is also restricted by its narrow focus on open-pollinated varieties and a limited geographic region.

a. Research Resource Input Variables (I)

The importance of high quality human resources is borne out by the major role played by a few senior scientists in the generation of maize technology. Quality rather than quantity of human resources has characterized the program. Fewer than 10 professionals, including one part-time expatriate scientist, are currently working on maize. Most, including the two senior

Table 11 -- Panama: Technological Events in Maize

Event	Impact
Introduction of hybrid varieties	Currently used on 80% of mechanized area, roughly 7,400 ha or 10% of total area. Responsible for 60% increase in yields over local varieties, valued at $880,000 or 6% of total maize production in 1983. Yields average 2-3 t/ha; potential yield of 5 t/ha or more, five times national average.
Development of improved open-pollinated varieties	Used on roughly 5,000 ha, or 7% of total area. Responsible for 40% yield increases over local varieties valued at $350,000 or 2% of total production in 1983. Yields average 2-3 t/ha; potential yield of 5 t/ha, five times national average.
Development of national seed industry	Nationally produced seed (all open-pollinated) supplies 40% of national seed market. Total market valued at $355,000 or 2% of total maize production. All hybrid seed imported. Vast majority of traditional farmers save own seed which never enters market.
Development of lower cost production practices	Minimum till package adopted on 43% of maize farms in Caisan (0.3% of total maize area). Savings of 20% realized by farmers who adopted the minimum till package; if adopted where higher-cost improved practices used, potential savings of 9% in national production costs.

scientists, are trained at the undergraduate level. Relevant training, particularly of an applied nature, has enhanced the capability of the senior scientists--both cite the importance of training received by working with CIMMYT scientists (Alvarado, 1985; Arauz, 1985). The continuity of these professionals within the TGS has been a crucial factor in the achievements realized despite limited support staff and financial resources.

Capital resources for maize research are slightly less than for rice research, but substantial in relation to the crop's contribution to agricultural production. IDIAP's budget for maize research in 1984 was roughly $386,000 or 18.4 percent of the total, while maize contributed just 3 percent to national production (Anon., 1984; IDIAP, 1984c). Funding from external sources (AID, CATIE, CIMMYT) provides an important degree of stability to the operating capital resources of the program, especially to those projects for which it is earmarked.

Physical facilities for maize research are limited, necessitating IDIAP's on-farm strategy. Modest field offices lack greenhouse and laboratory facilities. Modern laboratories are planned at IDIAP's proposed headquarters site on FAUP land at Tocumen. FAUP's program is somewhat better endowed, with experiment stations at Tocumen and Rio Hato, seed storage facilities at Tocumen and Alanje, and laboratories in Panama City. FAUP shares its seed storage facilities and laboratories with IDIAP.

b. Management Variables (M)

The impact of TGS efforts could be enhanced by improving its priority-setting mechanisms to focus more sharply on increasing productivity through the use of hybrid varieties and lower-cost agronomic practices. IDIAP's current focus has been determined to a greater extent by social concerns for the large numbers of traditional farmers than by economic concerns for higher productivity. Since this approach has not been successful in improving national productivity in maize, more research resources should be shifted toward technologies for mechanized producers, particularly those that could still be used by traditional farmers. Outreach efforts and linkages with technology transfer institutions need to be strengthened to promote adoption of new technologies.

Technical assistance available from international programs such as the PCCMCA, CIMMYT and CATIE has had a positive impact on maize technology development in the Panamanian TGS. However, program leaders must adopt additional research strategies, such as the use of hybrid varieties, if those of the international community are not adequate to ensure the achievement of national objectives.

Financial management has been inadequate to mitigate the effects on field research programs of insufficient operating funds and delays in their receipt. In addition to budgetary buffering mechanisms, IDIAP scientists should focus efforts on completing the most important activities. When budget cuts are necessary, it makes more sense to cut entire experiments of low priority than to cut funds for gasoline from all experiments. Further, IDIAP should examine the feasibility of maintaining a limited number of experiment stations to assure easy access and controlled experimental conditions. However, most of the internal management adjustments needed in the TGS are minor in relation to adjustments necessary in the national policy environment.

c. External Research Support Variables (X, Including D)

Maize is one of the few commodities for which demand is increasing in local markets (Anon. 1984), due to the rapidly expanding poultry industry. However, government intervention in agricultural markets is preventing national maize production adjustments.

National importation and marketing policies, coupled with protection of the poultry industry, constitute the most serious impediments to expansion of maize production in Panama. The unpredictability of maize importation (up to 30 percent of national needs) stifles national production. Imported maize has arrived to fill IMA silos just as local maize is being harvested, preventing IMA from buying and storing the local maize. In addition, though support prices are intended to guarantee higher income to farmers, they also sustain higher cost production practices. Gradual deregulation of maize could be tempered by more favorable credit policies (particularly for mechanization) until farmers can adjust their production practices.

Conflicting interests among the many maize growers have prevented the maize producers' association from gaining the political strength necessary to influence maize support programs and budgets (Arauz, 1985). Efforts to strengthen the maize commission should come from mechanized producers who have greater resources. Logically, poultry producers should also be pressing for lower maize support prices. However, price protection in the national poultry market reduces their incentive for action. If this protection were reduced or removed, vertical integration of the poultry industry through national production of maize could result in lower production costs and lower poultry prices for consumers.

A substantial expansion of the domestically produced maize market would encourage the private sector--particularly international seed companies--to invest in the development of hybrid varieties specifically for Panamanian conditions. Well-adapted hybrids would provide higher and more stable yields for mechanized producers who can afford the necessary inputs.

Government agricultural policy is currently oriented toward development of export crops, with secondary emphasis on import substitution. With the application of currently available technologies, Panamanian maize producers could supply greatly expanded poultry and livestock industries, even to the extent of self-sufficiency, were the government to begin making some of the structural adjustments necessary to de-regulate the agricultural sector.

4. Conclusions and Recommendations

a. Conclusions

i. Maize productivity is low and unit costs of key production inputs are high.

ii. The TGS has not had an impact on national maize yields. Low productivity and an exclusive focus on open-pollinated varieties constitute technological constraints.

iii. Market potential is high if production costs can be lowered.

iv. The policy environment is highly unfavorable.

v. Maize producers are dispersed and poorly organized.

b. Recommendations

i. Calculate productivity levels necessary to offset high production costs to determine whether the TGS can respond.

ii. Free research strategies from traditional production systems. Give top priority to validation of cost-effective agronomic management practices and testing of hybrid varieties in major maize regions. Identify constraints to adoption of improved open-pollinated varieties.

iii. Assess the potential of the domestic poultry market.

iv. Seek national consensus to improve the maize policy environment.

v. Organize producer associations with IPACOOP assistance.

D. Legumes

1. Historical Analysis

Beans, cowpeas, and pigeonpeas are considered basic grains and part of the traditional diet in Panama. Soybean is a new crop in Panama and not yet widely grown. The combined production volume of all legumes is only three percent of that of rice and 10 percent of maize.

Cowpea is the traditional legume crop of rural areas, and its production and consumption still far exceeds that of beans. Nevertheless, consumers (influenced greatly by importation of U.S. products) now favor red kidney beans. As a result, production credit and research programs for cowpea were cut and reoriented toward the more popular bean, which is imported in large quantities. In order to meet the demand for beans through national production, IDIAP's legume program has been focused on beans for the past decade. Only in the past year have official institutions begun to renew their interest in cowpea, in the hope of reducing bean imports.

a. Production and Consumption Trends in Cowpea

Cowpea production has declined in recent years (DEC, 1985), due to changing consumer demands and unfavorable marketing and credit policies. IMA's imports of cowpea have ranged from one-third to one-half of national consumption over the period (DEC, 1984a).

Cowpeas are produced almost exclusively on small farms of fewer than five ha and production methods are still traditional (Rodriguez and Aleman, 1982). Total area planted to cowpea was roughly 10,000 ha in 1983 over two planting seasons (DEC, 1985). National yields have held at 300 kg/ha for the past 30 years (ibid.). These are low by regional standards--optimum yields of 2 t/ha are now possible using improved varieties (IITA, 1984).

Over 50 percent of the cowpea harvest is consumed on-farm (DEC, 1985). The support price for cowpea is currently $550/t (Acosta, 1985), constrasting dramatically with the bean support prices, which reached $1,045/t in 1984-85 (ibid.).

b. Production and Consumption Trends in Bean

The area planted in beans is currently 730 ha (Acosta, 1985) or seven percent of the cowpea area. Over 90 percent of the bean crop is produced in Chiriqui province at elevations above 500 m (Acosta et al., 1983). Beans are not adapted to lower elevations where cowpeas perform significantly better. Production has increased to over 500 t in the last 25 years (IMA, cited in Valencia, 1981). Yields have doubled to over 700 kg/ha during the past decade (Acosta, 1985), largely due to the efforts of IDIAP's legume program.

Traditional practices are still used in half of the bean production area, while mechanized practices are used on the remainder. Minimum-till methods were recently introduced by IDIAP's team (IDIAP, 1984b). Three native varieties currently account for all national production. Over 80 percent of the farmers save their own seed, which is frequently unsatisfactory due to contamination and poor selection practices (De Gracia, 1984). Although productivity is improving, unit production costs are still high by regional standards (Table A.23). Nevertheless, with production costs of $360/ha and yields of 700 kg/ha or above, producers can realize profits of $250/ha or more.

National production currently satisfies 15 to 20 percent of demand, with the remainder imported by IMA. Imports were valued at over $2.5 million in 1982 (Acosta et al., 1983). IMA generally profits from importation. Nevertheless, delays of three to six months in the payment of national purchases are frequently common, as is true in other crops, with the result that national producers are reluctant (or unable) to expand production area.

Government intervention in the market and the absence of other major buyers act as a damper on increased production. Technical problems remain in the limited availability of improved seed and in the brief marketing window when beans glut the market (Silvera, 1985). The difficulty of obtaining credit is another important limiting factor (Acosta, 1985). Loans from the national agricultural bank (BDA), which finances virtually all bean production, decreased by over 90 percent between 1976 and 1983 (De Gracia, 1984). Furthermore, there is no national association of bean producers to promote favorable policies for the crop. Nonetheless, beans are clearly the legume of highest priority in the agricultural sector.

c. Production and Consumption Trends in Soybean

Soybean was introduced as a substitute for imported vegetable oils valued at $16 million annually (Silvera et al., 1979). Experimental plantings of 70 ha were carried out in 1977, with yields of 1.4 - 1.8 t/ha (ibid.), comparable to world levels. However, production has not expanded due to the lack of processing facilities. Oil extraction plants require high volumes of soybean seed for full-capacity operation. However, the company "Melo" processes soybeans to produce cake for poultry feed and can handle the production of up to 500 ha annually (Silvera et al., 1979).

It remains to be proven whether Panamanian farmers could produce soybean in sufficient volume and at low enough cost to justify the promotion of a national oil processing industry. An alternative would be to develop the production of soybean cake and meal for the rapidly expanding animal feed market.

d. Trends in Technology Generation and A lication

Technology generation for legumes began in the 1950s at INA with technical assistance provided by the Arkansas mission and the SICAP program (Silvera, 1985). Other institutions that have collaborated over the years are CATIE, FAO, the regional association--PCCMCA--which proved to be an important conduit for international sources of germplasm, and CIAT, whose bean program is now a major source of bean technology for the region.

The private sector has not participated in the development of legume technology. Not only is there a limited market for the final product, but the demand for seed and other inputs is correspondingly small by the predominantly traditional production sector. Moreover, seed of all three legumes can be saved by the farmer.

e. FAUP and IDIAP Legume Programs

Research on legumes at FAUP began during the 1960s. Bean and soybean programs underway at FAUP moved with the transfer of personnel to IDIAP upon its establishment in 1975. From 1975 to 1984, research on legumes was divided with minor exceptions between the two institutions--FAUP focusing on cowpea and pigeonpea, and IDIAP on bean and soybean. Only in the last year has IDIAP expanded its legume research to include cowpea with plans for the appointment of a part-time cowpea researcher (Acosta, 1985; Silvera, 1985).

FAUP's legume research has been especially strong in genetic improvement through selection. Early variety trials with beans began in the mid-1960s with materials obtained through the PCCMCA (Silvera, 1985). A major effort on cowpeas began in 1971 with the evaluation of 36 varieties provided by IITA through the PCCMCA (Rodriguez and Aleman, 1982). The result was a high-yielding cowpea variety suitable for mechanical harvest (ibid.). Grain legumes are accorded top priority along with cereals in FAUP research today (Neyra, 1983). Work continues on genetic improvement and agronomic practices, particularly mechanization (ibid.) and weed control (Rodriguez and Ducreux, 1982).

IDIAP investigators tapped international bean germplasm resources to develop improved varieties. Several hundred genetic lines received from CIAT and Cornell University were evaluated and two new varieties were ultimately developed which were resistant to web blight (Silvera, 1985). Resistance to web blight alone is responsible for a 15 percent increase in yield (ibid.). Yields of the new varieties average 1.5 - 1.8 t/ha--more than double the national average. The two varieties are currently being multiplied and will be distributed by ENASEM (Acosta, 1985).

Research on agronomic practices for beans was initiated in 1978. A complete package of techniques was developed within five years, incorporating minimum-tillage (IDIAP, 1983d). The new package reduces production costs by 10 percent (Acosta et al., 1983) and increases yields through better management practices. Incorporation of the new varieties should decrease costs of disease control and raise returns through higher yields.

Transfer of the bean technologies generated has been realized through on-farm research and field days organized by IDIAP and MIDA. IDIAP provided intensive training to a SENEAGRO extension agent in maize and bean production and mounted a short course in bean production in late 1984 for an audience predominantly of SENEAGRO agents (IDIAP, 1984b).

These results were achieved with minimum financial and human resources. Human resources consist of a senior legume breeder, a field researcher, an assistant, four field workers and three or four part-time specialists. Research costs for the past five years are estimated at $35,000, exclusive of salaries (De Gracia, 1984), or not quite 10 percent of the bean program budget. Clearly this is a modest program, yet it has achieved solid results in fewer than 10 years.

Between 1975 and 1980, two new soybean varieties were developed and agronomic practices were modified for Panamanian conditions (IDIAP, 1983d). International germplasm collections were screened and selected over 10 generations for yield, plant height, and disease resistance (Silvera et al., 1979; IDIAP, 1983d). Average yields of 1.8-2.5 t/ha were realized in experimental trials, comparing favorably with U.S. yields of 2.1-2.2 t/ha (IDIAP, 1983d). The two new varieties have been available for commercial use since 1980 and are distributed by ENASEM (Guzman, 1985). Though scaled-down research efforts continue, the soybean program is basically "on hold" until conditions appear more favorable for the development of the crop.

2. Impact of Legume Technological Advances

The impact of legume research on national yields has been significant in bean, but negligible in cowpea and soybean. The doubling of bean yields to over 700 kg/ha in the past five years was due entirely to improved agronomic practices. Panamanian bean yields are still slightly lower than regional averages (CIAT, 1983), although the new higher yielding varieties may close this gap. Key events, their impacts, and determinant factors are summarized in Tables 12 and Table A.24. (Key determinant factors for soybean were not quantified due to lack of data.)

The response of bean yields to technological advances indicates rapid adoption of new practices. The concentration of

Table 12 -- Panama: Technological Events in Legumes

Event	Impact
Development of improved bean varieties	Two new varieties resistant to web blight ready for release; no impact as yet. Potential to increase yields by 100-150%, from 0.75 t/ha to 1.5-1.8 t/ha. Value of increased production, if adopted on 50% of bean area, would be be $360,000, or 52% of current production value.
Development of cowpea varieties for mechanical harvest	No impact--virtually all cowpeas produced by traditional methods. Potential yield increase of 1.0 t/ha, if adopted on 20% of cowpea area, would be worth $550,000 at current support prices, or 33% of current production value.
Development of adapted soybean varieties and agronomic practices	No impact--still an experimental crop due to lack of market.

production in one region and the on-farm research strategy compensated for weakness in the extension system. However, the rate of impact can be expected to slow as production expands to other areas, unless technical personnel are added to extend adaptive research and the extension system is strengthened considerably.

In the case of cowpea, research efforts by FAUP have been modest but sustained over two decades. New varieties and agronomic practices were developed. Nevertheless, yields remain unchanged for more than 30 years. This can be attributed in part to the situating of research on experiment stations rather than on farms, and to the lack of institutional linkages to the extension system. Even more important was the low priority placed on cowpea research in the face of declining market demand and unfavorable credit and marketing policies.

Soybean research received high priority and achieved significant technological advances in a short time. However, the impact of these advances has been nil because of the failure to develop a market, either for soybean cake or for oil. The contrast among the three cases is illustrative of the major role of consumer preferences and market factors in determining the ultimate impact of technological advances.

3. Analysis of Key Variables

a. Research Resource Input Variables (I)

As in other commodity research programs, human resources have contributed to success in the face of limiting budgetary and physical resources. High quality, dedication, and continuity characterize the senior investigators who provided the leadership and stability necessary for progress. Relevant training abroad and at CIAT enhanced the investigators' ability to do the job and forge links to the international community. However, legume researchers fall short of a critical mass. Additional personnel was identified as a constraint to the expansion of IDIAP's legume program (Silvera, 1985).

Limited fixed and operating capital resources have not prevented considerable progress in the development of legume technology, indicating that small scale need not be inhibiting to technological change. However, as in other commodity programs, cuts and delays in receiving national funds for operating expenses are particularly damaging to on-farm research. The availability of operating funds should be stabilized and a modest increase in total legume research budgets should be approved, if the program is to expand to other production regions.

In terms of physical resources, FAUP is better endowed than IDIAP. However, limited laboratory facilities have hampered legume research in bean web blight and cowpea viruses. Plans for new laboratory facilities at Tocumen should alleviate the problem. Finally, the availability of legume germplasm from international sources was a key contributing factor to the success of national legume improvement efforts.

b. Management Variables (M)

Good management of limited resources has been the most important factor contributing to the development of legume technology. Priorities were appropriately set on increased productivity and more efficient production practices, and research methodologies employed were successful in achieving program objectives. Linkages to national policy and technology transfer institutions have been more effective for bean than for cowpea or soybean. However, linkages to the international community have been excellent in all three cases.

By focusing on selection rather than hybridization of genetic materials obtained from international sources, IDIAP's varietal development strategy for beans has been well suited to its resource level. An incentive to accelerate varietal development was created by the severity of the web blight problem. Participation in international networks coordinated by CIAT and PCCMCA has partially offset the shortage of research staff.

Within its agronomic research program, IDIAP's focus on lower-cost, minimum-till practices is clearly essential to reduce production costs. IDIAP's linkages to SENEAGRO will be increasingly critical, if the impact of the program is to expand beyond Caisan.

FAUP's institutional goals are considerably different from those of IDIAP, and so are its management strategies. Because FAUP's first priority is training, the generation and dissemination of technology are secondary. Cowpea technology is a case in point. Improved varieties and agronomic practices were developed but remained on the experiment stations due to the lack of linkage to the extension system, among other factors. FAUP's plans to expand its network of experiment stations nationwide will not solve the problem unless that linkage is forged.

c. External Research Support Variables (X, Including D)

Determinant factors in the national policy and farm production environments have favored the adoption of improved bean technologies, but discouraged the adoption of improved cowpea and soybean technologies. Macroeconomic policies are inconsistent with marketing interventions, particularly with respect to cowpea. The Legume Commission is ineffective in promoting more coherent policies. Credit for legume production is restricted and inhibits the expansion of national legume production. The farm production environment is most receptive to improved bean technology and least favorable to the adoption of improved cowpea technology.

Strong market forces have greatly influenced legume policies in Panama. Consumer preference for red kidney beans is reflected in government policies, which favor the production of beans over cowpeas through higher support prices. The lack of a market for soybean, due to unfavorable conditions for private investment in processing infrastructure, has effectively blocked the production of this potentially valuable crop in Panama.

All legumes are affected by incoherencies and inefficiencies in national marketing policies, i.e., late payments by IMA and importation of foreign beans and cowpeas. Clearly, policies on the importation of legumes--a profitable operation--are closely linked with support price levels of other crops, particularly rice. Measures to reduce rice subsidies could potentially stimulate the production of legumes and other commodities.

The National Legume Commission is composed of representatives of the national banks, IMA, ISA, IDIAP, ENASEM, legume importers, and producers (Acosta, 1985). Like other agricultural commissions, this one is not as effective as it could be, due to a failure of the participating institutions to act in concert (ibid.). Bean and cowpea producers are poorly organized and consequently ineffective in promoting their interests.

Public sector support services--particularly seed distribution and extension--do not currently satisfy national needs. ENASEM's capability to supply improved varieties of cowpea and bean should improve in the short term, aided by the World Bank. Strengthening of the technology transfer system will be essential for widespread adoption of new legume technologies, particularly in cowpea.

In the case of soybeans, a careful feasibility study is needed to determine the production potential and ultimate market demand for the crop under Panamanian conditions. Research efforts should be reduced or eliminated if the potential is low, and increased if high, with recommendations for appropriate policy incentives to stimulate adoption and commercial exploitation of the crop.

In conclusion, national legume policies should be revised. Realistic goals should be set for the reduction of legume imports in order to meet national production targets. Gradual steps to balance cereal production with a diversified production of legumes and other crops should be achievable at little or no cost through the reduction of imports and should ultimately result in greater efficiency in the agricultural sector.

4. Conclusions and Recommendations

a. Conclusions

i. Consumer demands have spurred bean research strategies and technology adoption.

ii. The untested potential of new bean production areas and the short harvest period are constraints to increased production.

iii. The market potential is high only for beans.

iv. The policy environment is in disarray.

b. Recommendations

i. Maintain the TGS focus on beans.

ii. Allocate TGS resources for variety trials in all potential bean areas, and extend the growing and harvest periods.

iii. Strengthen the TGS socioeconomic capability before investing in other legumes.

E. Onion

1. Historical Analysis

a. Production and Consumption Trends

Onions are a new crop in Panama, but second in importance among horticultural crops only to tomato. Demands for the commodity have not been met by national supplies, and imports have exceeded national production levels until recently. Production began in the late 1950s in the highlands and later spread to lowland areas on the Pacific coast. The commercial production of onions was still quite limited in the late 1960s (Anon., 1967) but has increased significantly in the last decade to over 5,000 t on 260 ha (Conklin, 1986; DEC, 1984b; Gaskell, 1985). Yields average 20-30 t/ha (De Leon et al., 1982), but may reach 70 t/ha or more in the highlands where state-of-the-art production techniques are employed by advanced growers (Gaskell, 1985). Many onion growers in the highlands are organized into strong cooperatives that have an influence on research and marketing policies.

Onions are typically grown on small areas of a few hectares in size, in rotation with other vegetable crops. Since the highland and lowland growing regions represent distinct agroecological zones, production technologies are area-specific. Onions planted in the highlands without irrigation require six to seven months to mature, whereas lowland onions under irrigation mature in four months (Gaskell, 1985). Production methods are labor- and input-intensive, resulting in high production costs of $4,000-$5,000/ha or more (De Leon et al., 1982; Gaskell, 1985). Labor accounts for 50-65 percent of total costs, due in large part to manual transplanting operations (De Leon et al., 1982; ISA, 1984b).

Prices received by producers fluctuate from a low of $396/t when onions glut the market in May to highs of $660 or even $880/t during scarce periods. Rates of return to production costs range from 150 to 200 percent, based on an average price of $484/t, expenses of $4,000-$5,000 and average yields of 20-30 t/ha (Gaskell, 1985).

National onion production is strongly affected by IMA's importation and marketing policies. IMA imports roughly 50 percent of Panama's yearly onion consumption at world prices of $242-$330/t and sells the onions at $440/t and above when nationally produced onions are available (Gaskell, 1985). Thus, IMA is a primary competitor of Panamanian growers in the marketplace.

b. Trends in Technology Generation and Application

Research efforts have been limited but more or less continuous over the past two decades, focusing on improved cultural management practices and the extension of the production season. Extensive use has been made of imported technologies. Key research institutions have been MIDA's precursor (MACI) and IDIAP. FAUP has not been involved in onion research except through collaborative thesis work. Private sector initiatives have been limited to the producers' associations, which have offered to assist IDIAP initiatives with the contribution of inputs, office space, and gasoline (Gaskell, 1985).

Research in the highlands was initiated by MACI in the late 1950s, with support from SICAP. A modest program was focussed on varietal testing and agronomic practices. Following the termination of the MACI program in 1967, no further onion research was carried out in the highlands until 1984 (Gaskell, 1985). Lowland onion research activity began in the mid-1960s as part of the University of Arkansas' technical assistance program at INA. Trials were of a very general nature, managed by a researcher who worked on several crops. A MACI scientist also began part-time work on onions in the late 1960s in Los Santos.

Research continued through the 1970s to a limited extent, but did not receive priority until the formation of IDIAP in 1975. The current onion research program at IDIAP consists of two Panamanian researchers in the lowlands and two researchers in the highlands, including one expatriate Ph.D. from Rutgers University. These individuals devote approximately half-time to onion research. Two additional professional staff for the highlands program have been included in IDIAP's budget request each year since 1983, but have not been approved by the Ministry of Planning, MIPPE.

IDIAP's onion research goals focus on the development of agronomic practices that improve the profitability of onion production, and on extending the production season. Research strategies include varietal trials, improved agronomic practices, and plant protection. Imported varieties developed in Texas and California are used exclusively for commercial onion production and have performed satisfactorily. Management of soil fertility and diseases in the seedbed and weed control are the principal agronomic concerns. Some postharvest research is also underway in collaboration with Rutgers University on onion dryers to improve storage during the rainy season A major goal is the development of management practices permitting the production of onions during the rainy season.

Top producers are quick to adopt the latest technologies and often conduct their own trials of new chemicals. IDIAP has wisely profited from their experience by carrying out much of its research through on-farm trials.

2. Impact of Onion Technological Advances

Onion research efforts have emphasized adaptation of imported technologies rather than technology generation. Varietal testing, screening of herbicides and development of management practices for the seedbed have made the greatest contribution to increased production to date.

Until recently, private producers in the highlands have taken the lead in accessing and testing new technologies. They provide significant input into the determination of research priorities and are an important component of technology generation and adaptation.

Gaps still remain in the technology generation and adaptation system. High production costs exemplify the problem. Technologies have not yet been developed that would permit direct seeding and eliminate labor-intensive transplanting. Also, agronomic practices are required to mitigate the effects of heavy rains, and herbicides are needed to control serious weed problems.

The impact of recent public sector research has been realized rapidly due to the policy of on-farm trials which was formalized in 1980. The virtual lack of a functioning extension service for the past few years has apparently not held back the application of results, at least in the highlands, due to the cohesiveness of the producer groups.

Key events in the development of technology for onion production and their impact are summarized in Table 13. Major determinants of this event are presented in Table A.26 and identified as I, M, X or D variables for entry in the intervention opportunities matrix (IOM).

3. Analysis of Key Variables

a. Research Resource Inputs (I)

Resource inputs have been minimal, but generally positive factors in onion technology development. Human resources have had a positive impact on technology generation and adaptation, particularly where continuously associated with the program. A critical mass has yet to be reached, however. Operating capital resources have been limited, but good outreach efforts by the research team, notably in the highlands, were effective in developing strong support on the part of producer cooperatives. Access to international germplasm was an essential resource for the production package.

The lowland onion research program has had a continuity of almost 20 years in human resources, carried over from the MACI program. Even with responsibility for other crops, the individual in charge (M.S.-trained) has been able to maintain the program and to train other professionals. The highland research program was fragmented by a loss of continuity for almost 20 years. Early efforts proved to be a useful start for top growers who, well-educated themselves, managed to maintain the impetus of technology generation and adaptation. The principal cooperative a critical force in reestablishing the highland onion research program in 1984 and still seeks its expansion. As noted earlier, yearly requests through the budget for additional personnel have been denied by the Ministry of Planning (MIPPE).

Total resources for IDIAP's present research program are $100,000 per year (excluding expatriate technical assistance personnel), roughly comparable to funds allocated for other vegetable and root crops (IDIAP, 1984c). Operating capital resources are low and habitually delayed. Solution of this institution-wide problem would contribute greatly to the continuity of research efforts. The willingness of the cooperatives to contribute gasoline and other inputs to the research program should certainly be exploited.

b. Management Variables (M)

The development of good linkages to the farm production environment, to national support institutions, and to the international community has been the most consistently positive management variable contributing to technological change. These linkages have brought continuity to the somewhat fragmented research program.

Table 13 -- Panama: Technological Events in Onion

Event	Impact
Introduction of onion varieties	Used on virtually 100% of production area, approximately 260 ha. Responsible for contribution of at least 7.3 t/ha to yields, valued at $816,000 or 36% of total production.

Efforts to transfer improved production practices to Panamanian farmers have in recent years included bulletins (De Leon et al., 1982), grower meetings, and field days. All these activities have been conducted by IDIAP researchers and technology-transfer specialists, but have lacked the involvement of MIDA extension personnel. Neglect of an organized extension service has undoubtedly delayed technology transfer, but the efforts of IDIAP and top producers have filled the gap to a certain extent.

In absolute terms, the onion research program has yet to reach a critical mass of professional personnel. A modest expansion of research efforts in both the highlands and the lowlands would accelerate technological advances in the crop and make import substitution a very feasible goal from the technological standpoint. However, a turnabout in marketing policies will be essential to permit national self-sufficiency in onions.

c. External Research Support Variables (X, Including D)

Technical problems remain, but national marketing policies currently constitute the principal constraint to increasing production volume. IMA is one of the principal obstacles to commercial incentives for Panamanian onion growers through competition in the marketplace. Although IMA argues that their imports prevent shortages of onions, there is a broad consensus that onions could be produced nearly year-round if an open market existed.

IMA's support price and quota policies also discourage farmers from adopting improved technologies. This was observed in the lowland production areas, where IMA guaranteed a purchase price of $396/t for yields of up to 12.25 t/ha. Since the growers could sell only a fixed amount of onions at a fixed price, they were uninterested in technologies that improved yields. It will be interesting to note the behavior of lowland producers in the future, since IMA canceled its contracts for onion production in 1985.

The misdirected polices of IMA reflect the general incoherence of agricultural policy in Panama. The progress of TGS individuals and institutions indicates an ability to buffer themselves from the mismanagement of the system through reliance on external funding, technical assistance, and adherence to internal goals.

4. Conclusions and Recommendations

a. Conclusions

i. Producers have led the TGS in technology adoption.

ii. International technology has been crucial, but technological constraints still face the TGS in postharvest storage and weed control.

iii. Market policies of IMA are the principal constraint to production expansion.

b. Recommendations

i. The TGS should develop stronger linkages with producer groups.

ii. Expand the TGS program with priority on evaluation of varieties for storability and identification of effective herbicides.

iii. Reduce gradually IMA's intervention in the market.

F. Tomato

1. Historical Analysis

a. Production and Consumption Trends

Tomato is by far the most important vegetable crop in Panama, surpassing onion and potato production in value and approaching the value of the maize crop. Production is oriented toward processing tomatoes for a market controlled exclusively by one company--the Panamanian Food Co.--owned by Nestle. That company has played a crucial role in the development and support of the tomato industry for over four decades. In no other commodity has the private sector played as direct a role in technology generation, or collaborated as closely with the public sector, as it has in tomato.

Tomato production volume has grown from 15 t when Nestle initiated its tomato operations in 1942, to 20,000 t in Los Santos province alone (Diaz, 1985) and 36,000 t nationwide for processing and fresh tomatoes (FAO, 1979, 1985; DEC, 1980). Processing tomatoes account for 80 to 90 percent of production volume (DEC, 1980; MIDA, cited in Anon., 1984). Production value in 1984 was $5 million in the principal region alone (De Leon, 1985; Diaz, 1985); nationwide the value of the commodity may exceed $10 million.

Panama's production volume is low--Mexico and Brazil are the big producers of the region. However, Panamanian yields surpass those of all but two countries in Central and South America, including Mexico, Brazil, Colombia, and Chile. Panamanian yields have more than doubled in the past two decades, rising from 12 t/ha in the 1960s to 26 t/ha in 1981 (IDIAP, 1983e). Thus, tomato is one of the few crops in which Panama leads the region in productivity.

Los Santos Province is the center of the growing region and produces 70 percent of the processing tomato harvest under irrigation during the dry season. In contrast, tomatoes for the domestic fresh market are produced in the cool, moist highlands of Chiriqui Province (Jimenez, 1981). Production area has increased from 800 to 1500 ha in the last 10 years (De Leon, 1985); IDIAP, 1983e). Currently there are 800 producers, each farming roughly two ha (De Leon, 1985).

The government intervenes in the marketing of tomatoes to the extent of restricting tomato product imports. Processing tomato production is carefully controlled by Nestle through contracts with producers that specify production quotas, planting and harvest dates, and price based on quality and date of delivery. Nestle does not finance production, although it does advance the producer seed, fertilizer, and other inputs. Possession of a contract enables a producer to obtain credit from the BDA, which finances two-thirds of the production. The BDA provided almost $1 million in loans to 500 producers in 1979 (Aparicio et al., 1981).

Estimated costs per kilogram for semi-mechanized production of processing tomato are roughly $0.10-$0.12. Labor, inputs, and transport account for the largest share of the costs (Aparicio et al., 1981). Prices paid for processing tomato vary from $0.11 to $0.17/kg, and are at least double the prices paid for processing tomatoes in California (Aparicio et al., 1981; De Leon, 1985; Diaz, 1985). With good yields and guaranteed contracts, producers are assured of a substantial profit.

Costs for semi-mechanized production of fresh market tomato are estimated at $0.22-$0.36/kg due to costly staking and packing operations (ISA/IICA, 1982; Jimenez, 1981). Producers receive prices ranging from $0.55-$0.90/kg, depending on size, quality, and date (Aparicio et al., 1981; DEC, 1984a). Despite lower productivity, profits can be considerably higher than for processing tomatoes, but there is significant risk associated with the lack of a guaranteed contract, limited technology, and lack of support services, such as those provided to processing tomato producers.

In summary, the productivity of the tomato industry has been good by national and regional standards. However, high production costs and consumer prices constitute a problem. Nevertheless, there are unexplored opportunities for expansion of fresh market tomato production for domestic consumption and for export.

b. Trends in Technology Generation and Application

When Nestle began purchasing tomatoes for processing in 1942, technology and experience in industrial tomato production did not exist. From 1942 until the mid-1960s, the TGS consisted of fragmented efforts by Nestle and the Ministry of Agriculture and Commerce (MACI). Ironically, the factor responsible for the strength of the TGS today almost caused the demise of processing tomato production in 1970. Bacterial wilt, caused by Pseudomonas solanacearum, caused crop losses of 60-80 percent and infects 80 percent of tomato production areas in Panama today (De Leon, 1985). It is recognized as the leading constraint to tomato production in the tropics worldwide (Villareal, 1980).

Although bacterial blight is endemic in the tropics, little had been done to develop resistant tomato varieties for Latin America. A Panamanian SICAP investigator began work on the development of a bacterial wilt-resistant variety upon his return from training abroad in 1966, and continues as leader of the IDIAP program to the present. Resistance was identified in materials obtained from North Carolina which had originated in Puerto Rico. The resistant variety 1-12 was released following five years of intensive work and saved the industry (De Leon, 1985; IDIAP, 1983e).

Persuaded by the success of public sector breeding efforts, Nestle began collaborating with the research program in 1973 and has been satisfied with its output since (Diaz, 1985). In 1975 the ministry's researchers moved to IDIAP, where the research program is based today. IDIAP's team currently consists of the senior scientist, two junior scientists, part-time assistance from disciplinary specialists, and a senior advisor. Nestle provides experimental fields, labor, laboratory services and eight technicians (De Leon, 1985; Diaz, 1985). FAUP has no research on tomato other than part of a plant pathology project (Neyra, 1983).

Research continues on maintenance of bacterial blight resistance, and varieties are rotated every four to six years due to mutations in the pathogen. IDIAP obtains potential sources of resistance from the Asian Vegetable Research and Development Center (AVRDC) in Taiwan, among other places. However, plants that are resistant in Taiwan are frequently susceptible in Panama, due to the difference in bacterial strains between Asia and Latin America (De Leon, 1985). Variety Tx1-12, an improved version of 1-12 with broader resistance to bacterial blight and higher yields, was released subsequently (IDIAP, 1983e). A third variety incorporates resistance to nematodes as well.

Although IDIAP's research priorities have been focused predominantly on processing tomato varieties, limited breeding efforts are now being carried out on fresh market tomatoes. However, considerable progress is necessary before varieties are developed that are suitable for the export market. Additional problems that require attention today are insects and water management. Improved management of irrigation could increase yields by 20 percent and cure physiological problems, such as blossom end rot (De Leon, 1985).

2. Impact of Tomato Technological Advances

Research efforts have had considerable impact on national tomato production. National yields rose from 12 t/ha in the 1960s to 22 t/ha by the end of the 1970s, due to the widespread adoption of variety 1-12. Production of the variety was valued at $3.5 million in 1980 (IDIAP, 1983e). New varieties have the potential to boost national yields once again. The variety Tx1-12 was planted on half of the national tomato area by 1982 and produced average yields of 36-40 t/ha (IDIAP, 1983e).

Considerable progress has also been made in agronomic practices. Producers are required to use high-quality seed produced by IDIAP and supplied by the company, which also provides technical assistance on cultural practices developed by the research program (Aparicio et al., 1981). Over a dozen different chemical applications are recommended because of high pest populations. Transplanting is practiced to permit better timing of the crop between rainy seasons and better control over plant populations (IDIAP, 1984a; Villareal, 1980). It would be advantageous to focus agronomic research on methods to reduce requirements for these costly inputs.

To date the research program has not worked on the development of improved cultural practices for fresh market tomatoes. Although many of the practices developed for processing tomatoes are already used for fresh market tomatoes, there are substantial differences in water management and labor inputs for staking and pest control practices because of the different climates in which the two crops are grown. Late blight caused by *Phytophthora infestans* is an additional constraint to highland production (Jimenez, 1981). Transportation from distant highland regions to urban centers is difficult and adds considerably to the cost of production. Trials should be conducted to determine the feasibility of fresh market tomato production in lowland regions that have a comparative advantage for tomato production, if expansion of the fresh tomato market is given priority.

The impact of bacterial wilt-resistant varieties on tomato production is summarized in Table 14. Major determinants of this event are presented in Table A.27. and identifed as I, M, X or D variables for entry in the intervention opportunities matrix (IOM), which appears in Table A.25.

3. Analysis of Key Variables

a. Research Resource Input Variables (I)

The tomato case provides an outstanding illustration of the importance of human resource quality and continuity to the

Table 14 -- Panama: Technological Events in Tomato

Event	Impact
Development of improved varieties resistant to bacterial wilt.	Two major new varietal releases since 1971, varieties rotated every 4-5 years. Adopted on 90% of production area. Responsible for over 100% increase in yield, from 12 to 26 t/ha, valued at $2.6 million or 54% of total production.

success and stability of the TGS. The role of the senior investigator was dramatized by the urgency of the bacterial wilt problem and its threat to the industry. The relevancy of his training undoubtedly contributed to his success in solving the problem. A weak link in the system will exist when he retires, unless his expertise is institutionalized through the training of new program leadership.

Human resources at the support staff level have been adequate, largely due to the collaboration of Nestle. The company provides eight technicians to complement IDIAP's two. Nestle technicians also perform an extension role in providing technical assistance to producers. Thus, the value of linking research and extension activities is once again demonstrated.

Nestle's contribution of human and capital resources has been an essential factor in program stability. Physical resources provided by Nestle consist of six hectares of experimental land plus basic laboratory services, such as soil analysis (De Leon, 1985). Though these resources have served well for field research, specialized laboratory facilities for bacterial wilt study would be highly desirable.

Dependence on the private sector for core funding of a research program has inherent risks. If Nestle were to experience financial reverses, research activities could be cut back or eliminated, as recently happened to the banana research program of United Brands (Stevens, 1985).

b. Management Variables (M)

The unique degree of collaboration between public and private research efforts has been a crucial factor in the success of the processing tomato industry in Panama. Complete integration of activities from research to support services to market development in a single system has been particularly effective where such linkages were not created by the public sector. The structure provided coordination for the management of human, financial, and physical resources toward a focussed goal.

Priority setting--a crucial management activity--was dictated by the bacterial wilt crisis in the tomato case. A narrow research focus was predetermined by the limits of the tomato production region and its clientele. The restricted focus increased the success of research and extension efforts in meeting the needs of the clientele.

While management of linkages within the TGS is effective, relationships with other national institutions in the ATMS are uneven in strength. Linkages with the BDA and the crop insurance agency, ISA, are indirect but functional. However, extension and seed production services developed through collaborative public/private research are not institutionalized within the public sector. If tomato production is to expand, the public sector must take the initiative to develop tomato seed production capability within ENASEM and extension expertise within IDIAP and SENEAGRO. To avoid duplication of effort, the public sector should concentrate on promoting fresh market tomato production.

Management of interactions with the international TGS is excellent. Linkages were established by the senior scientist during his postgraduate training at North Carolina State University and expanded to include AVRDC in Taiwan, the Universities of Delaware and Hawaii, and the Agricultural Research Center in Guadeloupe (De Leon, 1985; IDIAP, 1983e). Although AVRDC has probably had the largest input, the diversity of international connections has provided a balanced input to the program.

c. External Research Support Variables (X, Including D)

The tomato case clearly illustrates the importance of a favorable policy environment in stimulating market demand and, ultimately, agricultural technology generation and production. Government restrictions on imports provided the incentive for Nestle's investment in tomato processing. Favorable policies enabled Nestle to develop a strong national market despite high production costs.

Consistency and duration have also been key elements of the favorable policy environment. The prolonged duration of protection has enabled Nestle to make long-term commitments to research. Reassured of ultimately reaping the benefits of research, Nestle assumed the role of catalyst and facilitator of national research in tomato production.

The same model could also be used to promote the development of domestic soybean production. Protection from vegetable oil imports would provide the incentive for private investment in processing facilities, which in turn would generate demand for soybean in the marketplace. The time lag in gearing up production should not be as great as in processing tomato, since IDIAP has already developed the technology.

Input from the international TGS has also played a significant role in the development of the tomato industry, particularly in varietal improvement, intensive cultural practices and process engineering. In all cases, focused training--whether academic or in-service--was instrumental in transferring international expertise to nationals. As national expertise increases, the nature of inputs sought from the international TGS is also changing toward greater need for management skills appropriate to the increasing sophistication of the national ATMS.

Given the current market structure and high production costs, expansion of the domestic market for processed tomatoes is limited and the possibility of export is poor. The feasibility of phased reduction of market protection should be studied. Other alternatives must be explored to promote growth in the tomato market. Development of an export market for fresh fruit would permit a significant expansion of the tomato industry in Panama and greater stability. The successful collaboration between IDIAP and Nestle could be extended to this crop, drawing on IDIAP's research expertise and Nestle's experience in marketing, both nationally and internationally. Producers should also be encouraged to establish cooperatives to service their own production and marketing needs. Careful market studies are needed on the location, size and seasonality of markets, both domestic and international. A marketing information service will be critical to provide up-to-the minute information on prices in the major regional and world markets.

In conclusion, the lessons of the tomato case lie in the demonstrated success of government policies in promoting private sector investment in agriculture and in the powerful team that collaborative public/private research can form when harnessed to meet national needs. The public/private collaborative research model could be applied to other crops with high potential industrial value, such as soybean or maize.

4. Conclusions and Recommendations

a. Conclusions

i. Public/private research collaboration has been uniquely successful in the rapid achievement of high yields in processing tomato.

ii. The TGS successfully integrates TGS/TTS/TUS components for prompt adoption of research results.

iii. Processing tomato yields are high, but so are production costs; prices are uncompetitive on the world market. The domestic market exists only with government protection.

iv. Market protection created strong domestic market demand and stimulated processing tomato production. Competition to win production contracts with Nestle provided the incentive to increase productivity.

v. Growth in processing tomato production is unlikely due to high production costs and stiff competition in the international market.

b. Recommendations

i. Use the public/private collaborative research model to promote soybean and other industrial crops. Provide incentives for private investment in infrastructure and research.

ii. Select a narrow research focus on top priority problems. Target production regions and clientele. Integrate extension closely with research programs.

iii. Assign top priority to reduction of production costs. Reduce labor and input requirements. Study the feasibility of gradual reduction in domestic market protection.

iv. Create market demand for industrial crops by implementing phased restrictions on imports as necessary to create favorable incentives for private investment.

v. Promote fresh market tomato production in the lowlands. Expand the domestic market while technology is still under development. Establish linkages with export traders as production increases to build an international market.

G. Analyis of the Intervention Opportunities Matrix

Results of the analyses of this and previous chapters are summarized in the IOM for each survey observation (case study) in Tables A.20, A.22, and A.25. Twelve such observations were ultimately made--four relating to rice, four to maize, two to legumes, one to onions, and one to tomatoes. The independent variables of the model were assigned values of +1, -1, or zero (or left blank), respectively, when it was concluded that they had been on net contributing, inhibiting, or neutral in terms of their influences on the change in output attributable to the technological event under study. The change in output for each event was estimated as indicated in Tables 10 through 14; and the reasons for the scores assigned the independent variables are summarized in Tables A.19, A.21, A.24, A.26, and A.27. One member of the study team was chiefly responsible for scoring to preserve consistency between survey observations of the IOM.

More than 12 survey observations are needed to make reliable estimates of the separate effects of each variable on output. One means of accommodating this problem would be to represent each major determinant (or appropriate sub-set of variables) by a small number of "representative variables"--one, as a minimum. There was some appeal to this particular simplification in the case of Panama, since similar scores did emerge for variables within each of the four categories of major determinants. For example, non-zero scores for the variables in D were all positive for the introduction of improved varieties of rice and all negative for the introduction of hybrid maize varieties, implying that a single variable might adequately represent the full set of variables in D. However, closer inspection of the IOM revealed that, among the 220 non-zero scores assigned the independent variables in the 12 survey observations, 36--or well over 15 percent--did not correspond to the sign that dominated in the relevant major determinant. In an attempt to preserve these latter observations, the scores of the independent variables were ultimately aggregated by major determinant for each observation and regression analyses were performed of the dependent variable on the four major determinants, or on particular aggregations of those determinants. The data, summarized in this form, are presented here in Table 15; and a representative set of regressions estimated from them is presented in Table 16.

The first two regressions demonstrate the existence of a significant relation between sums of the major determinants and the estimated change in production resulting from the improved technology. However, both suggested that values of the dependent variables had been substantially overestimated for the last four survey observations of Table 16. Because this could be attributed to the fact that, in those cases, estimates of the effects on output of the changed technology probably included significant changes in cost-increasing agronomic practices, a dummy variable (D*) was introduced with values of 1.0 for those latter four observations and zero otherwise. Regressions #3 and #4 demonstrate that the resulting improvement was very substantial, as measured by the R-squared statistic. Additional regressions, estimated on other combinations of the major determinants, did not improve significantly on Regression #4.

These results give rise to the following major conclusions:

1. The model's determinants do influence the production impacts of technological change, and appear to represent a reasonably comprehensive set of variables describing the production performance of the ATM System.

2. Different coefficients could not be reliably identified for each major determinant. As a result, the mean scores of individual determinants provide a ranking of system constraints.

3. It is seen from Table 16 that D received a negative mean score and was, in this sense, most severely inhibiting to technological change. Further inspection of the IOM indicates that this negative mean score was much less associated with biophysical than with socioeconomic constraints, and that a majority of the latter constraints related to the case of maize. Markets/market management and prices/price interventions should clearly receive priority attention by authorities concerned with IMA's programs in rice, maize, cowpea, and onions. The

Table 15 -- Panama: Summary of scores assigned the percentage change in output and the four major determinants by survey observation

Survey Observation/Case Study	Percent Change in Output	Major Determinant			
		I	M	X-D	D
1. Introduction of improved rice varieties	17	2	6	7	4
2. Development of rice seed industry	10	3	2	5	0
3. Development of blast tolerant rice variables	12	0	4	4	2
4. Development of lower cost rice production practices	4	-2	1	0	2
5. Introduction of hybrid maize	2	1	4	3	-5
6. Development of improved open pollinated maize	6	4	-3	3	-6
7. Development of national maize seed industry	2	3	2	3	-5
8. Development of lower cost maize practices	9	0	4	0	-3
9. Development of improved bean varieties	52	2	6	4	0
10. Development of cowpea for mechanical harvest	33	2	2	2	-3
11. Introduction of onion varieties	36	4	4	4	0
12. Development of wilt resistant tomatoes	54	5	7	7	3
Mean Values	19.2	2.0	3.3	3.5	-0.9

Table 16 -- Panama: Regression results from the IOM data

Statistic or Independent Variable	Regression			
	1	2	3	4
Adjusted R-squared	0.375	0.443	0.933	0.925
Intercept	6.781 (6.41)	-1.252 (8.09)	3.289 (2.14)	3.500 (3.05)
I + M + X	1.656 (0.60)		0.793 (0.22)	
I + M		3.901 (1.61)		0.722 (0.72)
X		0.201 (1.13)		0.829 (0.42)
D*			30.747 (3.35)	30.947 (4.05)

constraints associated with existing cultural practices in rice, maize, beans, and cowpea indicate a need to increase attention to the differing area, crop, and farmer group requirements of new technology. And particular attention should be accorded the problems of weak producer participation in programs relating to maize.

4. Selected problems dealing with research resource inputs, research management, and external research support mechanisms were observed, though the results do not point to the same high priority, pervasive needs in these areas as was found for the farm production environment. If the (largely agronomic) work associated with developing lower cost production packages for maize and rice is to succeed, the availability of a range of research resource inputs--notably, fixed and operating capital--must be expanded. Human capital inputs have, fortunately, not represented major constraints to programs in production terms--in fact, high-level manpower received numerous positive scores in the IOM. However, program expansion, or shifts towards more basic research, would surely result in new manpower needs, especially at the highest levels of research leadership. Research management, similarly, has not posed severe limitations in production terms, except in the case of the introduction of improved maize varieties, though selective needs are signalled--on the side of internal management, in the case of rice (for evaluation and problem identification/priority setting activities) and, with respect to the management of research linkages, in the case of cowpea (for linkages with national policies and technology transfer programs).

5. National macroeconomic policies supported the introduction of new rice varieties and the tomato industry, but otherwise were an inhibiting or neutral force for technological change. A most significant fact about the operations of other external research support mechanisms is that the inputs received by Panama's ATMS from the international community have been positive and pervasive in their influences on technological change.

6. Finally, it should be noted that the average value of the dependent variable in Table 15 is slightly less than 10 percent (when the last four observations are reduced by 31 percentage points, corresponding to the value estimated for the coefficient of D* in Regression #4 of Table 16). By most any standard, this represents a small percentage change in production attributable to technological change, but one which is consistent with Panama's negligible rates of productivity change through time, IDIAP's relative youth, and the absence (until recently) of organized public sector technology transfer programs.

Two concluding remarks are in order. First, this study has employed an indicative, diagnostic methodology whose purpose is to highlight problem areas and system constraints. Action recommendations for the alleviation of these constraints will need to be carefully assessed in cost-benefit terms. Second, the statistical reliability of the results reported here could be strengthened by increasing the number of survey observations on Panama, The authors assign highest priority to additional work on Panama's livestock sector.

REFERENCES

Acosta, M. 1985. Coordinator, Legume Program in Caisan. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama. Personal communication.

Acosta, M. A., G. A. Silvera and J. C. Ruiz. 1983. Guia para el Productor de Poroto. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

Adames, A. J., D. Navas, et al. 1984. Informe de la Universidad de Panama: Seminario sobre ciencia y tecnologia en las universidades del istmo Centro-Americano. University of Panama, Panama City, Panama.

Alvarado, A. 1982. Guia para el Productor de Maiz. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

Alvarado, A. 1985. National Coordinator, Maize Program. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama. Personal communication.

Anon. 1967. Marketing of agricultural crops in the Republic of Panama. Report in two volumes prepared for the General Directorate of Planning and Administration of the Government of the Republic of Panama by Sanderson and Porter, Inc., New York.

Anon. 1984. Price policies and international trade in Panama's agricultural sector: 1970-83. Department of Agricultural and Applied Economics, University of Minnesota, St. Paul, Minnesota.

Aparacio, D., J. A. Castrejon and B. Rios. 1981. Produccion, commercializacion y financiamiento del tomate industrial en la Republica de Panama, 1976-1980. School of Economics, Faculty of Public and Business Administration, University of Panama, Panama City, Panama. Thesis.

Arauz, J. R. 1985. Western Regional Coordinator for Maize Research, Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama. Personal communication.

Atencion, P. and A. E. Calderon. 1980. Analisis y evaluacion de las principales investigaciones realizados en la Facultad de Agronomia, 1968-75. Faculty of Agronomy, University of Panama City, Panama. Thesis.

Barraclough, S. 1973. Agrarian Structure in Latin America. Lexington Books, New York.

Barrios, J. 1984. El sistema de cuotas en Panama: Descripcion, evaluacion y efectividad. Ministerio de Planificacion y Politica Economica, Panama City, Panama.

BDA. 1985. Prestamos concedidos por los bancos publicos y privados, por rama de actividad economica, 1979-82. Based on statistics from the National Banking Commission. Banco de Desarrollo Agropecuario de Panama, Panama City, Panama.

Bejarano, W. 1985. Regional Representative in Panama, Centro Agronomico de Investigacion y Ensenanza, Costa Rica. Personal Communication.

BID. 1982. Informe sobre el sector agropecuario de Panama. Banco Inter-Americano de Desarrollo, Washington, D.C.

CGR. 1985. Estadisticas preliminares sobre el sistema bancario Contraloria General de la Republica, Panama City, Panama. Mimeo.

CIAT. 1983. CIAT Report 1983. Centro Internacional de Agricultura Tropical, Cali, Colombia.

CIMMYT. 1984. CIMMYT Research Highlights 1983. Centro Internacional de Mejoramiento de Maiz y Trigo, Londres, Mexico.

CNL. 1975. Ley 51 (del 28 de agosto de 1975), por la cual se crea el Instituto de Investigacion Agropecuaria de Panama. Consejo Nacional de Legislacion, Panama City, Panama.

Conklin, F. 1986. Panama: Agricultural Sector Assessment. U.S. Agency for International Development, Panama City, Panama. Draft.

Cuellar, M. 1985. El sector comercial privado en el sistema de gestion de tecnologia agropecuaria de Panama (internal document). Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

DEC. 1980. Panama en Cifras, 1974-78. Direccion de Estadistica y Censo, Contraloria General de la Republica, Panama City, Panama.

DEC. 1984. Panama en Cifras, 1978-82. Direccion de Estadistica y Censo, Contraloria General de la Republica, Panama City, Panama.

DEC. 1984. Hoja de Balance de Alimentos: Anos 1979-82. Direccion de Estadisticay Censo, Panama City, Panama.

DEC. 1985. Superficie Sembrada y Cosecha de Arroz, Maiz y Frijol de Bejuco: Ano Agricola 1983/84. Seccion 312, Produccion Agropecuaria. Direccion de Estadistica y Censo, Panama City, Panama.

De Gracia, R. 1984. Situacion del cultivo del frijol en Panama. In: Compendio General para el Curso: Investigacion y Produccion de Frijol Poroto. Instituto de Investigacion

Agropecuaria de Panama, Panama City, Panama.

De Janvry, A., and C. Garramon. 1977. The dynamics of rural poverty in Latin America. J. Peasant Studies 4:206-16.

De Leon, G. 1985. National Coordinator, Tomato Program. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama. Personal communication.

De Leon, G., E. De Leon and A. Velasquez. 1982. Guia para productores de cebolla. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

Diaz, J. 1985. Manager, Agricultural Service. Nestle, Los Santos, Panama. Personal communication.

Elliott, H., R. Hertford, J. Lyman-Snow, and E. Trigo. 1985. Identifying opportunities to improve agricultural technology management systems in Latin America: A methodology and test case. Rutgers University, New Brunswick, New Jersey; and International Service for National Agricultural Research, The Hague, Netherlands.

FAO, 1979. 1978 FAO Production Yearbook, Vol. 32. Food and Agriculture Organization, Rome.

FAO, 1985. 1984 FAO Production Yearbook, Vol. 38. Food and Agriculture Organization, Rome.

FAUP, 1982. Investigaciones agropecuarias: Informe sobre los progresos de las investigaciones agropecuarias realizadas por la Facultad de Agronomia de la Universidad de Panama, 1977-78. Faculty of Agronomy, University of Panama, Panama City, Panama.

FAUP, 1983. Lineas y proyectos de investigacion (1983-84). Faculty of Agronomy, University of Panama, Panama City, Panama. Mimeo.

FAUP, 1984a. Informe sobre las labores de la administracion de la Facultad de Agronomia, Periodo 1981-84. Faculty of Agronomy, University of Panama, Panama City, Panama.

FAUP, 1984b. Investigaciones agropecuarias, 1981-83. Faculty of Agronomy, University of Panama, Panama City, Panama. Mimeo.

FAUP, 1984c. Lineas y projectos de investigacion (1984-85). Faculty of Agronomy, University of Panama, Panama City, Panama. Mimeo.

Gabinete, 1969. Decreto No. 60 (del 7 de marzo de 1969), por la cual se crea el Organismo Especial Denominado Oficinas de Regulacion de Precios. Gaceta Oficial, Panama City, Panama.

Gaskell, M. 1985. Visiting Researcher, Onion Program.

USAID/IDIAP/Rutgers University Project, Boquete, Panama. Personal communication.

Gavidia, R. M. and R. A. Samaniego, 1980. Investigaciones realizadas en el cultivo de maiz en Panama, 1952-79. Faculty of Agronomy, University of Panama, Panama City, Panama. Thesis.

Gordon, P. 1985. General Manager, Melo and Co., Panama City, Panama. Personal communication.

Green, D., C. Pray, and G. E. Schuh. 1983. Liberalization and the agricultural sector in Panama. University of Minnesota, St. Paul, Minnesota.

Guzman, R. 1985. Director of Marketing and Varietal Introduction, Empresa Nacional de Semillas, Panama City, Panama.

Harberger, A. C. 1984. Panama's fiscal and international debt crises: One problem or two? University of Chicago and University of California, Los Angeles.

Hayami, Y. and V. Ruttan. 1971. Agricultural Development: An International Perspective. Johns Hopkins Univ. Press, Baltimore.

IBRD. 1983. World Tables, third edition. Johns Hopkins University Press, Baltimore.

IDIAP. 1979. Plan para la generacion y transferencia de tecnologia. Instituto de Investigacion Agropecuaria, Panama City, Panama.

IDIAP. 1982. Evaluacion Fisica del Plan Operativo Anual (POA 1982). Direccion de Planificacion, Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1983a. Impacto de las politicas sectoriales en el cambio tecnologico en el sector agropecuario: Caso arroz, Republica de Panama. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1983b. Investigaciones en arroz: Un resumen de los avances y logros mas importantes obtenidos por el IDIAP. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1983c. Investigaciones en maiz: Un resumen de los avances y logros mas importantes obtenidos por el IDIAP. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1983d. Investigaciones en poroto y soya: Un resumen de los avances y logros mas importantes obtenidos por el IDIAP. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1983e. Investigaciones en tomate industrial: Un resumen de los avances y logros mas importantes obtenidos por el IDIAP. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1983f. Evaluacion de la investigacion pecuaria. Direccion de Investigacion Pecuaria, Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1984a. Guia para el productor de tomate industrial. Instituto de Investigacion agropecuaria de Panama, Panama City, Panama.

IDIAP. 1984b. Compendio General para el Curso: Investigacion y Produccion de Frijol Poroto. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1984c. Seccion financiera del Plan Operativo Anual para 1984. In: Plan Operativo Anual 1984. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1984d. Logros, difusion e impacto socio-economico de algunas tecnologias generadas por el IDIAP en el desarrollo de la produccion agricola. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1985a. Organigrama del IDIAP, 1985. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1985b. Flujograma del proceso de formulacion del Plan Operativo Anual 1985 (POA 1985). Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1985c. Personal tecnico del IDIAP, 1985. Departamento de Personal. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1985d. Financieros asignados al IDIAP, anos 1980-84. Direccion de Planificacion, Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP. 1985e. Resumen de los acuerdos oficiales del IDIAP con otras organizaciones. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

IDIAP/CATIE. 1984. Seleccion y priorizacion de areas geograficas para la investigacion agricola aplicada en Panama. Instituto de Investigacion Agropecuaria de Panama and Centro Agronomico Tropical de Investigacion y Ensenanza, Costa Rica.

IDIAP/CIMMYT. 1983. Desarrollando Tecnologia Apropiada para el

Agricultor: Informe de Progreso del Programa de Caisan en Panama. Instituto de Investigacion Agropecuaria de Panama/ Centro Internacional de Mejoramiento de Maiz y Trigo, Mexico.

IDIAP/FAUP. 1981. Memoria de la reunion tecnica de consulta con el sector agropecuario para definir prioridades en la investigacion agropecuaria. Instituto de Investigacion Agropecuaria de Panama and Faculty of Agronomy, University of Panama, Panama City, Panama.

IITA. 1984. Research Highlights for 1983. International Institute for Tropical Agriculture, Ibadan, Nigeria.

IMA. 1983. Memoria, 1983. Instituto de Mercadeo Agropecuario, Panama City, Panama.

ISA. 1984a. Programa de Aseguramiento Agricola 1984-1985: Cultivos de Invierno. Instituto de Seguro Agropecuario, Panama City, Panama.

ISA. 1984b. Programa de Aseguramiento Agricola 1984-1985: Cultivos de Verano. Instituto de Seguro Agropecuario, Panama City, Panama.

ISA/IICA. 1982. Zonificacion Agricola de la Provincia de Chiriqui. Instituto de Seguro Agropecuario and Instituto Interamericano de Cooperacion para la Agricultura, Panama City, Panama.

ISNAR. 1985. Agricultural Research Policy and Organization in Small Countries. International Service for National Agricultural Research, The Hague, Netherlands.

ISNAR/IFARD. 1984. Survey of national agricultural research systems. International Service for National Agricultural Research and International Federation of Agricultural Research Systems for Development, The Hague, Netherlands.

Jimenez D. C., V. 1981. Costo de produccion del tomate de mesa en Boquete, a nivel de productor. Faculty of Agronomy, University of Panama, Panama City, Panama. Thesis.

Lasso, R. 1985. National Coordinator, Rice Program. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama. Personal communication.

MIDA. 1984. Manual de Organizacion. Ministerio de Desarrollo Agropecuario, Santiago, Panama.

MIPPE. 1983. Ciencia y tecnologia en el presupuesto de inversiones del sector publico, 1983. In: Presupuesto de Inversiones, 1983. Ministerio de Planificacion y Politica Economica, Panama City, Panama.

MIPPE. 1985. Gasto publico en ciencia y tecnologia: Anos 1981-1984 (Cifras preliminares). Ministerio de Planificacion y Politica Economica, Panama City, Panama.

Neyra, C. 1983. Organizacion y Planeamiento de la Investigacion en la Facultad de Agronomia, Universidad de Panama: Un Resumen. USAID/FAUP/University of Delaware project, "Education for Rural Development." Panama City, Panama.

OIT. 1976. Desarrollo technologico y empleo productivo en la agricultura de Panama: Los casos de arroz y de la cana de azucar. Organizacion Internacional de Trabajo, Geneva, Switzerland.

Pachico, D. 1985. Agricultural Economist, Bean Program. Centro Internacional de Agricultura Tropical, Cali, Colombia. Personal communication.

Pinstrup-Anderson, P. 1982. Agricultural Research and Technology in Economic Development. Longman Group Ltd., United Kingdom.

Plucknett, D. L., and N. J. H. Smith. 1982. Agricultural research and third world food production. Science 217:215-219.

Pou, P. 1984. Empleo, inversion y crecimiento economico en Panama durante la decada del setenta. Ministerio de Planificacion y Politica Economica, Panama City, Panama.

Pray, 1984. Agricultural research in Panama: The role of IDIAP and ENASEM. University of Minnesota, St. Paul, Minnesota. Working paper.

Rodriguez, M. 1985. Director of Research, Faculty of Agronomy, University of Panama, Panama City, Panama. Personal communication.

Rodriguez, M. and R. Aleman. 1982. "Romefa:" Nueva variedad de frijol de costa (Vigna unguiculata) para Panama. In: Investigaciones Agropecuarias 1977-1980. Faculty of Agronomy, University of Panama, Panama City, Panama.

Rodriguez, M. and F. Ducreux. 1982. Combate quimico de malezas en frijol de costa (Vigna sinensis). In: Investigaciones Agropecuarias 1977-1980. Faculty of Agronomy, University of Panama, Panama.

Ruttan, V. W. et al., eds. 1977. Resource Allocation and Productivity in National and International Agricultural Research. Univ. of Minnesota Press, Minneapolis.

Sands, M., M. Gaskell, W. Bejarano, and L. Hertentains. 1985. Management experiences from three FSR/E projects in western Panama. Paper presented at the Farming Systems Research

Symposium, 1985. Kansas State University, Manhattan.

Schultz, T. W. 1964. Transforming Traditional Agriculture. Yale Univ. Press, New Haven.

Schultz, T. W. 1978. On economics and politics of agriculture. In: Schultz, T. W., ed., Distortions of Agricultural Incentives. Indiana Univ. Press, Bloomington.

Shaner, W. W., P. F. Philipp, and W. R. Schmehl, eds. 1982. Readings in Farming Systems Research and Development. Westview Press, Boulder, Colorado.

Silvera, G. 1985. Sub-Director General and Bean Breeder. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama. Personal communication.

Silvera, G., C. Baruco and A. Gonzalez. 1979. Guia para la produccion de soya. Publicacion Tecnica No. 8. Instituto de Investigacion Agropecuaria de Panama, Panama City, Panama.

Spinanger, D. 1984. The labor market in Panama: An analysis of the employment impact of the labor code. Kiel Institute of World Economics, Kiel, West Germany.

Stevens, C. 1985. Manager, Technical Services. United Brands, Panama City, Panama. Personal communication.

Tal, E. 1982. National science and technology issues: The case of Panama. Ministerio de Planificacion y Politica Economica, Panama City, Panama.

Traywick, J. 1985. Project Coordinator, Agricultural Technology Transfer Project. Ministerio de Desarrollo Agropecuario/Chemonics, Inc. David, Panama. Personal communication.

USAID. 1984. Agricultural technology transfer. United States Agency for International Development, Panama City, Panama. Project paper.

Valencia, A. 1981. Evaluacion de la politica de precios de sosten de algunos granos basicos. Faculty of Public and Business Administration, University of Panama, Panama City, Panama. Thesis.

Villareal, R. 1980. Tomatoes in the Tropics. IADS Development Oriented Literature Series. Westview Press, Boulder, Colorado.

Watts, V. 1985. President, Association of Rice Producers of Chiriqui. David, Panama. Personal communication.

APPENDIX TABLES AND DIAGRAMS

LIST OF APPENDIX TABLES AND DIAGRAMS

Diagram

Table A.1 -- Panama: ATMS Responsibility Chart

INSTITUTION	SUBSECTOR	PURPOSE OF ORGANIZATION OR GROUP	MAJOR DETERMINANTS INFLUENCED
MIDA	policy env	policy and coordination of public intervention	X,D,E,SE,F,I,M
MIPPE	policy env	formulation of budget and economic policy for Panama	X,D,E,SE,F,I
Legislature	policy env	national policy-making	X,D,E,SE,F,I
CRP	policy env	regulation of prices at consumer level	X,D,E,F
CAN	policy env	advise on national coordination of public interven	X,D,E,SE,F,I,M
CAR	policy env	coordination public agencies at regional level	X,D,E,SE,F,I,M
CAL	policy env	coordinate public activities, feedback from farmer	X,D,E,SE,F,I,M
CropCommissions	policy env	advise MIDA on prices and policies, selected crops	X,D,E,SE,F,I,M
BID	donor	support to ag credit, EMASEM	X,D,R,I
USAID	donor	support planning, generation, transfer, studies	X,I,M
CIID	donor	support national research: agric, information	X,I,M
IICA	donor	support ag devel in LA thru technical assistance	X,I,M
World Bank	donor	development lending, structural adjustment, plan	X,D,R
IMF	donor	loans to meet temporary balance of payments needs	X,D,R
IDIAP	generating	generate, transfer technology for small/med farmers	I,M
FAUP	generating	training agriculturalists, research extension	I,M
CIMMYT	generating	improved maize systems (open-pollinated varieties)	I
CIAT	generating	generate germplasm, training, methodology	I
CATIE	generating	regional technology generation, techn assistance	I
CIP	generating	germplasm, component research, part of Precodepa	I
Rutgers	generating	Technology generation, research management, train	I
ISNAR	generating	Research on organization and management of research	I
Chemonics	transfer	Technical assistance to SEMEAGRO, develop model	I
SEMEAGRO	transfer	Extension on national scale, develop approach	X,D,SE,F
BDA	services	credit to low income, small and medium farmers	X,D,R,E,SE
BNP	services	credit to cattlemen and large farmers, commerce	X,D,R,E,SE
Private Banks	services	credit and banking services, limited to large farm	X,D,R
EMASEM	services	seed production and distribution	X,D,E
Seed Companies	services	production selected seed for sale to EMASEM, farms	X,D,E
Input Suppliers	services	import, export, distribution of agricultural input	X,D,E
ANDIA	services	represent input suppliers as a class	X,D,E
COAGRO	services	fertilizer production, input supply, poultry	X,D,E
IMA	services	price supports, storage, market intervention, quota	X,D,E
ISA	services	agricultural insurance usually related to BDA	X,D,E,F
ENDEMA	services	mechanization service small farmers, Asentamientos	X,D,R,E
IPACOOP	services	public agency to assist cooperative movement	X,D,E
Pioneer Seed	services	sale of hybrid maize seed to local distributor	X,D,E,SE,F
Citricos	using	production (fruit juice) as state corporation	X,D,E
Nestle	using	production industrial tomato, milk products	E,SE
United Brands	using	production of bananas for export	X,D,E,SE
CorpBayano	using	protect ecology of Canal Basin, security, forestry	E,SE
SCNA	using	integrated rural development	SE
ANAGAN	using	represent cattlemen, lobby for legislation	SE
CONAC	using	represent colonization schemes, communal farming	SE
Arroceros	using	represent commercial rice producers as class	SE
Low Income Farm	using	subsistence farming	SE
Small Farmers	using	production for home consumption and market	SE
Large Farmers	using	production for market, integrated production	SE
Asentamientos	using	colonization, land reform, communal production	SE
Molineros	post harvest	storage, milling, rice, resale of seed	E,SE

Table A.2 -- Panama: Chronology of ATMS Institutional Events

YEAR	DESCRIPTION OF EVENTS
1945	IFA organized first Sociedades Agricolas in Chiriqui
1948	Servicio de Desarollo Agricola (SDA) created with Arkansas support
1952	Creation of SDA in MACI, formerly in INA
1953	Creation of Instituto de Fomento Economico (IFE)
1954-63	Begin work of SICAP (Servicio Interamericano de Cooperacion Agricola)
1959	Creation of Faculty of Agronomy (FAUP) Law , of 1959
1960	Central Agricola organized "Centrales"/supply inputs and credit
1960	Central Agricola organized Sociedades de Siembra for seed production and commercial production
1962	Law 37 (The Agrarian Code) established agricultural policy, social goals
1964	Seed program transferred to Ministry of Agriculture, increased installations
1968	Foundation of first asentamiento collective farm
1969	Research at INA-Divisa given national coverage, team strengthened
1969-73	FAO-MINAG agreement for research
1970	Creation of the Confederation of Asentamientos Campesinos (CONAC)
1970	Creation of Ministry of Agriculture and Livestock (MAG)
1972	Government disbanded extension service
1973	Reorganization of sector: creation of MIDA, INA
1973	Announce transfer of Faculty of Agronomy to David
1974	Creation of parastatal Corporacion Bayano in Canal basin
1975	Creation of IDIAP
1975	Sign agreement between IDIAP and IICA
1976	Planning IDIAP strategy, focus on research-extension link, regional program
1977	IDIAP signs agreement with IDRC for research on dual purpose cattle
1977	IDIAP signs agreement with CATIE for research on dual purpose cattle

Table A.2 -- (continuation)

1979	AID loan of $6 million and grant of $1 million to IDIAP
1979	BID, ROCAP support CATIE project
1979	IDIAP decides medium term plan, confirms concentration strategy
1980	Creation of IPACOOP (Instituto Panameno de Cooperativas)
1981	MIPPE creates division of Science and Technology
1981	IDIAP-FAUP priority setting exercise for research
1982	IDIAP decentralizes formal structure: 3 regional + 4 technical directorates
1982	FAUP creates extension program
1982	Technology transfer function formally placed in MIDA by Agricultural Incentives Law
1982	IDIAP converts Technology Transfer division to "Technical Information and Training"
1983	Transfer of FAUP to David in Chiriqui
1984	Creation of SENEAGRO (Servicio Nacional de Extension Agricola)
1984	Rutgers University and IDIAP/AID sign agreement
1984	USAID Agricultural Technology Transfer Project, SENEAGRO
1984	First SENEAGRO agents working closely with beans and maize researchers
1985	IDIAP creates Plant Protection Directorate and Socio-Economic Studies Directorate
1985-86	IDIAP building facilities at Tocumen near FAUP

Table A.3 -- Panama: Chronology of Major Technological Events, Rice

YEAR	NATURE	DESCRIPTION OF EVENT	KEY DETERMINANT Contributing (+) Inhibiting (-)
1932	mech	First mechanized and irrigated production of rice in Alanje	R+, B+
1942	mech	First attempts to introduce mechanization by IFA and INA	R+
1945	inst	IFA organized first Sociedades Agricolas in Chiriqui	SE+
1947	econ	Creation of the support price mechanism for rice	E+
1947	econ	Price regulation introduced to provide "fair prices to producers"	E+
1948	chem	Introduction of DDT (chlorinated insecticides)	B+
1949-53	econ	Seed imported from USA covers national needs	X+
1952	econ, inst	Formation of first Rice Growers Association to get price support	SE+
1952	chem	Introduction of 24D herbicides by Point 4, U. Arkansas, Central Agricola	B+
1953	econ	Beginning of domestic seed production by IFE and sale at premium over commercial rice	X+
1954-63	inst	Beginning of work of SICAP (Servicio Interamericano de Cooperacion Agricola)	I+, X+
1954-63	agron	SICAP fertilizer trials with farmers, demonstrations, recommendations still used	I+, X+, R+
1955	econ	Country is self-sufficient in rice for first time	X+
1955	chem	Initial use of chemical fertilizer by rice growers	B+
1955	econ	Collaboration of public and private entities in credit for fertilizer	X+
1955	biol	Generalized use of American varieties	X+, R+
1955	biol	Ing. Juan Ferrer study of principal rice diseases	B+
1957	chem	Introduction of phosphorous insecticides (Folidol)	B+
1957-64	biol	Ing. Diego Navas identifies principal rice pests	B+
1958	agron	Soil mapping of plains of Cocle permit agrological studies	B+
1960	inst	Central Agricola organized "Centrales"/ supply inputs and credit	X+

Table A.3 -- (continuation)

1960	inst, econ	Central Agricola organized Sociedades de Siembra for seed production	X+, SE+
1960+	biol	Pyricularia (blast) attack leads to effort on rice breeding	M+, B-
1963	biol	Introduction of varieties tolerant to blast	I+, B+
1963	chem	Introduction of herbicide (Propanil)	B+
1963	agron	Wide use of certified seed	R+
1964	inst	Seed Program transferred to Ministry of Agriculture, installations increased	X+
1965	biol	Massive change from American to Surinam varieties resistant to blast	R+, B+
1965	biol	FAUP begins first breeding work	I+, M+
1967	biol	Introduction of first dwarf variety IR-8	I+
1968	biol	Beginning of rice breeding program at INA-Divisa	I+, M+
1968	chem	Introduction of first fungicides by Japanese expert at INA	B+
1969	inst	Research at INA-Divisa given national coverage, team strengthened	X+, I+, M+
1970	chem	Introduction carbamate insecticides, less dangerous but incompatible with Propanil	B+
1970	chem	Introduction of systemic insecticides	B+
1970	econ	Role of <u>asentamientos campesinos</u> in rice production rises to 15%	E+, SE+
1972	biol	Widespread change from tall to dwarf varieties (CICA 4)	R+
1973	econ	Panama self-sufficient in rice seed	X+
1975	inst	Creation of IDIAP, transfer of leading rice breeders to IDIAP	I+
1975	agron	IDIAP begins production of basic and registered seed	X+
1977	biol	First blast tolerant varieties developed nationally (Damaris, Anayansi)	B+
1980	chem	Introduction of pyrethroid insecticides (compatible with Propanil)	B+
1980	agron	IDIAP introduces on-farm methodology	M+
1982	biol	CIAT/IDIAP collaboration initiated on upland rice	I+, M+
1985	agron	CATIE/IDIAP collaboration on low input systems	I+, M+
1985	econ	MIDA/IMA lowers support price for rice	E-

Table A.4 -- Panama: Farm Size Distribution Data, 1980.

Size Class	Farmland	Farms
--Hectares--	---------------Percent---------------	
0.0 - 0.5	0.2	33.3
0.5 - 2.9	2.1	25.8
3.0 - 9.9	5.7	16.2
10.0 - 49.9	25.9	18.1
50.0 - 199.9	32.0	5.6
200 or more	34.1	1.0
	100.0	100.0

Source: Conklin, 1986.

Table A.5 -- Panama and the U.S.: Prices of Pure Nitrogen Fertilizer, 1970-83.

Year	Country	
	United States	Panama
	----------U.S. dollars----------	
1970	0.097	-
1971	0.099	-
1972	0.096	-
1973	0.099	0.228
1974	0.187	0.319
1975	0.248	0.356
1976	0.167	0.486
1977	0.156	0.318
1978	0.136	0.340
1979	0.118	0.333
1980	0.143	0.394
1981	0.135	-
1982	0.135	0.363
1983	0.116	0.305

Source: Anon., 1984, Table 17.

Table A.6 -- Panama and Other Countries: Yields of Basic Commodities, 1980.

Commodity	Panama	Costa Rica	Colombia	Average South America
	Country			
	Kilos			
All Cereals	1,401	2,266	2,392	1,714
Rice	1,728	3,000	4,324	1,916
Maize	955	1,492	1,323	1,857
Potatoes	8,000	10,024	12,160	9,940
Cassava	8,333	6,696	10,386	11,663
Dry Beans	310	523	728	465
Sesame	500	533	563	588
Tomatoes	20,000	34,925	17,000	23,018
Onions	14,478	8,406	23,125	13,570
Carrots	9,231	-	26,000	16,999
Melons	8,333	-	11,000	13,095
Sugar Cane	49,868	51,686	90,000	59,704
Coffee	250	1,331	668	493
Cocoa Beans	250	328	510	500
Tobacco	1,606	852	1,640	1,312
Milk (per cow)	1,001	1,077	985	992
Beef/Veal	39	49	18	15

Source: FAO, 1985.

Table A.7 -- Panama/U.S.: Relative Farm Prices of Selected Commodities, Three Periods.

Commodity	Period 1970-73	Period 1975-78	Period 1980-83
	Panama Price/U.S. Price		
Maize	1.54	1.95	2.40
Sorghum	3.24	2.75	2.41
Rice	0.71	1.05	1.33
Potatoes	2.24	2.76	3.54
Tomatoes	5.89	5.53	9.04
Tobacco	0.61	0.60	0.78
Beef	0.53	0.61	0.64
Milk	1.39	1.22	1.14

Source: Anon., 1984, Table 16.

Table A.8 -- Panama: Implications of Key Macro Policies for the Agricultural Sector

POLICY	INTENTION OF POLICY	IMPLICATIONS OF POLICY FOR AGRICULTURE
Use of U.S. dollars as currency	stability of exchange rate, facilitates international service economy, self-generated inflation impossible	1. overvaluation of dollar hurts export and import substitution; 2. facilitates importation American chemicals, equipment; 3. exchange rate offers no protection from American producers; 4. compensating measures required for agriculture; 5. research essential to attain U.S. levels of productivity.
Reduction in budget deficit	containment of government expenditures on bureaucracy	1. compression of government budgets for public agricultural sector; 2. makes recruitment of new research staff difficult; 3. budget cuts may tend to fall on operating budgets rather than personnel.
Liquidation of state-owned enterprises	1. reduce budget deficit; 2. liberate investment funds for other purposes	1. closing of sugar mills; 2. review of Citricos de Chiriqui; 3. refrain from creating new public enterprises.
Revise labor legislation	1. social policies of 1970 gave Panama high labor costs; 2. less favorable interpretation of labor code; 3. facilitate the structural adjustment process.	1. power of unions in agricultural industries may be reduced; 2. restrictive practices in food industries may be lightened (e.g. milk, tomato, bananas); 3. more flexible hiring and firing practices may generate more employment.
Reinterpret Agricultural Incentives Law	1. progressive dismantling of protection by quotas; 2. self-sufficiency must be at world prices	1. privileged situation of certain crops will be reduced; 2. increased emphasis on cost-reducing technology; 3. increased attention to non-traditional exports.
Revise incentives to agricultural capital	1. reduce credit subsidy for agriculture; 2. review tax exemption for imported equipment and inputs	1. exchange rate and import legislation favored over-capitalization of agriculture; 2. research oriented towards meeting needs of mechanized farmers.
Expenditure on agriculture	1. relatively high expenditure on agriculture in relation to Agricultural Value Added	1. high expenditure ratio due to relatively small sector; 2. expenditure has not produced high productivity; 3. expenditure in form of subsidies, bureaucracy, and government enterprise; 4. reform of expenditure pattern sought by donors.
Creation of Science and Technology Unit, MIPPE	1. defence of research as necessary function; 2. monitoring of resources devoted to research	1. recognition that science and technology research is inadequate; 2. recognition of need to coordinate research policy among sectors; 3. forum for debate of agriculture versus other sectors.
Credit Policy	1. public sector credit small portion total; 2. differentiated clientele;	1. public credit targetted to small and medium farmers; 2. donors have favored specialized credit; 3. private banks select prime customers; 4. government use of credit as means of directing production is weak tool.

Table A.9 -- Panama: Bank Credit by Sector of Activity, 1975-84[a/]

Sector of Activity	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984*
Agriculture	74,959	72,735	96,619	71,166	75,596	97,701	110,651	158,943	155,103	122,929
Livestock	65,805	54,165	64,333	62,516	66,558	74,936	106,416	101,352	77,973	73,811
Agric. + Livestock Sub Total	140,764	126,900	160,952	133,682	142,154	172,637	217,067	260,295	233,076	196,740
Total Credit	8,846,139	10,498,165	10,240,140	14,678,761	19,940,614	21,681,826	29,135,280	28,622,326	24,060,554	11,589,527
Share of Agric. & Livestock	1.6	1.2	1.6	0.9	0.7	0.8	0.7	0.9	1.0	1.7

[a/] Thousands of Dollars

Source: CGR, 1985.

Table A.10 -- Panama: Loans to Agriculture by Public and Private Banks, 1979-82[a/]

DETAILS	1979	1980	1981	1982	1983
T O T A L	231,248	231,248	285,827	320,80.	283,459
- Agriculture	95,209	127,329	137,266	189,292	172,565
- Livestock	78,616	92,703	122,111	118,538	91,140
- Fishing	4,173	10,551	25,907	10,561	17,357
- Infrastructure Equipment	-	665	543	2,409	2,397
NATIONAL BANK OF PANAMA	32,837	57,965	61,196	45,360	33,440
- Agriculture	7,206	27,447	27,573	18,145	15,614
- Livestock	25,631	30,518	32,613	26,853	16,184
- Fishing	-	-	1,010	362	1,642
PRIVATE BANKS	113,478	125,223	181,798	225,496	216,993
- Agriculture	68,378	70,254	83.098	140,798	139,489
- Livestock	40,927	44,418	73,803	74,499	61,789
- Fishing	4,173	10,551	24,897	10,199	15,715
BDA	31,683	48,060	41,833	49,944	33,026
- Agriculture	19,675	29,678	26,595	30,349	17,462
- Livestock	12,058	17,767	15,695	17,186	13,167
-- Infrastucture Equipment	-	665	543	2,409	2,397

[a/] Thousands of Dollars

Source: BDA, 1985 .

Table A.11 -- Panama: Technical Personnel of IDIAP by Degree and Discipline, 1985

	B.S.	M.S.	Ph.D.	Total
Administration	9	3		12
Agric. Economics	6	5		11
Agric. Engineering		1		1
Agric. Sciences	48	4	1	53
Animal Sciences	12	4	1	17
Chemistry	7	1		8
Entomology		2		2
Forestry	2			2
Plant Breeding		2	2	4
Plant Pathology		2	2	4
Plant Sciences		1		1
Sociology	1	2	1	4
Soil Science		2		2
Statistics/Biometrics		2		2
Vet. Medicine/ Parasitology	5	1	1	7
Other	1	1		2
TOTAL	91	33	9	133

Source: IDIAP, 1985c.

Table A.12 -- Panama: Functional Breakdown of IDIAP Scientific Personnel[a/], 1984

Number of Scientists	Ing./Lic.	M.S.	PhD	Total
In Research Management	1	6	3	10
In Research Activities	88	26	11	125
Total	89	32	14	135

a/ Includes 6 expatriate scientists

Source: ISNAR/IFARD, 1984.

Table A.13 -- Panama: Functional Breakdown of IDIAP Budget, 1984

Cost Item	Amount	Percentage
Investment and Equipment	2.100.000 B/	38
Salaries and Personnel Costs	2.810.000 B/	51
Operating Costs	579.000 B/	11
Total	5.499.000 B/	100%

Source: ISNAR/IFARD, 1984.

Table A.14 -- Panama: Program Costs of IDIAP, 1984[a/]

Part of Program	Scientific Personnel Cost	Field Labor Costs	Research Materials	Other Costs[b/]	Total
Agriculture	859.730	65.337	126.692	1.041.957	2.093.716
Livestock	607.073	26.379	158.452	325.863	1.117.767
Technology Transfer	149.146	500	144.637	217.242	511.525
Total	1.615.949	92.216	429.781	1.585.062	3.723.008
Percentage of Total	43.4	2.5	11.5	42.6	100

a/U.S. dollars

b/Mainly personnel and travel costs

Source, IDIAP, 1985d.

Table A.15 -- Panama: Research Staff of Faculty of Agronomy, 1985

National Scientists	Number
PhD	6
MS	12
BS/Ingeniero Agronomo/Licenciado	11
Foreign Scientists	3
Total Scientists	31
Technical Support Staff	
University Graduates	18
Diploma (middle level)	4
Total Research Support Staff	22
Total Employees in Organization	263

Source: ISNAR/IFARD, 1984.

Table A.16 -- Panama: Research Budget of Faculty of Agronomy, 1984

Sources	Amount[b/]	Percent of Total
Ministry of Agriculture Development	100,000	33
University of Panama	300,000	50
Income from Operations[a/]	100,000	17
TOTAL	600,000	100
Uses		
Investment and Equipment	60,000	10
Salaries and Personnel Cost	300,000	50
Operating Costs:		
- Maintenance	190,000	32
- Inputs	50,000	8
TOTAL	600,000	100

a/ Commercial production of rice, maize, cattle.

b/ U.S. Dollars

Source: ISNAR/IFARD, 1984

Table A.17 -- Panama: Research Operating Budgets of IDIAP and FAUP, 1984

	IDIAP[a/]	FAUP[a/]	Ratio IDIAP/FAUP
Total Research Budget/Scientist	40,733	19,355	2.1
Operating Funds/Scientisr	16.279	8,571	1.9
Materials and Supplies/Scientist	4,288	1,612	2.5

a/ U.S. Dollars

Source: ISNAR/IFARD, 1984

Table A.18 -- 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	3.81
CR 5272	Costa Rica	6,103	3.21
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, 1985.

Table A.19 -- Panama: Major Determinants of Technological Events in Rice

Event: Introduction of Improved Varieties

Timing: Improved tall varieties introduced late 1940's and early 1950's from U.S. First dwarf variety introduced 1967. Introduction continues to present.

Extent: Widely adopted during 1950's, currently used on 80% of mechanized area (34,600 ha or 32.5% of total area), and to undetermined extent on non-mechanized area.

Impact: Responsible for yield increase of 40% from 1 t/ha or less pre-1950's to 1.4 t/ha post-introduction. This contribution valued at $7.9 million in 1983, or 17% of total production value. Yield potential 5-6 t/ha or more, double to triple national average of 1.9 t/ha.

Research Resource Inputs (I):

Human

+1 -Senior rice breeders at IDIAP and FAUP provided leadership.

Operating capital

0 -**Field research expenses** initially adequate for MACI, INA, SICAP, but currently inadequate for IDIAP, FAUP.

+1 -Extensive use of **international germplasm.**

Research Management (M):

Internal

+1 -Principal **problems identified** as excessive plant height and susceptibility to blast. **Priorities** motivated by need for fertilizer-responsive plant and blast epidemic crisis.

Linkages

+1 -Close contact by MACI, DAP with **farm production environment.**

+1 -Establishment of institutions and **national policies** promoting modernization of agriculture and adoption of new varieties (MACI, IFE, INA, SICAP).

+1 -Close coordination with DAP for **national technology transfer.**

+1 -Coordination with **national support institutions** for dissemination of new varieties (ENASEM).

+1 -Integration of assistance from the **international community** (SICAP, Arkansas Mission, IRRI, CIAT).

Table A.19 -- (continuation)

External Support Mechanisms (X), (excluding D):

National policy
+1 -Strong national macroeconomic/development policy promoting modernization of agriculture.
National technology transfer program
0 -Extensive commitment of human resources initially by DAP, but currently limited in SENEAGRO.
National support institutions
+1 -Private input suppliers (private seed companies and millers) imported and distributed seed, more recently are producing it nationally.
+1 -Public input suppliers (FAUP, ENASEM) produce and supply high quality national seed.
+1 -Other consumer groups, (e.g., Rice Commission, Seed Commission) currently help promote adoption of improved varieties.
International community
+1 -Basic knowledge available internationally on dwarfness in rice and tolerance to blast.
+1 -Technical assistance from the University of Arkansas.
+1 -International agricultural research centers (IRRI, CIAT) contribute germplasm and expertise.

Farm Production Environment (D):

Resource environs
+1 -High land and labor costs an incentive to adoption of higher yielding varieties.
Economic environs
+1 -Market management by IMA provides strong incentives for adoption of improved varieties.
+1 -Prices/price incentives subsidize rice production, encourage adoption of higher yielding varieties.
Social environs
+1 -Rice producer groups and farmer organizations help promote improved varieties.
Biophysical environs
-1 -Introduced varieties susceptible to blast disease--large amounts of pesticides required to combat epidemic.
Farmer decision environment
+1 -Large numbers of progressive farmers willing to risk adoption of new varieties to achieve higher yields.

+19
Total

Table A.19 -- (continuation)

Event: Development of National Seed Industry

Timing: Seed production program begun by IFE in 1953, transferred to MACI in 1964. FAUP produced seed beginning 1970's. IDIAP established 1975 and initiates basic and certified seed program that year. FAUP and IDIAP supply basic seed to ENASEM, created 1975.

Extent: Use of certified seed widespread by 1963. All rice seed produced nationally by 1973. In 1982, ENASEM supplied 20% of certified seed, private seed companies 30% and rice mills 50%.

Impact: Complete self-sufficiency for rice seed needs. Certified rice seed market volume was 6800 t in 1982, valued at $4.2-4.5 million, or 10% of total production.

Research Resource Inputs (I):

Human

+1 -**Graduate-level** expertise in FAUP and IDIAP.

Fixed capital

+1 -**Equipment** and processing facilities in FAUP, ENASEM; funds for improvement and expansion from BID.

Operating capital

+1 -**International germplasm** provided basis for improved national varieties.

Research Management (M):

Internal

+1 -**Priority-setting** in FAUP and IDIAP resulted in high national priority on achieving self-sufficiency in supply of improved seeds.

-1 -**Evaluation** of national seed industry quality control inadequate--regulations needed.

Linkages

0 -Linkages to **national policies** provided through National Seed Commission, but Commission not yet effective in regulating rice seed industry.

+1 -Linkages between FAUP, IDIAP and **national support support institutions** (ENASEM, National Seed Commission) crucial for development of national seed industry.

+1 -Coordination with **international** donors for expansion of national seed industry.

External Research Support Mechanisms (X), (excluding D):

National policy

+1 -**Scientific/technical policy** promoting national seed industry (IFE) and National Seed Commission.

Table A.19 -- (continuation)

National support institutions
0 -Recent growth of **private suppliers**/seed companies (e.g. Semillas Superiores) strengthens national seed industry, but unregulated supply of low-cost, poor quality seed from millers continues to weaken the industry.
+1 -**Public suppliers** and agencies (ENASEM, National Seed Commission) more advanced than many others in region.
+1 -**Other consumer groups** (producer groups and National Rice Commission) play important role in promoting national seed industry.

International community
+1 -**Basic knowledge** available from international community on organization and management of modern seed industry.
+1 -**Donors** (BID) making important contribution to expansion of national seed industry.

Farm Production Environment (D):

Economic environs
-1 -Higher **price** of certified seed a disincentive when lower cost seed available on credit from millers.

Social environs
+1 -**Farmer organizations** promote use of certified seed.

Farmer decision environment
0 -Large, progressive farmers have capital to **risk** on purchase of higher-cost certified seed, but smaller subsistence farmers do not.

+10.
Total

Table A.19 -- (continuation)

Event: Development of National Varieties With Blast Tolerance

Timing: First blast-tolerant varieties released by IDIAP in 1977. Development continues to present, four new varieties currently being readied for release.

Extent: Used on 20% of mechanized area (8.1% of total) and on undetermined percent of non-mechanized area.

Impact: National variety ranks first in yield (3.8 t/ha) and second in area (7,075 ha) among principal varieties on mechanized areas. Yield potential equal to introduced varieties and responsible for 40% yield increase valued at $2.0 million in 1983, or 4% of total production. In addition, tolerance to blast permits savings in production costs (especially pesticides). Adoption of blast-tolerant varieties on 50% of rice area would result in estimated savings of $3.6 million, or 8% of production value. Total potential contribution equal to 12% of production value.

Research Resource Inputs (I):

Human

+1 -**Senior** rice breeders at FAUP, IDIAP.

Fixed capital

0 -FAUP has **experimental fields**--but IDIAP research must be done on farms.

-1 -Lack of properly equipped **laboratories** for pathological studies.

Operating capital

-1 -**Gasoline** shortage imposing severe constraints on IDIAP's field research program.

+1 -Extensive use of **international germplasm.**

Research Management (M):

Internal

+1 -Top **priority** assigned to blast tolerance--motivated by blast crisis.

+1 -**Research methods** standardized with international network, produced successful national varieties.

Linkages

+1 -Close contact with **farm production environment** through IDIAP's on-farm research program.

+1 -Integration of assistance from the **international community** (CIAT, IRRI).

Table A.19 -- (continuation)

External Research Support Mechanisms (X), (excluding D):

National support institutions

+1 -**Public input suppliers** (ENASEM, Seed Commission) distribute and help promote seed of new varieties with blast tolerance.

+1 -**Other consumer groups** (Rice Commission) help promote adoption of new varieties with blast tolerance.

International community

+1 -**Basic knowledge** available from international scientific community on tolerance to blast.

+1 -**IARCS** (CIAT, IRRI), contribute germplasm and expertise.

Farm Production Environment (D):

Social environs

+1 -Rice producer groups and **farmer organizations** help promote adoption of blast-tolerant varieties.

Biophysical environs

0 -Blast **disease** epidemic a major constraint--now largely overcome by blast-tolerant varieties.

Farmer decision environs

+1 -Farmers eager to adopt new varieties since **risk** of crop loss to blast is so great.

+10
Total

Table A.19 -- (continuation)

Event: National Development of Lower Cost Production Practices

Timing: IDIAP/CATIE farming systems research began 1978, by 1983 included cost-benefit analysis of cropping combinations including rice, costs of labor and inputs, and alternative production practices. Project completed 1985.

Extent: Project focussed on two regions, in Chiriqui and Los Santos. Recommendations and extension program still under development.

Impact: None to date. Preliminary results indicate potential of alternative practices to reduce risks, reduce production costs by 8%, and increase yields by 17.6%. If package adopted on 45% of rice area, value at 1983 prices of potential yield increase would be $6.8 million or 14% of total production; production cost savings would be 4%.

Research Resource Inputs (I):

Human

+1 -**Senior** CATIE representative

-1 -**Scientific/technical** resources have not been focussed on lower cost production practices--especially in agricultural economics.

Fixed capital

-1 -Lack of **experimental fields**--IDIAP research must be done on farms under poorly controlled conditions.

Operating capital

0 -Insufficient **field research** funds for IDIAP's on-farm research program, partially alleviated by special project funds from CATIE.

-1 -**Gasoline** shortage imposing severe constraints on IDIAP's field research program.

Research Management (M):

Internal

-1 -IDIAP and FAUP have failed to **identify** high production costs as a major **problem.** Higher **priority** should be given to developing more efficient production practices, and to integrating work already initiated by CATIE.

+1 -**Formalized research methods** developed by CATIE in collaboration with IDIAP, need to be expanded by IDIAP, including rigorous economic and marketing studies.

Linkages

+1 -Linkages in place with **international community** (CATIE), should be strengthened.

Table A.19 -- (continuation)

External Research Support Mechanisms (X), (excluding D):

National policy
- -1 -Equality of Panamanian currency with US dollar puts Panamanians at a disadvantage with respect to production efficiency.
- 0 -Scientific/technical policy promoting self-sufficiency in rice counterproductive to production efficiency, now balanced by policy to contain rice production.

National technology transfer program
- -1 -Inadequate human resources available in SENEAGRO.

National support institutions
- 0 -Consumer groups (Rice Commission) generally supportive of cost-reducing technologies, have not yet pushed adequately for improved production efficiency.

International community
- +1 -Cost-reducing technologies and basic knowledge available from international community.
- +1 -Significant contribution from other international groups (CATIE).

Farm Production Environment (D):

Resource environs
- +1 -High labor costs an incentive to increase production efficiency.
- -1 -Existing cultural practices inefficient.

Economic environs
- +1 -Market management and guaranteed markets an incentive to investment in more efficient production practices.
- 0 -High prices set by IMA guarantee a good return regardless of production efficiency, but production quotas provide incentive to increase profit margin via increased production efficiency.

Social environs
- +1 -Strong farmer organizations supportive of cost-reducing innovations.

Farmer decision environs
- 0 -Higher risks associated with greater management skills acceptable to progressive farmers, but not to subsistence farmers.

+1
Total

Table A.19 -- (continuation)

CALCULATIONS

Contribution of Introduced Varieties

Yields pre-1950's (base yields) were 1 t/ha or less[c]
Yields early 1950's (post introduction) were 1.4 t/ha[c]
1.4 - 1.0 = .4 t increase
.4/1.0 = 40% increase
Assuming 40% of current base yield (mechanized rice) is due to varieties:
x + .4 x = 74.6 qq/ha[a]
x = 53.3 qq/ha, increase = 21.3 qq/ha
Introduced varieties used on 80% of mechanized area[d]
.80 x 43,230 ha[a] = 34,584 ha
Value of contribution of introduced varieties =
21.3 qq/ha x 34,584 ha x $10.75/qq[b] = **$7.9 million**
Value of total production (1983) =
4,396,000 qq[a] x $10.75/qq[b] = **$47.3 million**
Share of production value, 1983 =
$7.9/$47.3 million[b] = **17%** of total value

Contribution of Seed Industry

Volume of national seed market (which supplies 100% of national needs) = 150,000 qq[b]
Value of market (maximum savings over purchase on international market) =
150,000 qq x $30/qq[f] = **4.5 million**
Share of production value, 1983 = **10%** of total value

Contribution of National Varieties

Yield potential of national varieties equal to introduced varieties (40% increase over base yields)
National varieties used on 20% of mechanized area[d]
.20 x 43,230 ha[a] = 8,646 ha
Value of contribution of national varieties =
21.3 qq/ha x 8,646 ha x $10.75/qq[b] = **$2.0 million**
Share of production value, 1983 =
$2.0/$47.3 million[b] = **4%** of total value

In addition, tolerance to blast permits savings in production costs, due to reduced use of fungicides[d]
Adoption of blast-tolerant varieties on 100% of mechanized area would result in savings of **$3.6 million**[g]
Potential savings as share of production value =
$3.6/$47.3 million = **7.6%**

Total contribution of national varieties =
4% + 7.6% = **12%**

Table A.19 -- (continuation)

Contribution of Lower Cost Production Practices to Cost Savings

In addition, package reduces production costs by 8%[h]

Potential savings, if adopted on area fertilized (45% of total)

.08 x .45 = **3.6%** savings on total production costs

SOURCES

[a]DEC, 1985.
[b]Conklin, 1986.
[c]IDIAP, 1983a.
[d]Lasso, 1985.
[e]IDIAP, 1983b.
[f]Guzman, 1985.
[g]IDIAP, 1984c.
[h]Bejarano, 1985.

Table A.20 -- Panama: Intervention Opportunities Matrix for Rice.

	Introduction of improved varieties	Development of national seed industry	Development of national varieties with blast tolerance	Development of lower cost production practices
Research Resource Inputs (I)				
Human				
Senior	+1			
Graduate-level		+1	+1	+1
Scientific/technical				
Support staff				-1
Fixed Capital				
Experimental fields				
Labs/equipment		+1	0	-1
Documentation/libraries			-1	
Vehicles				
Operating Capital				
Facilities maintenance				
Field research expenses	0			
Gasoline				0
Publications/outreach services			-1	-1
International germplasm	+1	+1	+1	
Research Management (M)				
Internal				
Problem identification/Priority setting	+1	+1	+1	
Planning				-1
Evaluation		-1		
Formalized research methodologies			+1	
Personnel management				+1
Financial management				
Linkages				
Farm production environment	+1		+1	
National policy	+1	0		
National technology transfer programs	+1			
National support institutions	+1	+1		
International community	+1	+1	+1	+1
External Research Support Mechanisms (X-D)				
National policy				
Macroeconomic/development	+1			
Fiscal				-1
Science/technology		+1		
National technology transfer programs				0
Human capital	0			
Fixed capital				-1
Operating capital				
National support institutions				
Private research				
Private input suppliers	+1	0		
Public input suppliers	+1	+1	+1	
Other consumer/user groups	+1	+1	+1	
International community				0
Basic science knowledge	+1	+1	+1	
Foreign universities	+1			+1
IARCs	+1			
Donors		+1	+1	
Other international groups				+1
Farm Production Environment (D)				
Farm Resource Environs (R)				
Land/labor scarcity	+1			
Farm size				+1
Existing cultural practices				-1
Economic Environs (E)				
Markets/market management	+1			+1
Prices/price interventions	+1	-1		0
Social Environs (SE)				
Land tenure				
Farmer organizations	+1	+1	+1	+1
Biophysical Environs (B)				
Climate				
Insects				
Diseases	-1		0	
Farmer Decision Environs (F)				
Risk/uncertainty attitudes				
Existing farming/systems	+1	0	+1	0
Informal/Formal education				

Table A.21 -- Panama: Major Determinants of Technological Events in Maize

Event: Introduction of Hybrid Varieties

Timing: 1952-late 1970's in public sector, to present through private sector suppliers.
Extent: Currently used on 80% of mechanized area, roughly 7,400 ha or 10% of total area.
Impact: Responsible for 60% increase in yields over local varieties, valued at $880,000 or 6% of total maize production in 1983. Yields average 2-3 t/ha; potential yield of 5 t/ha or more, five times national average.

Research Resource Inputs (I):

Human
+1 -Scientific/technical expertise in MACI, INA, SICAP.
Fixed capital
+1 -Experimental fields used by MACI.
Operating capital
+1 -Field research expenses for MACI, INA, SICAP.
+1 -Extensive use of international germplasm.

Research Management (M):

Internal
-1 -Low priority currently accorded to hybrids by public sector TGS (IDIAP, FAUP).
-1 -Inadequate planning for national maize needs in IDIAP, FAUP. Strong influence of CIMMYT's emphasis on open-pollinated varieties.
-1 -Inadequate evaluation of varietal adoption patterns and failure to integrate into planning process.
Linkages
0 -Close coordination initially with DAP for national technology transfer. Linkages currently weak.
-1 -No coordination between national support institutions (ENASEM) on supply of hybrid varieties.
+1 -Integration of assistance from the international community (SICAP, Arkansas Mission, PCCMCA)

External Support Mechanisms (X), (excluding D):

National policy
-1 -Macroeconomic currency policy puts Panamanians at competitive disadvantage with U.S. producers; import policies a disincentive to adoption of hybrid varieties.

Table A.21 -- (continuation)

National technology transfer program

0 -Extensive commitment of **human resources** initially by DAP, but currently limited in SENEAGRO.

National support institutions

+1 -**Private input suppliers** import and distribute hybrid seed.

0 -**Other consumer groups**, (e.g., Maize Commission, Seed Commission) ineffective in promoting adoption of hybrid varieties.

International community

+1 -**Basic knowledge** available internationally on hybrid maize seed production--particularly from private U.S. companies.

+1 -Technical assistance from the **University** of Arkansas.

+1 -**Other international groups** (PCCMCA) helped promote adoption of hybrid varieties.

Farm Production Environment (D):

Resource environs

-1 -**Existing cultural practices** of subsistence farmers inappropriate for hybrid varieties.

Economic environs

-1 -**Market management** by IMA, large volume of imported maize and protection of poultry industry all disincentives to adopt more costly hybrid varieties.

0 -Favorable **prices** and subsequent price support policies provide incentives for higher yields achieved with hybrid varieties, but major market sector (maize consumed on-farm) unaffected by incentives.

Social environs

-1 -Maize producer groups and other **farmer organizations** weak; unable to promote modernization and adoption of hybrid varieties.

Biophysical environs

-1 -Bushy stunt disease a constraint to unadapted hybrid varieties.

Farmer decision environment

-1 -Subsistence farmers predominate, unwilling to **risk** high costs of hybrid varieties to achieve greater returns.

-1 -**Existing farming systems** ingrained by long tradition.

-2
Total

Table A.21 -- (continuation)

Event: Development of Improved Open-Pollinated Varieties

Timing: 1952 to present, most intensively since 1974 i. collaboration with CIMMYT.

Extent: Seven varieties developed in 15 years, used prim. by mechanized and semi-mechanized farmers. Used . roughly 5,000 ha, or 7% of total area.

Impact: Responsible for 40% yield increases over local varieties valued at $350,000 or 2% of total productio in 1983. Yields average 2-3 t/ha; potential yield of 5 t/ha, five times national average.

Research Resource Inputs (I):

Human

+1 -**Senior** maize breeder at IDIAP.

Fixed capital

0 -Lack of **experimental** fields did not hold back development of varieties.

Operating capital

0 -Funds for **field research** previously adequate, currently limiting in IDIAP's on-farm research program.

-1 -**Gasoline** shortage imposing severe constraints on IDIAP's field research program.

+1 -Extensive use of **international germplasm.**

Research Management (M):

Internal

0 -Top **priority** assigned to open-pollinated varieties resulting in highly focussed program, but work on hybrids excluded.

+1 -**Planning** and implementation effective in Caisan. Plans to extend work into other regions should be implemented to extend impact.

-1 -**Evaluation** did not address needs of mechanized maize producers for hybrid varieties.

+1 -**Formalized research methods** adopted from CIMMYT have been effective in producing open-pollinated varieties.

Linkages

+1 -Close contact with **farm production environment** through IDIAP's on-farm research program in Caisan; needs to be extended to other regions.

+1 -Good linkages to **national support institutions** (ENASEM) for multiplication and distribution of improved seed.

+1 -Integration of assistance from the **international community** (CIMMYT, CATIE, PCCMCA).

Table A.21 -- (continuation)

External Research Support Mechanisms (X), (excluding D):

National policy
- -1 -**Macroeconomic** currency policy puts Panamanians at competitive disadvantage with U.S. producers; import policies a disincentive to adoption of improved varieties.

National technology transfer program
- 0 -Extensive commitment of **human resources** initially by DAP, but currently limited in SENEAGRO.

National support institutions
- +1 -**Public input suppliers** (ENASEM, Seed Commission) distribute and help promote seed of improved open-pollinated varieties.

International community
- +1 -**Basic knowledge** available from international scientific community on maize improvement.
- +1 -**IARCS** (CIMMYT) contribute germplasm and expertise.
- +1 -**Other international groups** (PCCMCA) provide advisory forum on maize improvement.

Farm Production Environment (D):

Resource environs
- -1 -**Existing cultural practices** of subsistence farmers inappropriate for improved varieties.

Economic environs
- -1 -**Market management** by IMA, large volume of imported maize and protection of poultry industry all disincentives to adoption of more costly improved varieties.
- 0 -Favorable **prices** and subsequent price support policies provide incentives for higher yields achieved with improved varieties, but major market sector (maize consumed on-farm) unaffected by incentives.

Social environs
- -1 -Maize producer groups and other **farmer organizations** weak; unable to promote adoption of improved varieties.

Farmer decision environment
- -1 -Subsistence farmers predominate, unwilling to **risk** high costs of hybrid varieties to achieve greater returns.
- -1 -**Existing farming systems** ingrained by long tradition.

\+ 3
Total

Table A.21 -- (continuation)

Event: Development of National Seed Industry

Timing: MIDA multiplied seeds of early varietal releases beginning 1970; ENASEM founded 1975; significant quantities of improved seed first available 1978.
Extent: ENASEM currently sells 90 t of improved open-pollinated maize seed annually (12% of its business). 135 t of hybrid seed imported by private suppliers. ENASEM currently expanding maize seed production.
Impact: Nationally produced seed (all open-pollinated) supplies 40% of national seed market. Total market valued at $355,000 or 2% of total maize production. Vast majority of traditional farmers save own seed which never enters market.

Research Resource Inputs (I):

Human
+1 -Graduate-level expertise in FAUP and IDIAP.
Fixed capital
+1 -Equipment and processing facilities in FAUP, ENASEM; funds for improvement and expansion from BID.
Operating capital
+1 -International germplasm provided basis for improved national varieties.

Research Management (M):

Internal
+1 -Priority-setting in FAUP and IDIAP resulted in high national priority on achieving self-sufficiency in supply of improved seeds.
-1 -Evaluation of national seed industry quality control inadequate--regulations needed.
Linkages
0 -Initially national policies successfully promoted development of seed industry (IFE); currently national regulatory policies needed.
+1 -Linkages between FAUP, IDIAP and national support support institutions (ENASEM, National Seed Commission) crucial for development of national seed industry.
+1 -Coordination with international donors for expansion of national seed industry.

External Research Support Mechanisms (X), (excluding D):

National policy
+1 -Scientific/technical policy promoting national seed industry (IFE).

Table A.21 -- (continuation)

National support institutions

0 -**Private suppliers** import hybrid seed, but there is no private national production of maize seed, other than that contracted by ENASEM.

+1 -**Public suppliers** and agencies (ENASEM, National Seed Commission) more advanced than many others in region.

-1 -**Other consumer groups** (producer groups and National Maize Commission) weak; unable to promote national seed industry.

International community

+1 -**Donors** (BID) making important contribution to expansion of national seed industry.

+1 -**Other international groups** (private hybrid seed companies) providing hybrid maize seed for Panama.

Farm Production Environment (D):

Economic environs

-1 -**Market management** by IMA, large volume of imported maize, and protection of poultry industry all disincentives to adoption of improved varieties.

-1 -Higher **price** of certified seed a disincentive to subsistence farmers.

Social environs

-1 -Maize producer groups and other **farmer organizations** weak, unable to promote adoption of improved varieties.

Farmer decision environment

-1 -Subsistence farmers predominate, unwilling to **risk** high costs of improved varieties to achieve greater returns.

-1 -**Existing farming systems** ingrained by long tradition.

+3
Total

Table A.21 -- (continuation)

Event: Development of Lower Cost Production Practices

Timing: Early 1970's to present, most intensively since late 1970's in Caisan.

Extent: Minimum till package adopted on 43% of maize farms in Caisan (0.3% of total maize area).

Impact: Savings of 20% realized by farmers who adopted the minimum till package; if adopted where higher-cost improved practices used, potential savings of 9% in national production costs.

Research Resource Inputs (I):

Human

+1 -Senior IDIAP researchers

Fixed capital

-1 -Lack of experimental fields--IDIAP research must be done on farms under poorly controlled conditions.

Operating capital

0 -Insufficient field research funds for IDIAP's on-farm research program in Caisan supplemented from external sources.

-1 -Gasoline shortage imposing severe constraints on IDIAP's field research program.

+1 -Outreach good in Caisan, needs to be extended.

Research Management (M):

Internal

+1 -IDIAP has correctly identified high production costs as a major problem. Priority should be given to expanding work on more efficient production practices beyond Caisan.

0 -IDIAP planning narrowly focussed on Caisan--program expansion to other areas should be hastened.

+1 -Formalized research methods developed by CIMMYT have been valuable. Rigorous economic and marketing studies need to be emphasized.

Linkages

+1 -Linkages with the farm production environment in Caisan have been excellent and should be expanded.

0 -IDIAP has provided training for one SENEAGRO agent in minimum-till practices for maize, but the relationship between the two agencies needs clarification.

+1 -Close linkages with international community (CIMMYT, CATIE).

Table A.21 -- (continuation)

External Research Support Mechanisms (X), (excluding D):

National policy
- -1 -Equality of Panamanian currency with US dollar puts Panamanians at a disadvantage with respect to production efficiency.

National technology transfer program
- -1 -Inadequate **human resources** available in SENEAGRO.

National support institutions
- -1 -**Public support institutions** (ENDEMA) do not have appropriate equipment for minimum-till practices.
- 0 -**Consumer groups** (Maize Commission) ineffective in promoting improved production efficiency.

International community
- +1 -**Basic knowledge** on minimum-till available in U.S.; must be adapted to Panamanian conditions.
- +1 -Significant contribution from **IARCs** (CIMMYT) on production practices.
- +1 -**Other international groups** (CATIE) provided expertise on farming systems research.

Farm Production Environment (D):

Resource environs
- +1 -**Labor scarcity** and cost provide incentive to adoption of lower cost production practices.
- -1 -**Existing cultural practices** of subsistence farmers inhibit adoption of new practices.

Economic environs
- -1 -**Market management** by IMA, large volume of imported maize and protection of poultry industry all disincentives to maize production.
- 0 -Favorable **prices** and price support policies provide incentives for maize production, but major market sector (maize consumed on-farm) unaffected by incentives.

Social environs
- -1 -Maize producer groups and other **farmer organizations** weak; no incentive to promote lower cost production production practices nationwide.

Farmer decision environment
- 0 -Favorable adoption rate for minimum-till methods in Caisan, but subsistence farmers predominate elsewhere, hesitant to **risk** new production methods to achieve greater returns.
- -1 -**Existing farming systems** ingrained by long tradition.

+1
Total

Table A.21 -- (continuation)

CALCULATIONS

Contribution of Introduced Hybrids

Responsible for 20% increase in yields over improved O.P. varieties (due to heterosis) plus 40% increase over base yields (equivalent to improved O.P. varieties) for total of 60% increase over base yields

.40 x .8 t/ha = .32 t/ha increase
.20 x 1.12 t/ha = .224 t/ha increase
.32 + .224 = .54 t/ha increase

135 t of hybrid seed sold annually[d]

.0182 t plants one ha[c], so 135 t plants 7,400 ha

Value of increase due to introduced hybrids =
.54 t/ha x 7,400 ha x $220/t[b] = **$880,000**

Value of total production (1983) =
75,800 ha[a] x .91 t/ha[a] x $220/t[b] = **$15.17 million**

Share of total production value =
$880,000/$15,170,000 = **5.8%**

Contribution of Improved Open-Pollinated Varieties

Responsible for 40% increase over best local varieties[g]

.40 x .8 t/ha[a,e] = .32 t/ha increase to 1.12 t/ha

90 t of improved, O.P. varieties sold annually[d]

.0182 t plants one ha[c], so 90 t plants 4945 ha

Improved O.P. varieties used on approx. 5,000 ha

Value of increase due to improved O.P. varieties =
.32 t/ha x 5,000 ha x $220/t[b] = **$352,000**

Share of total production value =
$352,000/$15,170,000 = **2.3%**

Contribution of National Seed Industry

90 t O.P. seed (=2,000 qq) x $50/qq[c,d] = $100,000
135 t hybrid seed (=3,000 qq) x $85/qq[c,d] = $255,000

$355,000 value

Value of seed market, as share of total production value =
$355,000/$15,170,000 = **2.3%**

Value of nationally produced seed, as share of total market =
$100,000/$355,000 = **28%**

Additional 540 t seed produced by farmers for own use[a], never enters market

Contribution of Lower Cost Agronomic Practices to Cost Savings

In addition, practices reduce production costs by 20%[f]

Adopted on 223 ha in Caisan (0.3% of total area--75,820 ha[a])

Value of savings on total production costs =
.20 x .003 = **0.6%**

Potential savings, if adopted on total area fertilized =
.20 x .45 = **9%** potential savings

Table A.21 -- (continuation)

SOURCES

[a]DEC, 1985.
[b]Conklin, 1986.
[c]Alvarado, 1985.
[d]Guzman, 1985.
[e]IDIAP, 1983c.
[f]Arauz, 1985.
[g]CIMMYT, 1984.

Table A.22 -- Panama: Intervention Opportunities Matrix for Maize

	Introduction of hybrid varieties	Development of improved open-pollinated varieties	Development of national seed industry	Development of lower cost production practices
Research Resource Inputs (I)				
Human				
Senior		+1		+1
Graduate-level			+1	
Scientific/technical	+1			
Support staff				
Fixed Capital				
Experimental fields	+1	0		-1
Labs/equipment			+1	
Documentation/libraries				
Vehicles				
Operating Capital				
Facilities maintenance				
Field research expenses	+1	0		0
Gasoline		-1		-1
Publications/outreach services				+1
International germplasm	+1	+1	+1	
Research Management (M)				
Internal				
Problem identification/Priority setting	-1	0	+1	+1
Planning	-1	+1		0
Evaluation	-1	-1	-1	
Formalized research methodologies		+1		+1
Personnel management				
Financial management				
Linkages				
Farm production environment		+1		+1
National policy			0	
National technology transfer programs	0			0
National support institutions	-1	+1	+1	
International community	+1	+1	+1	+1
External Research Support Mechanisms (X-D)				
National policy				
Macroeconomic/development	-1	-1		-1
Fiscal				
Science/technology			+1	
National technology transfer programs				
Human capital	0	0		-1
Fixed capital				
Operating capital				
National support institutions				
Private research				
Private input suppliers	+1		0	
Public input suppliers	0	+1	+1	-1
Other consumer/user groups	0		-1	0
International community				
Basic science knowledge	+1	+1		+1
Foreign universities	+1			
IARCs		+1		+1
Donors			+1	
Other international groups	+1	+1	+1	+1
Farm Production Environment (D)				
Farm Resource Environs (R)				
Land/labor scarcity				+1
Farm size				
Existing cultural practices	-1	-1		-1
Economic Environs (E)				
Markets/market management	-1	-1	-1	-1
Prices/price interventions	0	0	-1	0
Social Environs (SE)				
Land tenure				
Farmer organizations	-1	-1	-1	-1
Biophysical Environs (B)				
Climate				
Insects				
Diseases	-1			
Farmer Decision Environs (F)				
Risk/uncertainty attitudes	-1	-1	-1	0
Existing farming/systems	-1	-1	-1	-1
Informal/Formal education				

Table A.23 -- Panama, Costa Rica and Colombia: Bean yields and costs of production.*

Location	Yield (kg/ha)	US $/ha	US $/kg
Chiriqui, Panama			
Conventional	700	398	0.57
No-till	700	363	0.52
San Isidro, Costa Rica	1158	278	0.24
Narino, Colombia	788	260	0.33

*Semi-mechanized production of bush beans in monoculture.
Sources: Pachico, 1985; Acosta et al., 1983.

Table A.24 -- Panama: Major Determinants of Technological Events in Legumes

Event: Development of Improved Bean Varieties

Timing: Begun 1950's by FAUP, intensified since late 1970's in IDIAP.

Extent: Two new varieties resistant to web blight being multiplied in preparation for release.

Impact: None as yet: potential to increase yields by 100-150%, from 0.75 t/ha to 1.5-1.8 t/ha. Value of increased production, if adopted on 50% of bean area, would be be $360,000, or 52% of current production value.

Research Resource Inputs (I):

Human

+1 -Senior legume breeder, IDIAP.

+1 -Graduate-level director of field program, IDIAP.

Fixed capital

-1 -Laboratory facilities lacking for pathological studies of web blight.

Operating capital

0 -New varieties developed despite limited field research expenses.

-1 -Gasoline shortages imposing severe constraints on field research.

+1 -Good outreach through on-farm research program--should be extended to other potential bean growing regions.

+1 -Access to international germplasm.

Research Management (M):

Internal

+1 -Priority given to web blight resistance, yield and consumer-preferred characteristics.

+1 -Planning focussed effectively on Caisan--should now be extended to other potential bean-producing regions.

Linkages

+1 -Linkages with farm production environment in Caisan excellent and should be extended.

+1 -IDIAP researcher a member of National Legume Commission, providing linkages to national policy.

+1 -IDIAP provided training for agents of national technology transfer program.

+1 -Excellent linkages between IDIAP and international community (CIAT, PCCMCA, Cornell University).

Table A.24 -- (continuation)

External Research Support Mechanisms (X), (excluding D):

National policy

-1 -**Macroeconomic** currency policy puts Panamanians at competitive disadvantage with U.S. producers; import policies and late payments disincentives to purchase of improved seed.

National technology transfer program

0 -**Human resources** limited in SENEAGRO, but training already begun with IDIAP bean program.

National support institutions

0 -**No national private input suppliers** are providing improved seed.

+1 -Distribution of improved bean seed by **public input suppliers** (ENASEM) still limited, but ENASEM taking steps to increase bean seed production and distribution capability.

0 -**Other consumer groups** (Legume Commission) weak, ineffective in promoting new varieties.

International community

+1 -**Basic knowledge** available from international scientific community on bean improvement.

+1 -Important contribution of germplasm from **foreign universities** (Cornell).

+1 -Important contributions from **IARCs** (CIAT).

+1 -Important advisory role by **other international groups** (PCCMCA, CATIE, FAO).

Farm Production Environment (D):

Resource environs

-1 -**Existing practice** of saving seed impedes adoption of new varieties.

Economic environs

+1 -Strong **market** demand provides incentive for adoption of improved varieties and increased production.

0 -High support **prices** offset by late payments by IMA.

Social environs

0 -Weak **farmer organizations** ineffective in promoting adoption of new varieties.

Biophysical environs

0 -Web blight **disease** a constraint to production, largely overcome in improved varieties.

+12
Total

Table A.24 -- (continuation)

Event: Development of Cowpea Varieties for Mechanical Harvest

Timing: 1960's through early 1970's in FAUP.
Extent: "Romefa" variety developed--suitable for mechanical harvest with experimental yields of 2.3 t/ha. Production yields of 1.35 t/ha achieved on pilot level.
Impact: Insignificant, since 99% of cowpea production realized on small farms with traditional production methods. Potential yield increase of 1.0 t/ha, if adopted on 20% of cowpea area, would be worth $550,000 at current support prices, or 33% of current production value.

Research Resource Inputs (I):

Human
+1 -Senior legume researcher, FAUP.
Fixed capital
+1 -Experimental fields available for FAUP research.
-1 -Limited laboratory facilities have constrained FAUP study of cowpea virus problems.
Operating capital
0 -Initial on-farm research facilitated outreach, but no outreach efforts currently incorporated in FAUP research program.
+1 -Access to international germplasm from IITA through PCCMCA.

Research Management (M):

Internal
+1 -Problem identified correctly as improving yield and reducing labor requirements.
+1 -Planning effective in achieving research goals.but
0 -Evaluation of research indicates success in improved variety yielding eight times national average--but impact minimal due to poor adoption rate.
Linkages
0 -Linkages with farm production environment initially good, but currently poor.
-1 -FAUP not represented on National Legume Commission, no direct linkages to national policy.
-1 -No provision for linkages with national technology transfer program.
+1 -Linkages with national support institutions most effective with ENASEM.
+1 -Effective linkages between FAUP and international community--to IITA through PCCMCA.

Table A.24 -- (continuation)

External Research Support Mechanisms (X), (excluding D):

National policy
- -1 -**Development** policies favor beans over cowpeas, resulting in unfavorable import and credit policies for cowpeas.

National technology transfer program
- 0 -Limited **human resources** in SENEAGRO, ineffective in promoting new varieties and production practices.

National support institutions
- 0 -**Public input suppliers** (ENASEM) taking steps to improve production and distribution of improved varieties; but limited availability of credit a severe constraint.
- 0 -**Other consumer groups** (Legume Commission) weak, ineffective in promoting new varieties.

International community
- +1 -**Basic knowledge** available from international scientific community on cowpea improvement.
- +1 -Important contributions from **IARCs** (IITA).
- +1 -Important faciliting role of **other international groups** (PCCMCA).

Farm Production Environment (D):

Resource environs
- +1 -**Labor scarcity** and cost an incentive to adopt varieties suitable for mechanical harvest.
- -1 -**Existing cultural practices** impede adoption of mechanization and new varieties.

Economic environs
- -1 -Weak **market** demand and continued importation are disincentives to increased production and adoption of new varieties.
- -1 -Support **prices** favor bean production; late payments by IMA a further disincentive.

Social environs
- 0 -Weak **farmer organizations** ineffective in promoting adoption of new varieties.

Farmer decision environs
- -1 -Subsistence farmers predominate--unwilling or unable to **risk** new farming systems and varieties.

+3
Total

Table A.24 -- (continuation)

CALCULATIONS

Potential Contribution of Improved Bean Varieties

Potential yield increase of 100%, from .73 t/ha to 1.5 t/ha[c]

1.5 - .73 = .75 t/ha increase

Value of increase, if varieties adopted on area where improved practices already used:

.75 t/ha x 440 ha x $1100/t = $363,000

Value of total production =

.726 t/ha x 880 ha x $1100/t = $703,000

Potential increase due to varieties as share of total value =

$363,000/$703,000 = 52% potential increase

Potential Contribution of Improved Cowpea Varieties

Production yields of 1.35 t/ha achieved on pilot level[e]

Potential increase of 250%, from .3 t/ha to 1.35 t/ha

1.35 - .3 = 1.05 t/ha increase

Assuming at least 50% of increase due to agronomic practices:

1.05 - .52 = .5 t/ha increase due to varieties

Value of increase if adopted on 20% of cowpea area =

(approximately same area adopting improved practices in maize)

.20 x 10,000 ha[d] = 2,000 ha

.5 t/ha x 2,000 ha x $550/t[b*] = $550,000

Current production value =

.3 t/ha x 10,000 ha x $550/t = $1.65 million

Value of increase as share of current production value =

$.55/1.65 million = 33% potential increase

*Support price

SOURCES

[a]IDIAP, 1983d.

[b]Conklin, 1986.

[c]Acosta, 1985.

[d]DEC, 1985.

[e]Rodriguez and Aleman, 1982.

Table A.25 -- Panama: Intervention Opportunities Matrix for Legumes, Onion & Tomato

	Development of improved bean varieties	Development of cowpea varieties for mechanical harvest	Introduction of onion varieties	Development of tomato varieties resistant to bacterial wilt
Research Resource Inputs (I)				
Human				
Senior	+1	+1		+1
Graduate-level	+1		+1	
Scientific/technical			+1	+1
Support staff				
Fixed Capital				
Experimental fields		+1		+1
Labs/equipment	-1	-1		-1
Documentation/libraries				
Vehicles				
Operating Capital				
Facilities maintenance				
Field research expenses	0			+1
Gasoline	-1			
Publications/outreach services	+1	0	+1	+1
International germplasm	+1	+1	+1	+1
Research Management (M)				
Internal				
Problem identification/Priority setting	+1	+1	+1	+1
Planning	+1	+1		+1
Evaluation		0		
Formalized research methodologies				+1
Personnel management				+1
Financial management				
Linkages				
Farm production environment	+1	0	+1	+1
National policy	+1	-1		+1
National technology transfer programs	+1	-1	0	
National support institutions		+1	+1	
International community	+1	+1	+1	+1
External Research Support Mechanisms (X-D)				
National policy				
Macroeconomic/development	-1	-1	-1	+1
Fiscal				
Science/technology				
National technology transfer programs				
Human capital	0	0		
Fixed capital				
Operating capital				
National support institutions				
Private research				+1
Private input suppliers	0		+1	+1
Public input suppliers	+1	0	+1	0
Other consumer/user groups	0	0	0	
International community				
Basic science knowledge	+1	+1	+1	+1
Foreign universities	+1		+1	+1
IARCs	+1	+1		+1
Donors				
Other international groups	+1	+1	+1	+1
Farm Production Environment (D)				
Farm Resource Environs (R)				
Land/labor scarcity		+1		
Farm size				
Existing cultural practices	-1	-1		
Economic Environs (E)				
Markets/market management	+1	-1	-1	+1
Prices/price interventions	0	-1	-1	+1
Social Environs (SE)				
Land tenure				
Farmer organizations	0	0	+1	
Biophysical Environs (B)				
Climate				
Insects				
Diseases	0			0
Farmer Decision Environs (F)				
Risk/uncertainty attitudes		-1	+1	+1
Existing farming/systems				
Informal/Formal education				

Table A.26 -- Panama: Major Determinants of Technological Events in Onions

Event: Introduction of Onion Varieties

Timing: Late 1950's, continues to present.
Extent: Used on virtually 100% of production area, approximately 260 ha.
Impact: Responsible for contribution of at least 7.3 t/ha to yields, valued at $816,000 or 36% of total production.

Research Resource Inputs (I):

Human
+1 -Graduate-level personnel in IDIAP.
+1 -Scientific/technical personnel in MACI.
Operating capital
+1 -Good outreach through on-farm research program, field days, pamphlets.
+1 -Exclusive use of imported adapted varieties, developed from international germplasm.

Research Management (M):

Internal
+1 -Accorded highpriority among vegetable crops, second only to tomato.
Linkages
+1 -Linkages with farm production environment in highlands good, could be exploited even more.
0 -Linkages to national technology transfer program weak.
+1 -Linkages effective with national support institutions for credit, insurance, cooperative assistance, supplies.
+1 -Good linkages between IDIAP and international community (private seed companies, SICAP, University of Arkansas, Rutgers University).

External Research Support Mechanisms (X), (excluding D):

National policy
-1 -Macroeconomic currency policy puts Panamanians at competitive disadvantage with U.S. producers; import policies a disincentive to increased production and expanded commercial production.
National support institutions
+1 -Private input suppliers provide fertilizers, chemicals, seeds.
+1 -Public input suppliers provide credit, insurance, assistance to cooperatives, supplies, limited extension (BDA, ISA, IPACOOP, ANDIA, COAGRO).

Table A.26 -- (continuation)

0	-**Other consumer groups** (Onion Commission) weak, ineffective in promoting improved agronomic practices.
International community	
+1	-**Basic knowledge** available from international scientific community on commercial production practices for onions.
+1	-Important contribution from **foreign universities** for technical assistance (Arkansas, Rutgers), varieties (Texas A&M).
+1	-Important role of **other international groups** (private companies) in supply of seeds, chemicals.
Farm Production Environment (D):	
Economic environs	
-1	-**Marketing** and import practices of IMA the major constraint to expansion of commercial production.
-1	-Support **prices**, quotas, and late payments by IMA all disincentives to expanded commercial production.
Social environs	
+1	-Strong **farmer organizations** in highlands effective in promoting their interests.
Farmer decision environs	
+1	-Progressive farmers in highland cooperatives taking **risks** to expand their production, providing leadership for national onion producers.
+12 Total	

Table A.25 -- (continuation)

CALCULATIONS

Contribution of Introduced Onion Varieties

Responsible for base yields of 7.3 t/ha (1970)[c]
Used on 100% of production area[b]
Value of varietal contribution =
7.3 t/ha x 260 ha[c] x $430/t[c] = **$816,000**
Value of current production =
20 t/ha[b,d] x 260 ha x $430/t = $2.24 million
Varietal contribution, as share of total value =
$816,000/$2.24 million = **36%**

SOURCES

[a]DEC, 1984b.
[b]Gaskell, 1985.
[c]Conklin, 1986.
[d]De Leon et al., 1982.

Table A.27 -- Panama: Major Determinants of Technological Events in Tomato

Event: Development of Varieties Resistant to Bacterial Wilt

Timing: 1966 to present; first variety released 1971.
Extent: Two major new varietal releases since 1971, varieties rotated every 4-5 years. Adopted on 90% of production area.
Impact: Responsible for over 100% increase in yield, from 12 to 26 t/ha, valued at $2.6 million or 54% of total production.

Research Resource Inputs (I):

Human
+1 -Senior tomato breeder, IDIAP.
+1 -Scientific/technical assistance in Nestle.
Fixed capital
+1 -Six ha of experimental fields provided by Nestle.
-1 -Laboratory facilities lacking for pathological studies of bacterial wilt.
Operating capital
+1 -Field research expenses contributed by Nestle.
+1 -Direct outreach to targeted producers through Nestle's extension services.
+1 -Access to international germplasm from Taiwan, Puerto Rico, North Carolina State University, Universities of Delaware and Hawaii, Agricultural Research Center in Guadeloupe.

Research Management (M):

Internal
+1 -Narrowly focussed priorities dictated by severity of bacterial wilt epidemic and threat to industry.
+1 -Research planning made maximum use of international germplasm and expertise, varieties produced in time to save industry.
+1 -Research methodology successful in achieving desired results.
+1 -Flexible personnel policy permitted senior researcher to develop private seed production program in conjunction with research program, ensuring seed supply of newest varieties.
Linkages
+1 -Linkages extremely close between Nestle and selected farm production environment in Los Santos; contracts specify use of new resistant varieties.
+1 -Linkages between Nestle and national policy-makers ensuring market protection justified long-term investment in varietal improvement by Nestle and IDIAP.

Table A.28 -- (continuation)

+1 -Good linkages between IDIAP and **international community** for germplasm and expertise.

External Research Support Mechanisms (X), (excluding D):

National policy

+1 -Favorable **macroeconomic** development policy providing market protection for Nestle key to stimulating long-term investment in development of improved varieties.

National support institutions

+1 -**Private research** by Nestle in collaboration with IDIAP responsible for development of varieties with bacterial wilt resistance.

+1 -**Private input supplier** (senior IDIAP researcher) provides seeds of new varieties.

0 -**Public input suppliers** (BDA) provide credit, but tomato seed production and distribution capabilities lacking in ENASEM.

International community

+1 -**Basic knowledge** available from international community on bacterial wilt resistance.

+1 -Important role of **foreign universities** in providing appropriate training (North Carolina State), resistant germplasm and testing of experimental varieties (North Carolina State, Universities of Hawaii and Delaware).

+1 -Important role of **international agricultural research** centers (AVRDC) in providing germplasm and testing experimental varieties.

+1 -Important role of **other international groups** (national agricultural research institutes) in testing of experimental varieties.

Farm Production Environment (D):

Economic environs

+1 -Government import protection and **market management** by Nestle crucial incentives to investment in varietal development.

+1 -Guaranteed contracts and **prices** assured a market for new bacterial wilt-resistant varieties.

Biophysical environs

0 -Endemic bacterial wilt **disease** still an important constraint, but largely overcome by resistant varieties.

Farmer decision environs

+1 -**Risk** of bacterial wilt reduced dramatically by use of wilt-resistant varieties; **uncertainty** in varietal selection reduced by specification of wilt-resistant varieties in production contracts.

+22
Total

Table A.27 -- (continuation)

CALCULATIONS

Contribution of Improved Varieties

Responsible for 117% yield increase, from 12 to 26 t/ha[c]

26 - 12 = 14 t/ha increase

Adopted on 90% of production area[e]

.90 x 1500 ha[c] = 1350 ha

Value of increase due to improved varieties =

14 t/ha x 1350 ha x $140/t = **$2.65 million**

Value of current production =

35,000 t[a] x $140/t[c] = **$4.9 million**

Contribution of increase, as share of total value =

$2.6/$4.9 million = **54%**

SOURCES

[a]FAO, 1979.

[b]FAO, 1985.

[c]De Leon, 1985; Diaz, 1985.

[d]Conklin, 1986.

[e]IDIAP, 1983e.

Diagram A.1 -- Panama: Organigram for I.D.I.A.P 1985