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INITIAL DRAFT

SOCIO-ECONOMIC IMPACT ANALYSIS OF TECHNOLOGIES GENERATED BY THE SOIL MANAGEMENT AND OTHER CRSPS IN THE HUMID TROPICS

PROJECT REPORT

SOIL MANAGEMENT COLLABORATIVE RESEARCH SUPPORT PROGRAM

NORTH CAROLINA STATE UNIVERSITY

JANUARY 3, 1994

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FORWARD

The Soil Management Collaborative Research Support Program (CRSP) initiated activities in 1981 by establishing primary research sites in the humid tropics, acid savannas and semi-arid tropics. The center for the humid tropical research was Yurimaguas, Peru where nine (9) years of experience had already been gained. Secondary humid tropic sites were initiated in Sitiung, Sumatra, Indonesia and Manus, Brazil. In 1990 the USAID S&T bureau desired to quantify the impact of long-term supported soil management research in the immediate vicinity and the degree of transfer to other humid tropical areas. This study was initiated through a $200,000 grant, USAID DAN-1311-G-00-0039-00, to the Office the Management Entity of the Soil Management CRSP and sub-granted to the Soil Science Department of North Carolina State University.

This study started in August 1990 and after working through numerous uncontrollable difficulties was completed in January 1993. The increase in terrorists activities in Yurimaguas, Peru forced travel restriction to this flagship primary research site and all studies had to administered through host country institutions. The Gulf War in January 1991 halted all USAID supported international travel for a period of six (6) months. This restriction delayed the initiation of field data collection for impact measurements in Indonesia beyond the period when the senior scientists was stationed in Sitiung and limited the detail and depth of the local data collection. The fruits of these efforts are presented as separate sections in this draft report and will be published as separate and complete professional reports.

These impact assessments revealed that soil management technology does not have specialized and specific agriculture clientele group, but benefits and serves all society and is utilized from high level policy makers to farmers that apply the technology. Soil management technology, based on good science, has a large user group and certainly has long-term utility. The transfer of soil management technology has more informal routes than it does direct and purposeful paths. It is safe to say the Soil Management CRSP success can best be measured by the large following established over the years of quality research, training and publication. The impact of this technology when serving as short-term training, undergraduate and graduate soil management subject material will bring about, in the long-term, and hopefully positive changes on how we manage our tropical soils for sustainable development.

Roger G. Hanson, Director
Soil Management CRSP

PREFACE

This report is the product of close collaboration between a specialist in program evaluation and co-authors representing various disciplinary specialties including soil management, forestry, anthropology, and psychology. The evaluation specialist has had extensive experience in international development but no prior association with the SM-CRSP. The report, therefore, combines the impartiality of an external review and the technical expertise of program leaders. The study design, analysis and interpretation of results are strengthened by this diversity of talent and perspectives. The authors gratefully acknowledge the collaboration and support of the many individuals and institutions.

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1. SUMMARY

The present and future well-being of the people living in the humid tropics depends upon soils research. Collaborative soil management research is helping develop the knowledge necessary to manage, in a sustainable manner, approximately 1.7 billion hectares representing 38 percent of the land resource of 72 developing countries. Once regarded as unsuitable for agriculture, today the humid tropics are the principal areas of global agricultural expansion. Growing population pressures combined with traditional slash and burn practices, if left unchecked, will lead to the eventual degradation of most of these rain forest reserves with little or no long-term social or economic gain. The expansion of subsistence agriculture will only extend the poverty pandemic to the regions. Research on soil management, however, is helping to develop productive and sustainable alternatives to slash and burn methods and to lay the technical foundation for a rational management of soils in the humid tropics.

The opportunities created through this research program clearly effect developing countries' basic food securities, generate economic surpluses, improve social conditions and conserve natural resources. Technology is generated collaboratively with host country scientists and transferred to national institutions for dissemination. Benefits to the U.S. accrue in the form of strengthened world markets, social and economic stability, as well as protection of tropical forests, genetic diversity and global climate.

A collection of studies explore the social and economic impacts of soil management research in the humid tropics. The studies use a variety of methods: surveys of rural households, tracer survey of program graduates, analysis of documents and secondary data sources, and site visits to primary and network research sites.

Coordinated studies using rapid impact appraisal surveys in Peru, Indonesia and Bolivia illustrate some of the benefits of soil management research and also some of the serious, unresolved social and technical problems. A twenty year history of collaborative research in Peru has produced a set of management options available to agricultural producers in the humid tropics. Unfortunately, turbulent political and economic conditions in Peru have constrained outreach operations and private investments in agriculture. In Indonesia, collaborative soil management research has been instrumental to the viability and sustainability of transmigration populations on acid, infertile lands. Research in Bolivia, in connection with the RISTROP network, is using, adapting and extending soil management practices to new lands and different socio-economic contexts.

Education and training are fundamental activities of the SM-CRSP. Education and training of U.S. and international students are improved by the global perspectives that come from collaborative research. A study combining surveys of current students and alumni reveal new perspectives about the educational program. The study profiles SM-CRSP students and alumni and describes their educational and post-educational experiences. The results provide a unique view of the program from the participant perspective and provide feedback to SM-CRSP program leaders and faculty for current and future program planning. Program graduates report retrospectively on the relevance of education to their career roles and responsibilities in international development. Current students report prospectively on the program as they prepare for future careers.

Program outreach involves communications with policy-makers, scientists, and special interest groups. Publications, site visits and networks are important means of outreach. Visitors received at research sites and requests for publications show that interest in the activities of the program is high and extends to other regions throughout the world. Networks extend the range of research and multiply the benefits. The coordination of researchers working across different sites enables the research methodologies to be tested and validated for a variety of user conditions. No single research team would be able to replicate the diversity and the depth of site experience that is represented by the collective action of the network.

Research and technology transfer are helping to develop attractive land use options that are applicable in the humid tropics. Adoptions of improved land use practices are beginning to have effects at the farm and community level. Still there remains a huge mismatch between the land's agronomic potential, as proven by research, and the social and economic capacity of people to use the lands in an environmentally sound and sustainable manner.

Results suggest that research is a necessary but insufficient part of development strategy. The benefits of collaborative soil management research and training, depend on the extent to which institutions, markets and policies are in harmony with technical recommendations. A coherent and articulated set of national policies, credit, market information, agroindustry and continued international investment in research and extension are needed to increase productivity and mitigate the continued environmental degradation and poverty pandemic in the humid tropics.

2. TOWARD SUSTAINABLE AGRICULTURE AND NATURAL RESOURCE MANAGEMENT IN THE HUMID TROPICS: ASSESSING THE IMPACTS AND CONSTRAINTS[1]

Frank J. Smith and T. Jot Smyth

Challenged by the goal of sustainable development, the international agricultural research system is attempting to restructure and revitalize itself. Applied research and technical support services are regarded by proponents as powerful instruments for alleviation of a related set of environmental, economic and social problems (Figure 1). External demands are driving research to be more multidisciplinary, more agro-ecological, more collaborative, more oriented to serve client/user needs and more responsive to social and economic realities of developing countries. Future research is expected to accommodate these demands within the constraints imposed by budgets. The implications for research management clearly are that we need a new research framework, tools, design standards, measures of program impact and strategies to facilitate technology-based, sustainable social and economic well-being. Traditional concepts and measures of research productivity are no longer sufficient for monitoring and managing research programs which depend on dynamic interactions between agronomic, economic and social factors. Continuous quality improvement in research and technical services requires the development of new information systems guided by the knowledge accumulated through research and indigenous experience. It is in this context and with these premises that this paper reviews the impacts and constraints of a leading research program for soil management in the humid tropics.

In cooperation with the U.S. Agency for International Development (USAID) the Soil Management CRSP was established in 1981 with the goal to develop and adapt improved soil management technology that is agronomically, ecologically and economically sound for developing countries in the tropics (SM-CRSP, 1988). In order to achieve this worthy goal the SM-CRSP has lead a multi-institutional collaborative effort on research and training in soil management. The research program has three major thrusts: natural resource management, sustainable development, and outreach.

The SM-CRSP is one of 13 CRSPs supported by the U.S. Agency for International Development (USAID) and one of four CRSPs working in the humid tropical ecosystems around the world (CRSP Council, 1990). The humid tropics is that portion of the tropics where there is no more than a three-month dry season and temperature is not a limiting

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factor to plant growth. The native vegetation is tropical rainforest. Soil acidity and nutrient deficiencies (Cochrane and Sanchez, 1982) and weeds (Mt Pleasant et al., 1990) are common constraints to sustained crop production. Less is known about social and economic constraints, and more specifically (a) what are the strategies that will enable farmers to make the difficult transition from traditional practices of "slash and burn" to land use options that are productive and sustainable, and (b) how can collaborative research facilitate technology transfer?

This paper reviews the available data and methods for assessing the impact of agriculture research and finds them inadequate for the expanding scope of research oriented toward sustainable agriculture and natural resource management in the humid tropics. With this backdrop, the paper describes a pragmatic attempt to develop quantitative and qualitative evidence of the socio-economic impacts and constraints of the Soil Management Collaborative Research Support Program (SM-CRSP) since 1981. Based on the findings and experiences in many countries, the paper concludes with observations about constraints and suggestions for future programming including general conceptual and operational design for a new research management information system.

LAND USE SYSTEMS AND DECISION SUPPORT TOOLS

The SM-CRSP has helped produce and field test alternatives to traditional shifting cultivation and pasture systems (Sanchez et al.,1990). Improved land use systems are intended to match the different needs and conditions of the landscape and the socio-economic milieu as follows:

Paddy rice systems are recommended for sustained production of irrigated rice in alluvial soils. General features of the systems include: a) land clearing by slash and burn or bulldozer with shear blade; b) five crops in a two year period with recommended short-stature varieties yielding 12-15 ton/ha/yr; c) supplemental irrigation every two weeks; d) minimal fertilization; and e) transplanting for the first two crops with the option of broadcast seeding in subsequent crops.

High-input systems are designed to manage soil constraints to continuous crop growth by appropriate levels of liming, fertilization, or other factor inputs in areas with sufficient road, credit and market infrastructure to make this possibility attractive (Sanchez et.al., 1990). These are intensive, fertilizer-based, continuous cropping systems which often require mechanized tillage. This is the type of agriculture used for commercial food production in the U.S.

Low-input systems are based on the cultivation of plant species adapted to the principal acid soil constraints. These systems seek to maximize nutrient recycling and minimize, but do not necessarily eliminate, purchased inputs (Sanchez et.al., 1990). The selection of acid-tolerant strains, residue return, and the absence of tillage are important features of this system. Also included is the use of mulches and/or manures, nitrogen-fixing cover crops, and fertilizer and pesticide applications when needed. The low-input system is considered a transitional technology because weed control problems limit the stability of this system in the long term. Within the pool of native soil nutrient reserves, phosphorus is the first element to need replenishment.

In Yurimaguas, Peru a recommended low-input cropping system includes a kudzu fallow, a rotation of acid-tolerant rice and cowpea cultivars, crop residue return, chemical control of weeds and pests, and the use of small amounts of fertilizers. While low-input cropping is considered transitory, the low-input cropping system has remained productive much longer than expected. Seven continuous crops in three years have yielded a total of 13.8 tons per hectare of rice and cowpea grain. Purchased chemical inputs account for only 8% of total production costs. Removing only the grain enhances nutrient recycling values of main elements except for phosphorous (SM-CRSP, 1989).

Agroforestry systems combine trees of food or wood value with annual crops and/or animals on the same piece of land either spatially or temporally (Sanchez et al., 1990). The planting of a rapidly established ground cover crop to decrease soil erosion and suppress weeds is an important feature of the agroforestry system. Alley cropping systems involve the production of annual crops between hedges of leguminous (N-fixing) trees. Mulch from periodic pruning of the trees is applied to alleys where crops are grown.

Legume-based pastures use a combination of forage legumes with grasses that are tolerant to acid conditions. Maintenance fertilization and grazing rotations are important management features for prolonging pasture productivity (Lara et al., 1991; Castilla, 1992).

Recuperation of eroded steeplands in areas of steep slopes (≥30%) and high rainfall is achieved using selected ground covers and multipurpose trees. For example, it may include the planting of a creeping, acid-tolerant legume or stoloniferous grass species followed by acid tolerant and commercially valuable tree species, such as coffee or achiote.

The SM-CRSP has also pioneered the development of decision-aids and problem solving tools that help farmers systematically diagnose and remedy problems that are largely site-specific.

Fertility Capability Classification (FCC) is a land use classification system. The FCC system focuses on the upper portion of the soil where plant root activity is greatest and where management practices are most influential (Buol, 1987). Attention is given to those physical and chemical factors within the plow layer which have a primary influence on plant growth and responsiveness to management. Farmers and planners can use results of FCC classification to select areas for farming.

Acidity Decision Support System (ADSS) and Phosphorus Decision Support System (PDSS) are computer programs for diagnosing and evaluating the impact of soil acidity or phosphorus deficiency in a farmer's field or site (Sofyan et al.,1991; Sigman et al., 1991; and Yost et al., 1991). They enable the user to determine what corrective measures are needed and what the estimated economic consequences of those measures would be. The ADSS determines how much

aluminum in the soil needs to be neutralized with limestone in order to reduce Al toxicity so that the selected crop can produce its maximum yield. The PDSS estimates how much fertilizer P should be added to correct for P deficiency.

These management options and problem-solving tools have the potential to positively transform social, economic and environmental trends. However, acceptance of technological innovation is not automatic or certain. National institutions and private sector organizations play a critical role in technology transfer. The challenge for the SM-CRSP is to facilitate exchange of information and promote greater understanding of problems and technical solutions between researchers and the national institutions that have a mandate to serve farmers, policy-makers, and other client groups. Relevant research questions are: (a) what are farmers perceptions of alternative technology, (b) what factors influence technology adoption and utilization, (c) what are the salient concerns and constraints effecting production, and (d) what distinguishes between farmers who are adopters and nonadopters?

EVALUATING THE RETURNS TO AGRICULTURAL RESEARCH AND EXTENSION

Thirty years of studies have assessed the impacts of agricultural research and extension. According to Ruttan (1987) evaluation methodologies have evolved through three relatively distinct phases: a) early studies examined the effects on shifts in production and supply functions of agricultural commodities; b) then studies began to address the effects of human capital, technology, and infrastructure; and c) research began attempts to understand how technology influences production and applications to neglected areas such as forestry, postharvest handling and social systems. In recent years, the clear emphasis on sustainable agriculture and natural resource management requires further development of measures and methods of program evaluation based on a broader conceptualization of the scope and impact of program activities.

A number of approaches have been developed and used to assess the impact of research and extension. They represent different options and possibilities for application with or without modification to the case of sustainable agriculture and natural resource management. They are described as follows:

The <u>economic-surplus (ES) approach</u> estimates returns on investment by measuring the change in consumer and producer surplus from a shift to the right in the supply curve due to technological change (Evenson et al., 1979; Ganoza, 1990). The ES approach, based on price theory, yields estimates of returns on research investment from supply and demand elasticity and equilibrium prices and quantities before and after the supply shift resulting from research-induced changes in production technology. The main advantage of the economic-surplus approach is that it allows the distribution of benefits between producers and consumers which has important development and policy implications if the product is being sold in the market. However, in the case of the predominantly small farmers of the humid tropics, most production is consumed by the household -- the producing farmer is the principle consumer. Supply and demand elasticities and equilibrium prices are difficult to obtain for local markets.

The econometric (EC) approach constructs production, profit and supply functions and computes coefficients of the marginal effects of fixed and variable inputs (Griliches, 1964; Norton, 1981). A particularly useful formulation is a utility function that specifies the expected returns to different management decisions. Substantial knowledge is required in order to specify the econometric model. The econometric method is a more rigorous empirical analysis of the impact of research on output, but it requires systematic data series on inputs and outputs over an extended period of time. The EC approach is widely used for commodity-based programs where there is adequate data series for factor and product variables. The EC approach is problematical when applied to resource management research and training, where benefits are diverse, difficult to measure, and lag over long time periods.

The cost/benefit (C/B) approach computes time-adjusted net benefits received. The C/B approach can be used for analysis of a single production unit or production aggregates. Management strategies can be based on one or more of the following: a) reduce input costs, b) increase benefits, c) reduce time to payoff, and d) delay of input costs. Computation of the internal rate of return (IRR) has become a common standard for evaluation of programs. Net benefits are discounted at a rate (r) which produces zero net benefit as follows:

$$\text{SUM } t=0\text{-}n \ (B_t - C_t)/(1 + r)^t = 0.$$

The value, r, is a nominal rate of return and therefore it should be judged relative to prevailing interest rates or returns from other investment alternatives.

The yield gap approach compares the differences in productivity of traditional practices and improved practices based on research (Ganoza, 1990). The yield gap is created and enlarged by investment in research. The yield gap is narrowed as producers assimilate improved practices demonstrated by research. Investments in extension help producers "catch-up" with the productivity standards demonstrated through research. Information about the size of the gap has important policy implications because if the gap is large, it implies a need for additional emphasis on extension programs. If the gap is small, it implies a need to allocate time and resources to developing new technologies through research. Research and extension are complementary elements in the development process.

The diffusion/adoption approach is based on more than 30 years of international field studies on innovation and development (Rogers, 1983; Herdt et al., 1983). Diffusion/adoption studies have looked at technology diffusion in relation to personal characteristics of the farmers/decision-makers, the technology, change agents and their interaction. Adoption refers to a decision by an individual, household or organization. The aggregate levels of adoption over time can be represented in a diffusion curve. Many studies have shown the plot of the cumulative adoption over time takes the form of an S-shaped (sigmoid) curve. General models of the diffusion process (Mahajan and Peterson, 1985) represent the level of adoption as a function of the total number of potential adopters in the social system (N'), an external factor (a), and internal factor (b), as follows:

$$dN(t)/dt = (a + bN(t))[N'-N(t)].$$

In practice the external factor is typically represented by expenditures for outreach activities, extension, and mass media. The internal factor captures the influence of interpersonal communication and interaction between prior adopters and potential adopters in the social system. Using time-series data on the number of adoptions in a minimum of three time periods, one can estimate coefficients of internal and external influence. Figure 2 presents the diffusion trajectories for different levels of the coefficients "a" and "b." It can be observed that the effect of "a" is greatest in the initial period of diffusion when the number of prior adopters is small; conversely the effect of "b" increases over time as the number of adopters increases.

Many factors may effect the rate of diffusion of innovations. Differences in technology adoption and utilization between regions reflect cultural, social and landscape differences. Differences in technology adoption and utilization within a region of relatively homogeneous culture, social structure, and landscape reflect psychological differences in frames of reference, values, resources, and perceptions of risks and rewards of the technology relative to the market. Analysis of indigenous practices gives clues to the attributes and processes of farmer decision-making.

Table 1 presents a summary of research on the returns to investment in agricultural research in the humid tropics. The results are based on agricultural performance in different countries, using different methods, making different assumptions and based on different time periods. In consideration of these differences, it is striking that the results show a rather consistent and positive impact of research and extension. Although helpful, these studies give an incomplete accounting of the returns to research because most evaluations are narrowly focused on changes in agricultural output. The studies do not address issues of equity (e.g., distribution of the returns between small and large farming units); sustainability of returns; or social and environmental implications. The challenge for researchers is to extend the scope of study to include the diversity of impacts attributable to research and extension.

CONCEPTUAL FRAMEWORK FOR IMPACT ASSESSMENT

A multidisciplinary research group was formed to plan and implement a socio-economic impact assessment of the Soil Management CRSP. To help orient the impact assessment and identify existing information, the team reviewed SM-CRSP program documents and conducted interviews with SM-CRSP faculty at NCSU. Included among the documents reviewed was a report of an external evaluation team (Coulter et al., 1988). The previous evaluation was oriented to issues of reorganization and tactical use of scarce resources. It recommended that research programs be reoriented over the subsequent years with greater effort going towards output of new technologies and methodologies. It also made a number of recommendations that, if followed, would facilitate impact assessment: "...all future project reports must include a statement of the significance of the accomplishments of each project. Each report should also include a statement of the accomplishments of the university/host country program to that date, the significance of those accomplishments, and an indication of potential

accomplishments in the next 3 to 5 years. Reports should give a clear indication of what portion of the research being reported is supported by the SM-CRSP."

From program papers and interviews elements of the SM-CRSP strategy were revealed. The elements then were organized by the team to create a conceptual framework (Figure 3) for assessment of the social and economic impacts. The conceptual framework serves to identify, group, and order the program elements: inputs, processes, products and impacts.

Program inputs include human resources, capital and information of the participating CRSP institutions. North Carolina State University and University of Hawaii have been primarily oriented toward research in the humid tropics while Texas A&M and Cornell have concentrated on other ecosystems. This report, therefore, will focus on the inputs, processes, products and impacts of NCSU and Hawaii. At present there is no itemized system accounting for the program inputs allocated or expended for different programs, processes, products, or impacts. Also, systematic and reliable information on the capital and in-kind contributions of collaborating institutions and countries are unavailable. This information would have to come from improvements in the information systems of the collaborating institutions. Until full cost accounting information can be obtained, analyses of returns on research investments will be incomplete.

Program processes of the SM-CRSP are based on a philosophy that research, development, education and outreach are mutually complementary activities. Knowledge is generated through a collaborative research process involving scientists and students from U.S. and international institutions. Outreach is a relatively new activity that consists mainly of communications with client groups and networking with national and international institutions to obtain the benefits of synergy and disseminate methods, results, and recommendations. SM-CRSP outreach is not designed for direct service to farmers, but rather to national organizations and nongovernment organizations who serve farmers. In practice, it is difficult to isolate and evaluate the separate effects of training, research, and outreach.

Program products include the Ph.D.s graduated, cultivars selected, technical systems developed, publications authored, and laboratories equipped. These products are relatively easy to count, but it is very difficult to quantify their utilization and effects on ecological, agronomic, institutional, economic and social measures.

Research impacts are environmental, economic, social, and institutional. The benefits are in part private and part social. They are both local and global. The impacts may lag and accrue over many years. Research impacts depend on the local capacities to apply and extend knowledge. Science offers multiple options for use of soil resources. Narrowly focused studies of selected commodities, represent only part of the total benefit of research in soil management. Collaborative international research has impact most directly at the institutional level (Horton, 1990). There is no single or limited set of quantitative measures that captures the magnitude and diversity of the SM-CRSP impact, but systematic collection of a selected set of impact measures and development of an impact index will be an important part of future research on sustainable development. A challenge to researchers, therefore, is to enlarge the scope and measure of impact assessment which will serve the interests of policy-makers, program planners, investors

and others. Toward this end, the general design of a research management information system is proposed. Impact indicators and measures are suggested in Table 2.

TOWARD A MANAGEMENT INFORMATION SYSTEM

International agencies collate estimates of the national and sectoral aggregates for many of the measures listed in Table 2. National estimates may serve as important points of reference, but cannot accurately reflect program impacts or constraints where the impact areas are defined by landscape and socio-economic parameters and not by national boundaries. It is, therefore, necessary to develop and apply appropriate measures of impact locally. Development of appropriate measures of local impact through collaborative research would provide much needed standards for the analysis of variation of program results within nations and comparison of program results across sites. Once developed, the systematic and repeated use of measures would enable monitoring and dynamic analyses of the multiple influences of programs and site characteristics. Questions of sustainability could then be subjects of quantitative analysis.

Development of appropriate measures would also be an important step toward the creation of a management information system that would facilitate the global mandate of the SM-CRSP. The impact measures would provide the substance for the design of a multi-purpose research management information system. The structure of the management information system would be composed of a set of files which are cross-referenced, linked and related using available data base software. The system would serve the multiple uses of research managers, scientists, and clients. Because impact measures would serve a variety of development interests, it is reasonable to expect inter-institutional cooperation and collaboration in the design and data collection. The contents in Table 3 are tentative and presented only to illustrate possibilities.

SITES AND METHODS

A multi-site, multi-method research strategy (Figure 3) was planned to produce information relevant to the elements and impacts identified in the conceptual framework. The variety of methods used at each country-site elicited data from individual farmers, observations and insights of regional research and extension service professionals, and national program overview from national and international leaders and policy-makers. In this way, the researchers hoped to achieve some convergence and cross-validation of findings from different sources for each site. Across site comparisons are more difficult to interpret, but they reveal differences that are attributable to a mix of social, cultural and landscape factors. From these methods, we can also glean some useful indications about what kinds of information are most useful for impact assessment, what are the difficulties in elicitation of reliable and valid information and what measures have most potential for inclusion in a SM-CRSP management information system.

Sites

Visits were scheduled to gather information in selected international agricultural research institutions and host country institutions. Visits were made to a) two SM-CRSP primary research sites (Yurimaguas, Peru and Sitiung, Indonesia) to obtain information and plan field activities with site coordinators; b) six extrapolation/network sites to see

how soil management technology is being replicated and adapted to site-specific requirements; c) ten workplaces of SM-CRSP alumni to interview alumni with respect to their roles and impacts; and d) six collaborating international institutions to determine the extent to which they are using SM-CRSP methods. A listing of research sites and collaborating institutions is presented in Table 4.

At each site available documents were reviewed and interviews were conducted. Deficiencies in systematic data on socio-economic impact was unfortunately common to all sites. Information systems need to be designed and built. Site visits often provided an opportunity to renew contacts with program alumni and verify information obtained from the tracer survey. The site-visits served the purpose of raising the consciousness about the importance of collecting systematic socio-impact data.

Impact Surveys

In order to begin to address the deficits in available socio-economic information about CRSP impacts three rapid impact surveys were planned and implemented. Sites were the regions of influence of the Yurimaguas and Sitiung research stations and the network site in the Chapare region of Bolivia. The surveys generated data in the three sites on questions of demographics, land use, and constraints to adoption of soil management options. In addition, each survey explored questions of special interest to the site collaborators. In Yurimaguas the survey explored in depth the use of forests, forest products and agroforestry. In Sitiung the survey was structured to provide preliminary information on four land use options being developed and promoted in the area: paddy rice, upland rice, alley cropping and an agroforestry system of rice and rubber. In the Chapare of Bolivia the particular concern was for the development and promotion of alternative technology based on soil management and the reduction of slash and burn and cultivation of coca.

Educational Impacts

Educational program impacts were assessed principally by a tracer study of SM-CRSP alumni and a survey of current Soil Science students at NCSU. Both quantitative and qualitative data were produced that related to educational processes and post-graduate activities.

Outreach

Outreach activities of the CRSP were quantitatively evaluated by frequency analyses of publication requests received, the register of official visitors received at research sites and the scope of network activities. The visitors registry at the Yurimaguas research station provided a unique historical record of visitors, their place of residence, the purpose of their visit and their profession.

SUMMARY OF IMPACTS

Evidence of soil management impacts in the humid tropics is limited, because systematic measures of impact have not been collected as part of on-going research activities. However, from the combination of ex-post methods described above some tentative results and conclusions are summarized below. The results are summarized by impact category, following the conceptual model.

Agronomic Impacts

Changing land use practices are evident in all sites studied in the humid tropics but with variations that reflect local traditions, differences in landscape and social and economic characteristics. In Yurimaguas, Peru, uncertainty and socioeconomic hardship aggravated by political turmoil, terrorism, macroeconomic adjustment programs including the closure of the Agrarian Bank have been dominating influences in the region during the 1980s and 1990s. In this context the land use options developed by the SM-CRSP are contributing to incipient innovation and diversification of local production.

The paddy rice double cropping system has been widely adopted in the fertile flood plains of the Amazon basin of Peru. Approximately 13,000 hectares are currently using this system in Alto Mayo, central and upper Huallaga, and Yurimaguas. Average farm yields are 5000 kg/ha. It is estimated that the paddy rice system can be expanded to 100,000 hectares in the region. As a result of the high diffusion and adoption, the production of rice in the humid tropics of Peru have increased 40% in the last ten years (INIAA, 1991).

In Peru, the high-input system has proven to be sustainable over a sequence of 37 cropping cycles (Sanchez et al., 1990). Average soybean yields of 2.5 t/ha are approximately equal to yields achieved in the U.S. Corn yields are high for the area. One indicator of the adoption of high-input systems is the increasing mechanization of production. In 1972 there were only 2 tractors in the Yurimaguas region; in 1993 there are more than 30 tractors. The recommended applications of fertilizer and lime are widely followed in Pucallpa and in the area of influence of the USAID special project in the upper Huallaga valley, where dolomitic limestone deposits near Tingo Maria are being mined to supply farmers. The high-input system also has encouraged improved tillage practices. With heavy rains, traditional tillage (disc plowing) contributes to soil erosion. Minimum and zero tillage represent important advances in the area.

For the infertile and acid soils of the humid tropics where infrastructure in roads, markets, and credit is deficient, the low-input systems provide modest increases in net benefits to adopting farmers. The system is not sustainable for more than three years but in comparison with the traditional system of shifting cultivation it extends the productive use of land. It serves as an intermediate technology that offer farmers an improved return during the transition period while tree crops and pastures are being established. The low-input system eventually fails due to increased weed pressure and declining soil fertility. Use of legume cover crops can delay weed infestation and soil nutrient depletion.

Pastures associations of grasses and legumes are being promulgated within the humid tropics. These systems have the capacity to produce 400 to 800 kg/ha/yr in a sustainable system with a land carrying capacity of 4.5 animals/ha (Castilla, 1992). Farmer adoption is indicated in area surveys and confirmed by the increasing demand for improved seed for pastures. The improved pasture technology assures that land degradation attributed to expansion of traditional pastures in Brazil will not be repeated.

Several agroforestry systems hold potential for sustainable development in the humid tropic regions. One example is peach palm (*Bactris gasipaes*) which is tolerant of the acid soil conditions. Peach palm begins to bear fruit in the fifth year after planting and will continue to produce for a period of 15 to 20 years (Villachica, 1990). The nutritional value of the fruit is equal to or better than corn. The heart of palm (germ stem)

is another product which has an established international market. A local industrial processing capacity is needed to assure producers of a stable market.

In Sitiung, Indonesia extensive work has led to recommendations and new outreach technology for overcoming soil fertility constraints in the transmigrations areas where large-scale bulldozing of primary tropical rainforests had severely affected soil productivity (Wade et al., 1988). The goal was to make sustained production of basic food crops possible by improved soil management following principles developed in Yurimaguas and elsewhere. Although some of these soils were so affected by improper land clearing that not even weeds could grow, they were readily transformed into successful upland rice-soybean production systems with the judicious use of lime and fertilizer. Unlike similarly affected sandy Ultisols and Alfisols in South America and Africa, where physical land reclamation is needed, only chemical reclamation was necessary for these well-structured clayey Oxisols and Ultisols. The use of organic inputs, such as crop residues and *in situ* green manure crops, helped decrease lime, fertilizer and weed control requirements.

The soil management practices developed in Yurimaguas, Peru and Sitiung, Indonesia are now widely disseminated through research networks and outreach activities. They constitute the base knowledge for much of the on-going research and development in the extrapolations sites in Bolivia, Brazil, Costa Rica, Paraguay and Zambia.

Economic Impacts

Economic returns to producers from improved soil management practices are generally superior to traditional practices and, perhaps even more important, they constitute an important transition toward a more intensive, profitable and sustainable system of production. A summary of the economic returns of land use options is presented in Table 5. The summary presents the returns achieved in experimental plots (Sanchez & Benites, 1987; Villachica, et al., 1990) and in farmers fields (Chapters 3 and 5 of this report). Internal rates of return to soil management options generally are positive and superior to traditional practices. Net present values obtained from low-input systems generally are modest and much of the production is consumed by the household leaving little or no surplus for investment. A feasibility study suggests that significant gains to farmers and technical assistance providers are possible through contract mechanisms (Castedo, 1993). Economic research is needed to further explore the elasticities of factor and product prices in local markets.

Scales of production are generally small in part because access to capital is very limited. Surveys of farmers indicate that labor is the principal factor constraint in low-input and agroforestry systems. Most labor is supplied by the producer household. Contract labor tends to be somewhat more available in Indonesia than in Peru, where producers rely more on an informal system of reciprocal labor cooperation between neighbors.

Producer access to product markets in the humid tropics is difficult. Even in Indonesia where development in the transmigrant areas is more concentrated, market infrastructure and transport is minimal. In the Amazon basin population densities are much less and production areas are scattered along river or road arteries. Under these

conditions, most production is consumed by the household and any surplus is traded in local markets.

Analyses of economic impacts are constrained by the lack of reliable and systematic data on farm production, farm management and factor and product markets. Farmers are keenly aware of market imperfections and make their production decisions accordingly. Economic impacts of new production technology are constrained by market capacities. Consistent with the recommendations of Day (1992), future research should provide balance on consideration of the technical aspects of both supply-side development strategies based on transfer of production technology and demand-side marketing strategies.

Social Impacts

In the humid tropics much of total production is consumed locally, and overdependence on traditional low valued grain (principally rice and corn) contribute to inadequate diet and poor health profiles. Protein deficiency is particularly acute, with adverse consequences for human growth and productivity. Low-input management options are targeted to poorer farmers in order to improve soil fertility and human nutrition. Incorporation of leguminous crops into the farming system serves the dual objectives of improving and sustaining commodity yields while at the same time introducing new food commodities which increase food energy and protein (Table 5). In farm surveys nutritional benefits are mentioned by more than one third of farmers as reasons for adoption of leguminous crops. Intercropping systems tested produce a desirable balance of carbohydrate, protein and fat for subsistence level farm families (Benites, 1981). This balanced production is most beneficial to families relying entirely on self-produced food. Where there is adequate transport infrastructure and market access, the same balance could be achieved more profitably and efficiently by growing the required areas of each crop in rotational monocultures or in continuous corn with fertilization.

During the decade of the 1980's the traditional production of coca leaf was expanded by increased international demand. In Bolivia coca production skyrocketed from approximately 20,000 tons to 160,000 tons annually. Between 50,000 and 70,000 families migrated from the highlands to the tropical forest areas where they depend on coca cultivation for their livelihood. In Peru, the magnitude of coca production is much greater and its illicit revenues support both institutional corruption and terrorism.

Cultivation in coca has been responsible for much of the deforestation in the humid tropics of Bolivia and Peru. Hundreds of thousands of hectares of virgin rain forest have been cleared for coca production, degrading the environment and diverting resources from food production. Government strategies to control coca production by force alone have had very limited impact on total production, because without knowledge of viable alternatives, farmers necessarily persist in growing coca. Attempts to discourage further migration to coca areas by withholding government transportation, health and education services only further marginalizes this population and diminishes access to alternative technology.

The SM-CRSP in collaboration with the Bolivian Institute for Agricultural Technology has tested and promoted cropping systems to serve as alternatives for farmers who wish

to reduce their economic dependence on production of coca. A multistrata farming system offers farmers a more diversified base of production. Site visits and interviews (Sturm and Smith, 1993) have revealed that the required capital outlay, restricted credit access and expected profitability are the factors which most strongly influence farmers' adoption decisions. Continuing technical assistance is needed to develop markets and policies which favor transition toward these sustainable production systems.

In Indonesia, research is helping to identify technical and socioeconomic factors which constrain agricultural production in the transmigration areas (Colfer, 1991; Chapter 5 of this report). Large numbers of Indonesian farmers are being relocated to less populated islands where they attempt to produce basic food crops on acid and infertile soils. Differences in characteristics of farm sites and farmer socioeconomic status require different management options. Four basic management options being developed in the region are paddy rice, low-input upland systems, alley cropping and agroforestry. In order to facilitate diagnosis and management in the region, decision-tools have been developed and validated for management of soil acidity and phosphorus deficiency.

Environmental Impacts

Poverty and environmental degradation are linked in a negative cycle in the tropics. Population pressures have created demands for food and fiber that have led to massive deforestation, decreased fallow periods, soil erosion, abandonment of lands and general degradation of the natural resource stocks. Degradation of the environment in turn limits future production and perpetuates rural poverty. The extent of environmental degradation is not well documented in terms of its social and economic consequences. This negative cycle, however, can be broken by improved soil management and appropriate development policies.

Sustainable management options can have the effect of reducing deforestation (Sanchez et al., 1990). Some management technologies are available while others are still evolving. For every hectare put under sustainable agriculture five to ten hectares of rain forests are saved each year.

Environmental impacts differ across research sites. Differences are apparent in the kinds and extent of degradation. In Indonesia and Brazil, population policies and government support for road construction and land clearing are well documented (Repetto and Gillis, 1988). In Bolivia and Peru, as previously mentioned, much of the influx of population and deforestation of the humid tropics has been fueled by the boom in illicit coca production for export. Development of alternative technology for coca producers represents a continuing challenge.

Policy Impacts

Development policy is inevitably shaped by political forces, but collaborative research can play an important role in informing decision-makers of the technical implications of the policy options. Also deficiencies or the absence of technical information can lead to misguided policy. Such was the case in Paraguay where transition to a high-input production technology with favorable terms of trade for imported fertilizer increased national wealth and reduced deforestation. More recently, uncertainties in land tenure policy have had overwhelmingly negative land use effects, as land was "improved" by clearing in order to establish property claims (Smith, 1992).

Land tenure is more clearly established in Indonesia than in the Amazon basin countries. In the transmigration areas landuse is restricted to small family plots (1 hectare). Under these circumstances land use is more intensive and sustainability has a different connotation than in the Amazon basin where land access is less restricted.

Landsat photography shows that over 72 percent of the deforestation in Brazil prior to 1980 was done to establish pasturage for cattle ranching. With generous incentives, investors cleared forest with bulldozers and expanded the population of cattle in the Amazon to almost 9 million head. Because of unimproved pasture technology and poor management these land are now badly degraded. The SM-CRSP has help to lay the technical foundation for new policies aimed at conserving primary forest and reclaiming degraded lands for productive use. In Brazil and Indonesia tax and credit policies have been reformed to better manage soil resources and discourage bulldozer use for land clearing (Repetto and Gillis, 1988).

Policies of technical promotion also vary by countries. In Indonesia, the extension system is centralized and controlled. Research findings are submitted for review and approval for dissemination through the national system. The collaboration between research and extension is more evident in Peru (ISNAR, 1985), Bolivia (Sturm and Smith, 1992) and Brazil (Flores, 1991).

Institutional Impacts

Building effective national capacity for science and technical support for a productive agriculture sector continues to be a principal part of a sustainable development strategy of the SM-CRSP. Graduate education and nondegree training in soil management are an integral part of the collaborative research process. SM-CRSP member-institutions have awarded more than 118 graduate degrees to persons representing 18 countries. A tracer study of SM-CRSP alumni (Chapter 6 of this report) indicates that ninety-six percent of the program participants completed their degrees and have accepted important roles and responsibilities internationally. Graduates and trainees share knowledge gained in CRSP programs with co-workers, students, government agencies, farmers and others, thus multiplying the benefits of training. The results provide a retrospective evaluation of the educational program and update on activities, achievements and impacts of alumni. A previous evaluation concluded (Gray et al., 1990) and this study (Chapter 6) confirms that SM-CRSP alumni continue to be an underutilized resource. Systematic collection of information from current students and alumni could facilitate overall program operations.

Outreach within the SM-CRSP activities includes communications, training, networking, and decision-support activities which facilitate knowledge and technology transfer to user groups. A recent study of SM-CRSP outreach suggests substantial demand for SM-CRSP publications (Chapter 7 of this report), and there appears to be a reasonable match between the investments in research and the topical demands for research programs. Visitors from all over the world have come to Yurimaguas for formal training and collaborative research. The guest register at the Yurimaguas experiment station shows 3,182 visitors between 1975 and 1990. Research methods and findings developed by TropSoils have been shared through international networks and they

provided substantive advancements for the transferal of knowledge on improved resource management and related subjects.

Analyses of other CRSP activities in the humid tropics reveal possibilities for future cross-CRSP collaboration. Cowpea used in low-input systems has both soil management and nutritional benefits. Adoption and impact could be enhanced with greater exchange of CRSP generated knowledge on selection, production and post-harvest use of cowpea. Nutrient management is a common theme of both the Soil Management and Pond Dynamics CRSPs. Animal production using improved pastures and agro-silvi-pastoral systems for infertile, acid soils is a natural area for collaboration between the Soil Management and the Small Ruminant CRSPs. Sustainable development is a concept that has universal acceptance among the CRSPS and merits collaboration on methods of impact assessment.

CONCLUSIONS

1. Largely untouched by the green revolution, millions of subsistence farmers of the humid tropics continue to slash and burn forests without awareness of alternative land use options. Population pressures combined with traditional slash and burn systems are perpetuating rural poverty, degrading the lands, and diminishing the prospects of sustainable development.
2. The social and economic impacts of the SM-CRSPs and other CRSPs in the humid tropics are varied. Impacts are economic, social, environmental, institutional and scientific and they vary with site and population characteristics. Improvements in impact measures, data collection and use of canonical models are required to capture the multiple dimensions of benefit that flow from soil management research.
3. Continued development of an impact-oriented, conceptual framework for the SM-CRSP is needed for analysis and interpretation of past research and to orient future research toward gaps in information and constraints to technology utilization. The conceptual framework also can be used to develop public appreciation for research and to promote a better alignment of public values and research priorities.
4. Research has opened-up substantial gaps between what is possible and what is common practice. These gaps represent potential economic returns for those who can apply and adapt generic technologies to the range of conditions and constraints faced by producers in the humid tropics.
5. Low-input technology provides an appropriate first step out of the vicious cycle of poverty and environmental degradation. Use of crop varieties which are tolerant of the main soil constraints is an affordable option for poor farmers. Incorporation of leguminous grains into the traditional farming system is an additional low cost strategy for increasing yields and extending the productive capability of the land, therefore reducing the need for deforestation of new land. Rice/cowpea systems produce a superior economic return and have nutritional benefits for consumers.

6. Continuous cropping is a viable option for producers in the humid tropics who have access to credit, markets and technical support. Continuous cropping substitutes capital (for mechanization) for labor.
7. Paddy rice systems are developed to take advantage of the natural wet lands and river flood plains of the humid tropics. Management of soil and water in paddy rice systems enable sustainable, continuous cropping. Yields of rice from paddy systems provide a superior economic return and thus present strong incentives for farmers to shift from traditional slash and burn to sustainable paddy systems.
8. Legume-based pastures are an improved low input-system for livestock producers. Adaptable to any scale, small farmers can benefit from this low-input technology.
9. Agroforestry represents a sustainable and diversified production system, that offers relatively attractive economic returns. It is a particularly appropriate technology as a productive buffer to protected watersheds, natural reserves and parks. Woodlots, living fences and alley cropping technology are being introduced and adopted by local populations. Costs of plant propagules and labor are principal constraints to their use by limited-resource farmers.
10. Soil management research tends to be site-specific. Site differences in soil, landscape, social and economic factors determine recommendations. Extrapolation to other sites is problematical. Adjustments in the technology are required in response to the unique set of physical and social factors in a region. Decision aid tools such as FCC, ADSS and PDSS help users tailor technical remedies to fit special needs and circumstances.
11. Labor is the primary input in most swidden farming systems. Forest clearing, at the present time is constrained principally by difficult land access, credit access and strenuous labor requirements. Road construction, credit policies and labor saving technology must be carefully evaluated for possible adverse effects on forest clearing. Labor quality is also a factor constraint. Productivity of labor is a problem and excessive dependence on child labor is common.
12. It was largely through the dedicated efforts of SM-CRSP researchers using a combination of research methods, ingenuity and pragmatism, that the lands of the humid tropics are now regarded as suitable for agriculture. Methodologies pioneered by SM-CRSP are available for monitoring technical factors of soil management systems, diagnosing problems as they occur, testing possible remedies, and determining the efficient levels of inputs. Comparable methodologies are needed for monitoring the social and economic factors, determining adoption constraints, identifying information needs, and assessing the effects of policies.
13. The Fertility Capability Classification (FCC), ADSS and PDSS are structured approaches which clarify the problems and management options available to researchers and producers. FCC has been adopted as a framework for the FAO international data base on land resources.
14. Social and institutional problems pandemic in the humid tropics represent barriers to rapid technology transfer. Governments have important roles to play in securing human and property rights, enforcement of contracts, building social infrastructure,

fostering conditions of free and competitive markets, access to education, health services, market information and investment in research for development.

15. Transaction costs are a major impediment to technology adoption. A feasibility study indicates that joint ventures between farmer/producers and private extension providers who manage transaction costs can generate substantial economic returns to both partners.
16. Adoption or rejection of new technology depends on available information. Recent settlers and those who participate in extension activities are significantly more likely to adopt recommended innovations in farming practices. Male and female heads of household participate in the decisions to adopt new technology. Consultations with neighbors and extension agents are also influential. There is little if any indication that farmers are resistant to innovation without cause.
17. Scarcity of well-trained scientists and insufficiency in institutional support for science-based development programs is a continuing problem. Education and training have long-term benefits for both U.S. and international institutions.
18. Outreach requires an unbroken chain of two-way communications between researchers and producers at all levels. National institutions need to find ways to stabilize and professionalize operations. Political and institutional failures obstruct the flow of benefits and impacts from research.
19. Traditional outreach activities are difficult in the humid tropics where communications infrastructure is deficient, travel is difficult, and where language and educational differences are impediments to mutual understanding. More user-oriented communications and problem-solving tools are needed. A more satisfactory integration of research and practice is needed based on explicitly stated program objectives.
20. Multipurpose information systems are lacking and are urgently needed by the SM-CRSP to better serve internal management requirements as well as better information services to potential users. The content and capacity of the information systems need to be planned with effective participation of collaborators and user groups. Program budgets and expenditures should be structured (itemized) by programs and objectives. Measures of program performance need to be specified in advance.

REFERENCES

Benites, Jose R. 1981. Nitrogen response and cultural practices for corn-based cropping systems in the Peruvian Amazon. Ph.D. Dissertation, North Carolina State University, Raleigh, N.C.

Buol, S.W. 1987. Fertility capability classification system and its utilization. p.317-331. *In* M. Latham (Ed.) Proceedings of the first regional seminar on soil management under humid conditions in Asia: Asialand, October 13-20, 1986. International Board of Soils Research and Management, Bangkok, Thailand.

Castedo, L, and D. Hoag. 1993. Technical, financial and marketing assistance to enhance farmer incomes in Bolivia: a feasibility study. M.S. Thesis, North Carolina State University, Raleigh, NC.

Castilla, C.E. 1992. Carbon dynamics in managed tropical pastures: the effect of stocking rate on soil properties and on above- and below-ground carbon inputs. Ph.D. Dissertation. North Carolina State University, Raleigh, NC.

Cochrane, T.T. and P.A. Sanchez. 1982. Land resources, soils and their management in the Amazon region: a state of knowledge report. p.137-209. *In* S.B. Hecht (ed.) Amazonia: agriculture and land use research. CIAT, Cali, Colombia.

Colfer, C.J.P. 1991. Toward sustainable agriculture in the humid tropics. TropSoils Bulletin Number 91-02.

Coulter, J., P.E. Hildebrand, M.D. Thorne, and S.L. Rawlins. 1988. TropSoils External Evaluation, 1986-1987. Soil Management CRSP, North Carolina State University, Raleigh, NC.

Day, J.C. 1993. The Soil Management CRSP plan: perspectives from resource economics. pp.51-54. *In* Workshop record: the Soil Management CRSP global planning session, January 25-28, 1993. Soil Management CRSP, North Carolina State University, Raleigh, N.C.

Echeverria, R.G. 1990. Assessing the impact of agricultural research. *In* R.G. Echeverria (ed.) Methods for diagnosing research system constraints and assessing the impact of agricultural research. International Service for National Agricultural Research (ISNAR), The Hague, Netherlands.

Evenson, R.E., P. Waggoner, and V.W. Ruttan. 1979. Economic benefits from research: an example from agriculture. Science 205:1101-1107.

Flores, M.X. 1991. Projeto EMBARPA: A pesquisa agropecuária rumo ao século XXI. EMBRAPA, Secretaría de Administração Extratégica, Brasilia, DF.

Ganoza, V.G., G.W. Norton, C. Pomareda, R.E. Evenson, and E. Walters. 1990. Evaluating agricultural research and extension in Peru. *In* R.G. Echeverria (ed.) Methods for diagnosing research system constraints and assessing the impact of agricultural research. International Service for National Agricultural Research (ISNAR), The Hague, Netherlands.

Gray, C.C.; W.E. Larson and P.F. Pratt 1990. Report of the external evaluation panel. Soil Management CRSP, North Carolina State University, Raleigh, N.C.

Griliches, Z. 1964. Research expenditure, education and the aggregate agricultural production function. American Economic Review 54:961-974.

Herdt, R.W. and C. Capule. 1983. Adoption, spread, and production impact of modern rice varieties in Asia. International Rice Research Institute, Los Banos, Philippines.

Horton, D.E. 1990. Assessing the impact of international research: concepts and challenges. *In* R.G. Echeverria (ed.) Methods for diagnosing research system constraints and assessing the impact of agricultural research. International Service for National Agricultural Research (ISNAR), The Hague, Netherlands.

INIAA. 1991. Generacion de tecnologia agricola para el tropico humedo. Proyecto Suelos Tropicales, Yurimaguas, Peru.

ISNAR 1985. INIPA's response to Peru's needs for agricultural research and extension. Report No. R22e for the Government of Peru, Lima.

Lara, D., C. Castilla, and P. Sanchez. 1991. Productividad y persistencia de pasturas asociadas bajo pastoreo en un Ultisol de Yurimaguas. pp. 86-89. *In* T.J. Smyth,

W.R. Raun, and F. Bertsch (eds) Manejo de suelos tropicales en Latinoamerica. North Carolina State University, Raleigh, N.C.

Mahajan, V. and R.A. Peterson. 1985. Models for innovation diffusion. Newbury Park: Sage Publications.

Mt Pleasant, J., R.E. McCollum, and H.D. Coble. 1990. Weed management in a low-input cropping system in the Peruvian Amazon region. Trop. Agric. 69:250-259.

Norton, G. and J. Davis. 1981. Evaluating returns to agriculture research: a review. American Journal of Agricultural Economics 63(4):685-699.

Repetto, R. and M. Gillis. 1988. Public policies and the misuse of forest resources. World Resources Institute, Cambridge University Press, Cambridge.

Rogers, E.M. 1983. Diffusion of innovations. (3rd Edn.) The Free Press, New York.

Ruttan. V.W. 1987. Future research evaluation needs. *In* W.B. Sundquist (ed.) Evaluating agricultural research and productivity. Miscellaneous Publication 52-1987. Minnesota Agricultural Experiment Station, University of Minnesota.

Scobie, G.M. and T.R. Posada. 1978. The impact of technical change on income distribution: the case of rice in Colombia. American Journal of Agricultural Economics 60:85-92.

Sanchez, P.A., C.A. Palm, and T.J. Smyth. 1990. Approaches to mitigate tropical deforestation by sustainable soil management practices. *In* H.W. Scharpenseel, M. Schomarker and A. Ayoub (eds.) Soils on a warmer earth. Elsevier, Amsterdam.

Sanchez, P.A. and J. Benites. 1987. Low-input cropping for acid soils of the humid tropics. Science 238:1521-1527.

Sigman, V.A., T. Dierolf; A. Sofyan, L. Arya, I.P.G. Widjaja-Adhi, S. Itoga, A. Istiqlal, Z. Li, M. Oka; R. Yost, and Yunizar. 1991. Decision support systems for diagnosing and recommending economically feasible, farmer-acceptable, and environmentally safe, soil-management practices. pp.332-340. *In* T. McBride (ed.) TropSoils technical report, 1988-1989. Soil Management CRSP, North Carolina State University, Raleigh, NC.

Smith, F.J. 1992. Social and economic impacts of soils research in the tropical savannas: case studies from Brazil, Paraguay and Zambia. Technical report prepared for USAID under subgrant to North Carolina State University, Phsychology Department, Human Resource Development Program, North Carolina State University, Raleigh, N.C.

Soil Management CRSP. 1988. TropSoils Administrative Report, 1981-1986. Soil Management CRSP, North Carolina State University, Raleigh, N.C.

Soil Management CRSP. 1989. TropSoils extension proposal, 1989-1994. Soil Management CRSP, North Carolina State University, Raleigh, N.C.

CRSP Council. 1990. Global research for sustainable food production. USAID, Bureau for Science and Technology. Washington, D.C.

Soil Management CRSP. TropSoils Technical Report, 1988-1989. North Carolina State University. Raleigh, NC.

Sofyan, A. L. Arya, I.P.G. Widjaja-Adhi, S. Itoga, A. Istiqlal, Z. Li, M. Oka, V. Sigman, R. Yost, and Yunizar. 1991. pp.326-332. *In* T. McBride (ed.) TropSoils technical report, 1988-1989. North Carolina State University. Raleigh, NC.

Sturm, L. and F.J. Smith. 1993. Bolivian farmers and alternative crops: some insights into innovation adoption. Journal of Rural Studies 9(2):141-151.

Villachica, H., J.E. Silva, J.R. Peres, and C.D. Magno. 1990. Sustainable agricultural systems in the humid tropics of South America. Soil and Water Conservation Society, Ankeny, Iowa.

Wade, M.K., D.W. Gill, H. Subagjo, M. Sudjadi, and P.A. Sanchez. 1988. Overcoming soil fertility constraints in a transmigration area of Indonesia. TropSoils Bulletin No. 88-01. Soil Management CRSP, North Carolina State University, Raleigh, N.C.

Yost, R., T.J. Smyth, S. Itoga and Z. Li. 1991. Uso de sitemas de apoyo-decisión para hacer recomendaciones de cal y fósforo. pp.177-185. *In* T.J. Smyth, W.R. Raun, and F. Bertsch (eds) Manejo de suelos tropicales en Latinoamerica. North Carolina State University, Raleigh, N.C.

Table 1. Summary of returns from investments in agricultural research and extension in the humid tropics, 1975-1990.

SOURCE	PERIOD	COUNTRY	COMMODITY	METHOD	IRR[a]
					%
Monteiro, 1975	1923-1985	Brazil	Cocoa	ES	19-20
Pee, 1977	1932-1973	Malaysia	Rubber	ES	24
Herford, 1977	1957-1980	Colombia	Rice	ES	60-82
Herford, 1977	1960-1980	Colombia	Soybean	ES	79-96
Evenson & Flores, 1978	1950-1965	Asia	Rice	EC	73-78
Flores et al., 1978	1966-1975	Philippines	Rice	EC	46-71
Scobie, 1978	1957-1964	Colombia	Rice	ES	79-96
Avila, 1981	1959-1978	Brazil	Irrigated rice	ES	114-119[b]
Avila, 1983	1974-1986	Brazil	Training	ES	22-30
Martinez & Sain, 1983	1979-1982	Panama	Maize	ES	188-332
Salmon, 1984	1965-1977	Indonesia	Rice	EC	133
Ayres, 1985	1955-1983	Brazil	Soybean	ES	51[b]
Librero & Perez, 1987	1956-1983	Philippines	Maize	EC	27-48[b]
Norton, et al., 1987	1981-2000	Peru	Rice	ES	17-44

[a] Internal Rate of Return; varies within a range dependingon assumptions or periods of analysis.
[b] Includes extension.
ES=economic surplus; EC=econometric.
Source: Echeverria, 1990.

Table 2. Impact indicators and measures[a].

INDICATORS	TENTATIVE MEASURES
Ecological	
Water quality	Dissolved oxygen (milligrams/liter)
	Fecal coliform (number/100 milliter sample)
Ambient air quality	Sulfur dioxide (micrograms/m^3)
	Suspended particulate (micrograms/m^3)
	Carbon dioxide (t/capita)
	Carbon dioxide (t/Million $ GNP)
Forest conservation	Hectares Saved/1 ha of alternative production
Agronomic	
Productivity	Commodity yields (t/ha)
Factor inputs	Fertilizer use (t/ha)
	Pesticide use (kg/ha)
	Lime use (t/ha)
Irrigation	Percent of total production
Institutional	
Information systems	Files (Number of Records)
Human Resources	M.S./Ph.D. degrees (number)
	Nondegree training (number)
Policy	
Land tenure	Percent
Credit access	Percent
Market access	Percent
Economic	
Microeconomic	NPV/ha of alternative production (US$)
	Internal rate of return (%)
	Household consumption (% of total production)
	Concentration (% of total production from one commodity)
Macroeconomic	GNP/capita (US$)
	Rate of inflation (%)
	Annual growth rate (%)

Table 2. (continued

Social	
	Population growth rate (%)
	Life expectancy at birth (years)
	Adult literacy (%)
	Access to health services (%)
	Access to safe potable water (%)
	Access to safe sanitary facilities (%)
	Daily calorie supply (% of requirement)
	Daily protein supply (% of requirement)
	Schooling by gender (%)
	Child immunization (%)
Science	
Decision support systems	Utilization (number of users by category)
Soil classification	Utilization (number of users by category)
Biological collections	Entries (number)
Networks	Participants (number)
Knowledge production	Publications (number)
Problem-solving	Requests for technical assistance (number)

[a] Definitions and units of measure follow conventions established jointly by the World Bank and the United Nations Development Program (e.g. World Development Report, 1992; Human Development Report, 1992).

Table 3. File directory of CRSP management information system.

FILES	TENTATIVE CONTENTS
Universities/Institutions	Name
	Institution name, number and address
Projects	Project Name and number
	Budget (allocations by projects and objectives)
	Product objectives (knowledge, technology, decision tools, capacities and facilities)
	Impact objectives (agronomic, environmental, economic, social, institutional and scientific)
	Expenditures by objective
Impacts	Agronomic, environmental, economic, social, institutional and scientific (Table 2)
Human Resources	Name
	Institutional affiliation and address
	Demographics (age, gender, race)
	Areas of expertise
	Participation in projects
Collaborators/Customers	Name and address
	Collaborator type; size of collaborator service population, areas of participation (projects and objectives)
	Impact measures: Adoption/diffusion of CRSP products (utilization numbers and rates), value added
Requests for Services	Name and address (requesting service)
	Name and address (responding to request)
	Date of request, date of response, type of service, purpose of request
Graduates/Students	Name
	Demographics (gender, age, race, nationality, rural/urban residence, socio-economic status)
	Graduate education (start date, termination date, specialization, research area, degrees earned)
	Employment (current position title, time allocations to teaching, research, extension, policy-making, and administrations)
	Post-doctoral training
	Project collaboration
	Achievements (publications, honors and impacts)

Table 4. Research Sites and Collaborating Institutions

RESEARCH SITES	EXTRAPOLATION SITES	INTERNATIONAL CENTERS
Yurimaguas, Peru*	Chapare, Bolivia*	FAO, Rome
Sitiung, Indonesia*	Manaus, Brazil	ISNAR, The Hague
	Porto Velho, Brazil	IBSRAM, Bangkok
	Asuncion, Paraguay	IRRI, Los Banos
	Kasama, Zambia	CIAT, Cali
	Rio Frio, Costa Rica	ICRAF, Nairobi

* surveyed research sites

Table 5. Summary of annual returns to producers from land use systems in the humid tropics.

LAND USE SYSTEM[a]	COUNTRY	NPV[b]	IRR[c]	SOURCE
		US$/ha	%	
Experimental Results				
Shifting cultivation[d]	Peru	-217	-37	Sanchez & Benites, 1987
Low-input (rice/cowpea)[d]	Peru	-153	-70	Sanchez & Benites, 1987
Agroforestry (rice/cowpea/peach palm)	Peru	136	146	Villachica et al., 1990
On-Farm Results				
Upland rice	Peru	-62	-14	Chapter 3
Rice/cowpea[e]	Peru	183	137	Chapter 3
Paddy rice	Indonesia	44-150	46-67	Chapter 5
Upland rice	Indonesia	39-64	99-110	Chapter 5
Rice/soybean	Indonesia	147	101	Chapter 5
Alley cropping (rice/flemingia)	Indonesia	-124	-23	Chapter 5
Agroforestry (rice/rubber)	Indonesia	107	94	Chapter 5
Low-input pineapple	Bolivia	3542	41	Castedo, 1993
Pineapple (technical management)				
returns to farmer	Bolivia	8469	74	Castedo, 1993
returns to contractor	Bolivia	5438	256	Castedo, 1993
Pineapple (technical management + 60% leverage)				
returns to farmer	Bolivia	16,760	112	Castedo, 1993
returns to contractor	Bolivia	11,147	459	Castedo, 1993

[a] Based on median values adjusted to 1-ha equivalents.
[b] Net Present Value, based on discount rate of 15%.
[c] Internal Rate of Return.
[d] Market price of commodities adjusted to July 1991 values.
[e] No loan or transport costs.

LIST OF FIGURES

Figure 1. Forces driving social, economic, and environmental change.

Figure 2. Cumulative adoption of technology over and 18-year period.

Figure 3. Conceptual framework for SM-CRSP impact assessment.

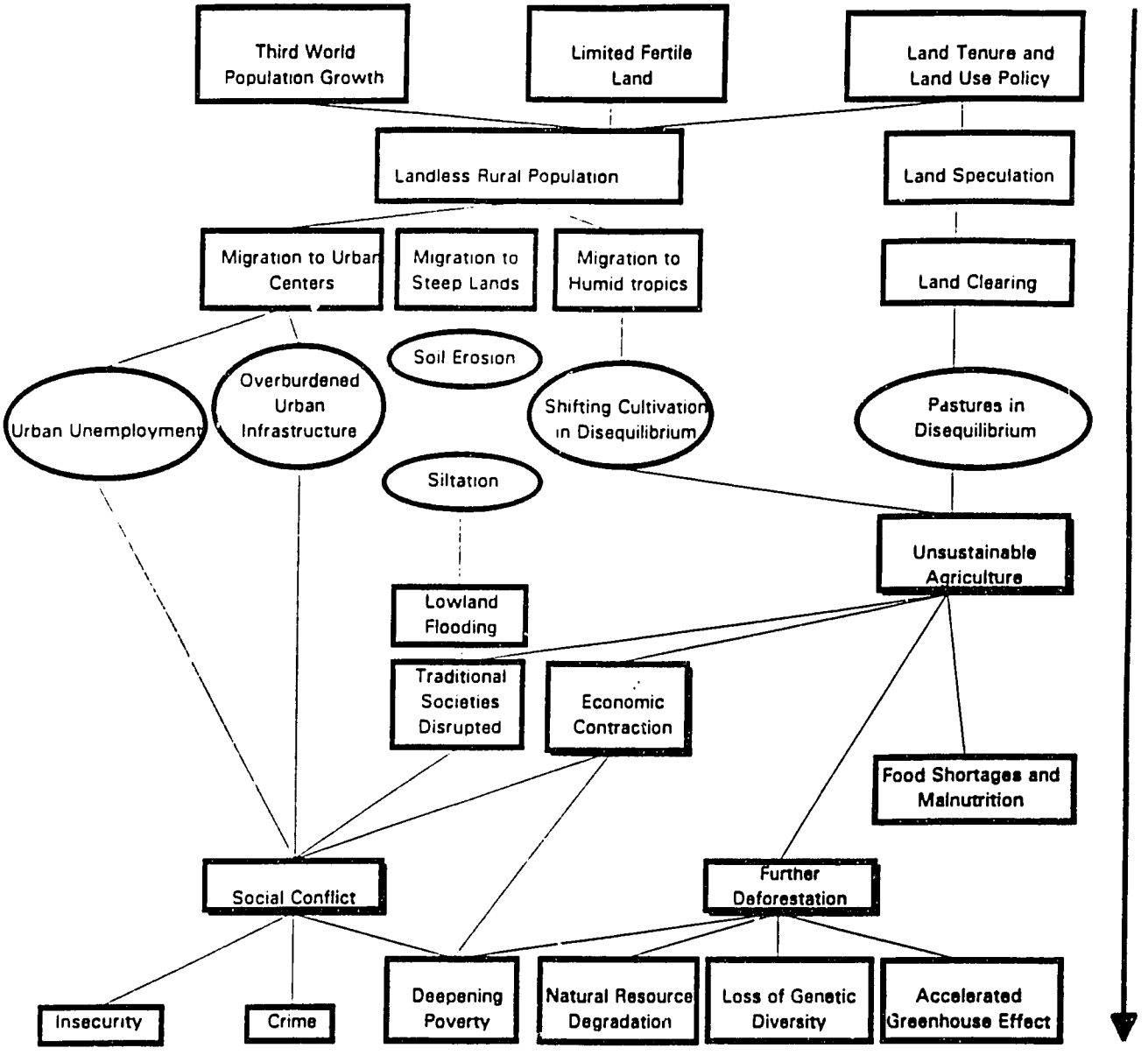
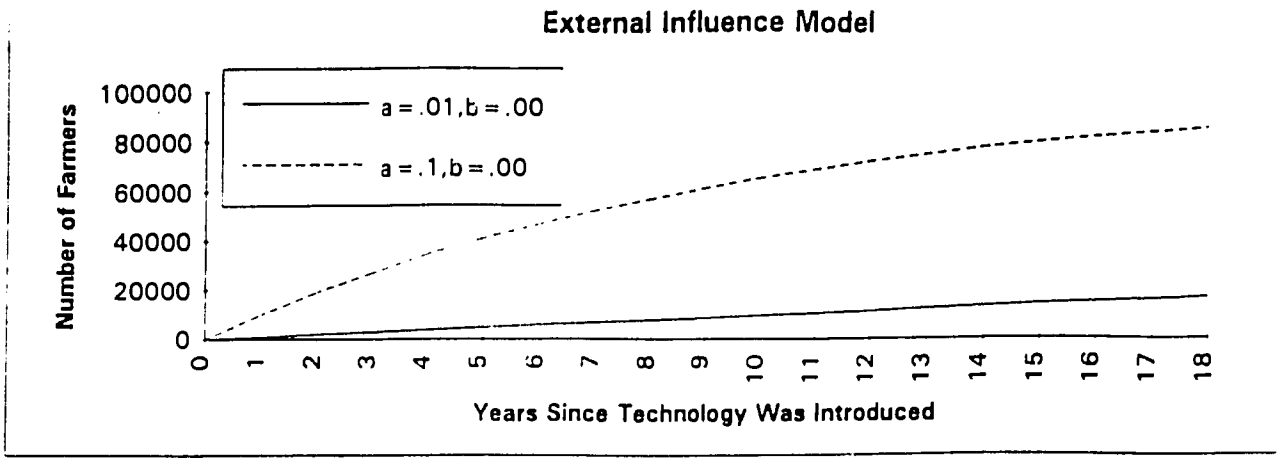
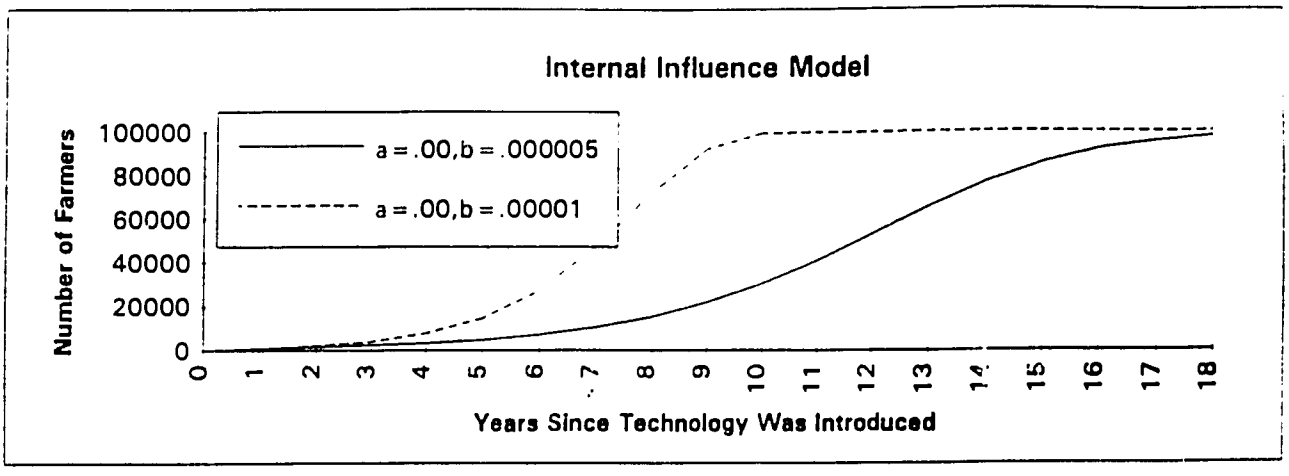

Third World Population Growth
Limited Fertile Land
Land Tenure and Land Use Policy
Landless Rural Population
Land Speculation
Migration to Urban Centers
Migration to Steep Lands
Migration to Humid tropics
Land Clearing
Soil Erosion
Urban Unemployment
Overburdened Urban Infrastructure
Shifting Cultivation in Disequilibrium
Pastures in Disequilibrium
Siltation
Unsustainable Agriculture
Lowland Flooding
Traditional Societies Disrupted
Economic Contraction
Food Shortages and Malnutrition
Social Conflict
Further Deforestation
Insecurity
Crime
Deepening Poverty
Natural Resource Degradation
Loss of Genetic Diversity
Accelerated Greenhouse Effect

Fig. 1


External Influence Model
Number of Farmers
100000
80000
60000
40000
20000
0
a = .01, b = .00
a = .1, b = .00
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Years Since Technology Was Introduced


Internal Influence Model
Number of Farmers
100000
80000
60000
40000
20000
0
a = .00, b = .000005
a = .00, b = .00001
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Years Since Technology Was Introduced

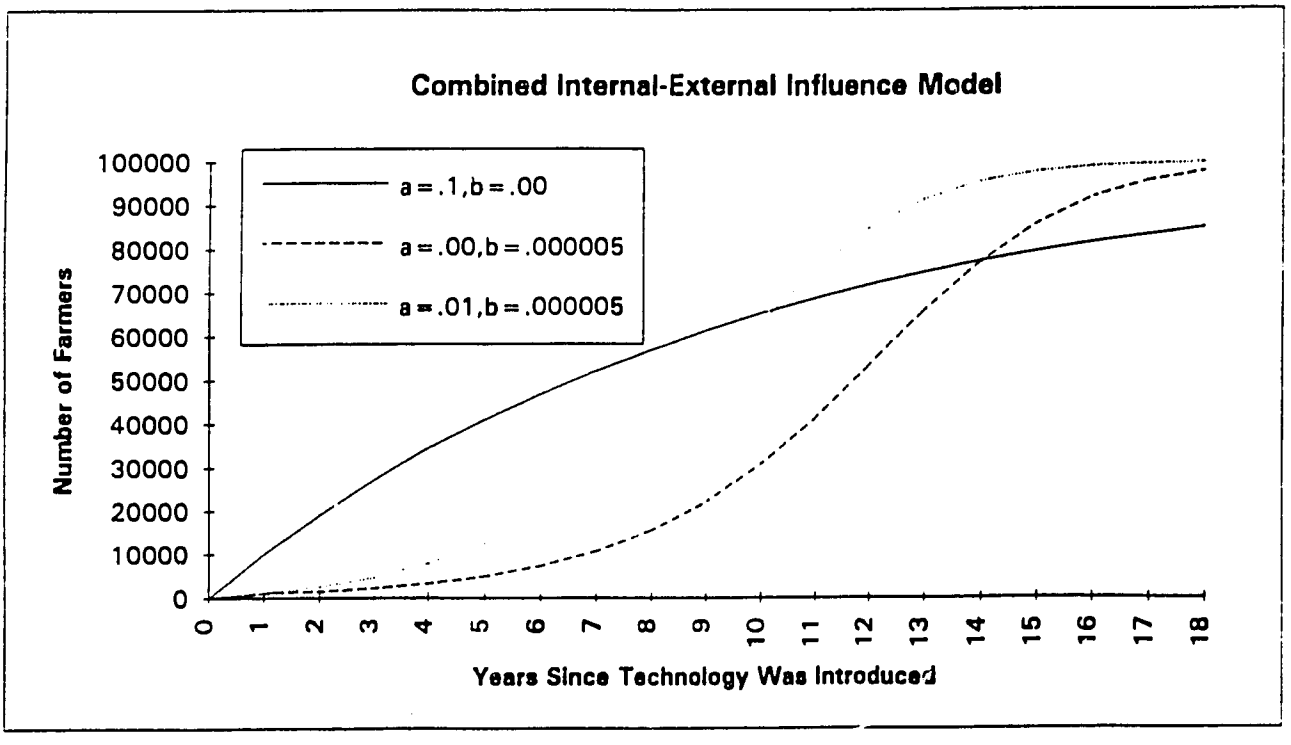

Combined Internal-External Influence Model
Number of Farmers
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
a = .1, b = .00
a = .00, b = .000005
a = .01, b = .000005
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Years Since Technology Was Introduced

Fig 2

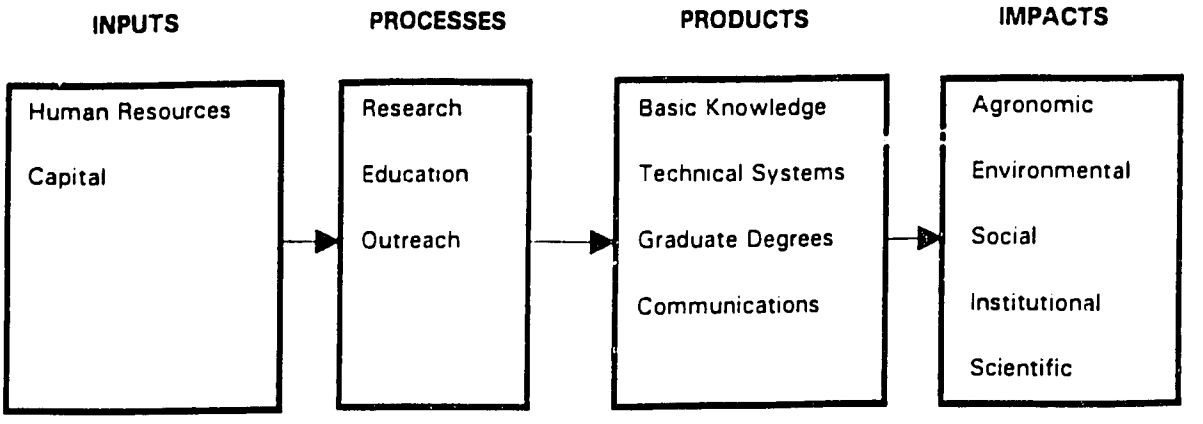

INPUTS
PROCESSES
PRODUCTS
IMPACTS
Human Resources
Capital
Research
Education
Outreach
Basic Knowledge
Technical Systems
Graduate Degrees
Communications
Agronomic
Environmental
Social
Institutional
Scientific

Fig 3

3. CHANGING LAND USE PRACTICES IN THE HUMID TROPICS OF YURIMAGUAS, PERU[1]

Frank J. Smith, Julio Alegre and Lawrence Szott

The tropical rain-forests represent a vast biological and economic resource. Approximately 1.7 billion hectares representing 38 percent of the land resource of 72 developing countries are comprised of rain forest landscape (Cochrane and Sanchez, 1982). Once regarded as unsuitable for agriculture, today the humid tropics are the principal areas of global agricultural expansion. Clearing in the Amazon Basin is estimated to occur at the rate of 1.2 million hectares per year and is associated mainly with subsistence farming by shifting cultivators and pasture establishment by cattle ranchers (Hecht, 1982). Population pressure combined with traditional slash and burn practices, if left unchecked, will lead to the eventual degradation of most of these rain forest reserves with little or no long-term social or economic gain. The expansion of subsistence agriculture will only extend the poverty pandemic to the regions. However, research on soil management is helping to develop productive and sustainable alternatives to slash and burn methods and to lay the technical foundation for a rational management of the soils of the humid tropics.

U.S. AID and North Carolina State University's Tropical Soils Program collaboration with the Government of Peru was initiated in 1972 with the purpose of developing improved soil management options for the Peruvian Amazon and to validate and transfer appropriate technology. The early years of collaboration were devoted to exploring the feasibility of continuous cropping. Based in part on the very promising indications of early research, the Soil Management CRSP was founded in 1981 to a) increase and sustain agricultural production in a form that is economically and ecologically viable and b) to develop a set of scientifically based management options for different soil, socio-economic, and ecological conditions of the humid tropics. Yurimaguas has been a primary research site, but research networks, training and outreach are extending and transferring the benefits throughout the region and the world. After more than twenty years of continuous soil management research it is appropriate to assess the program impacts, constraints and progress toward unresolved problems.

This paper examines the changes in land use in the Amazon basin of Peru and the role of collaborative research and outreach as instruments of economic and social development in the region. Four objectives of the study were: 1) develop descriptive data on changing land use practices in the region of Yurimaguas, Peru, 2) determine the present development of agroforestry, 3) estimate the extent of land use innovation, and

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[1]The authors gratefully acknowledge INIAA/Peru and particularly the staff of the San Ramon Experiment Station in Yurimaguas for their dedicated participation as part of the survey teams. Special thanks are extended to T. Jot Smyth, Stanley Buol, R.E. McCollum, Manuel Arca, Hugo Villachica, Americo Valdez, and Angel Salazar for technical support. The study was supported by USAID Grant DAN-1311-600-0039-00 to the Soil Management Collaborative Research Support Program (TropSoils).

4) identify the socio-economic conditions and constraints which limit adoption of improved land use practices.

BACKGROUND

The Amazon watershed covers an area of nearly 7 million square kilometers (Cochrane and Sanchez, 1982). The Amazon basin occupies 60 percent of Peru, 55 percent of Brazil, 48 percent of Ecuador, 35 percent of Colombia, 33 percent of Bolivia, 19 percent of Guyana, 6 percent of Venezuela, and 5 percent of Surinam. The low land jungle is land below 500 meters in elevation with predominantly forest vegetation, warm constant temperatures, high rainfall and meandering river systems. The low land jungle appears uniform but in fact contains a substantial degree of variation in topography and soils.

The humid tropical landscape of Peru is classified as tropical rainforest and represents approximately 56.2 million hectares or 44% of the land area of Peru. Slopes vary between 0 and 30%. Seventy-five percent of the land is characterized by acidic and infertile soils; 50% percent of the soils of the jungle are Ultisols with gentle slopes. Only 5% of the land is considered well drained, with good fertility and favorable topography for agriculture (Sanchez y Benites, 1987).

Population data are not very precise but it is estimated that approximately 15 million people inhabit the Amazon plains (Webb, 1990) of which 2.5 million live in Peru (Rodriguez, 1991). Approximately half are dedicated to farming. Peru has encouraged migration into the Amazon region to absorb surplus population and relieve political pressure from other areas; to provide the economic base for regional development; to expand production and to integrate and occupy national territory. Although threatened, the tropical forest of Peru still is essentially intact because agriculture and deforestation have been confined mostly to areas along the rivers and the few roads around frontier communities.

Yurimaguas is located at the confluence of three tributaries of the upper Amazon river system (Pananapura, Shanusi, and Huallaga Rivers). Yurimaguas was originally founded around 1700 as a Jesuit mission. It was mainly populated by the Yurimaguas tribe who had fled from the Portuguese (Chaumiel, 1985). In Yurimaguas, Peru the indigenous populations of the region have been displaced or assimilated (Rhoades, 1985). Yurimaguas had prior links to the international economy of rubber (1880-1914) and later barbasco and timber extraction. The population growth in the city of Yurimaguas has more than doubled from 15,000 in 1972 to 31,600 in 1991. Much of this growth was due to a short-lived oil boom in the early 1970s which led to a surge in migration. The 1980s and 1990s brought still more people to the region as part of the international coca trade. Also in the 1980s, policies promulgated by the National Agrarian Bank created market conditions favorable for the production of rice as a cash crop which stimulated the migration of some coastal growers and day laborers to look to the flood plains of the Peruvian Amazon basin.

Cassava, plantains, upland rice and corn are the traditional crops of the region. Shifting cultivation is the traditional method of coping with the infertile, acidic conditions of the soil and weeds. The forest is slashed and burned to produce a bed of ashes

containing nutrients for plant growth and organic binding of toxic aluminum cations. Heavy rains and high leaching rates quickly dissipate nutrients. After producing one or two crops or three or four years of pasture, productivity declines and lands are abandoned and revert to a secondary forest fallow. After a secondary fallow period of 15 to 20 years, the cycle can be repeated. While the lands are fallow, farmers clear and use other lands.

With sparse population, the forest can sustain shifting cultivation with minimum environmental degradation. However, when population pressure increases, as it has, the areas of contiguous clearing for cultivation or pastures are increased and the fallow periods are shortened. Consequently forest regeneration is cut short, land is degraded, productivity declines, and economic and social conditions worsen. The challenge of research has been to achieve sustainable agricultural production through improved land use. The main constraints to extended crop production in the Amazon are soil acidity, P deficiency, micronutrient deficiency, low effective cation exchange capacity (Cochrane and Sanchez, 1982), and weed encroachment (Mt Pleasant et al., 1990). The main factors associated with declining livestock production are phosphorus deficiency, grazing management and poor adaption of pasture grasses to the humid tropical environment (Serrao, et al., 1979).

Without application of improved soil management, population pressures in the humid tropical regions will inevitably result in continued natural resource degradation and persistent human poverty. Therefore, the SM-CRSP and the Government of Peru have joined in a program of collaborative research to develop the technical capacity through research, training and outreach for more productive and sustainable agriculture in the Amazon region. The collaboration has been continuous over a period of more than twenty years. The principal challenges for the future is to facilitate the transfer of technology while building the research capacity to address emergent problems and unresolved questions. Systematic socioeconomic information and models are needed to diagnose constraints, prescribe appropriate applications technology, and evaluate socioeconomic impacts.

The remainder of this paper, examines the changing land use practices in the humid tropics of Yurimaguas. Findings from a survey of farmers provide a representative description of current practices, perceived problems, and priorities for future action. The results also establish a quantitative baseline for future reference and guide to future development of appropriate analytical tools for general use throughout the humid tropics.

METHODOLOGY

The study area is predominantly characterized by small farms on acid, infertile soils with limited market infrastructure and capital. As such, the sample area fits the target conditions for low-input approaches to soil management (Sanchez and Benites, 1987). The sampling domain for the study was established using geographic criteria. The region was divided into six sectors defined by characteristics of the landscape and means of farm-to-market transportation (Figures 1 and 2). A sample of 166 households was selected from all rural households within a 17 km radius of the city of Yurimaguas using a stratified (by sector) random design.

Implementation of the survey followed plans and procedures developed by the authors with collaboration and approval by the participating national and international institutions. Local direction, control and logistical support for the survey was arranged by the second author who is the technical director of the agricultural experiment station. Twenty five extension workers from the area were selected, grouped into teams for training and conduct of the survey. Interviewers were native residents working in a technical capacity at the experiment station. The training session consisted of two days of instruction at the experiment station on the elements of the rapid appraisal survey and one day of pilot testing in the field. Consistency in method and recording of responses was stressed. The purpose of the survey was described in simple terms so that survey teams could in turn explain the purpose of the survey to the farmers they interviewed.

A pilot test of the survey was conducted with a small group of farmers who had characteristics similar to those in the region of work. The pilot test revealed difficulties with the vocabulary, phrasing and sequencing of questions; adjustments in the survey were made accordingly. Maps of the sectors were prepared to guide the survey teams. Time schedules for the field survey and the logistical support of the survey workers within the sectors were provided.

Efforts were made to foster farmer cooperation and to control data quality and validity. All interviewers were given INIAA identification documents so that farmers would be assured of the legitimacy the of survey workers and control any suspicion that the survey was gathering information that might be used against the farmer. A survey guide was prepared to elicit consistent information from each farmer/decision-maker on household demographics, changing land use practices, perceived problems/constraints to technology transfer, technical innovation, and selected social and economic factors. Survey workers spent an entire day at the farm site with each sample respondent, worked together with the farmers/decision-maker, shared meals and established a rapport. The informal survey was completed in the normal course of the days activities. Interviewers helped the farmer to understand the questions asked and probed with follow-up questions if the farmer's response was unclear. Responses were recorded on prepared forms by the survey technicians. In addition, a sketch was made of the farm with characteristics of topography, soils, crops, cropping systems and infrastructure. Supervisors reviewed the work of the survey teams daily to verify that the questionnaires had been filled-out correctly and completely.

In order to control for possible errors of reporting and interpreting, redundancies were designed into the questionnaire that provided a check on the internal consistency and reliability of responses. Responses were also checked against available external references. Efforts were made to elicit information in a form that would be most familiar to the farmer. For example, labor was elicited in terms of person/days by activity: land clearing, planting, weeding, harvesting, etc. Labor costs then were estimated by reference to the market price for day labor. The above procedures provide safe-guards against misinterpretation and misrepresentation.

Farmer's responses were recorded on the survey form and subsequently were coded onto data sheets for computer processing. Descriptive results are presented as

absolute frequencies, percentages, means, medians, and ranges. The median is used as a measure of central tendency to minimize the effect of extreme values.

RESULTS

Demographic Characteristics of Rural Households

Most of the farmers interviewed report having come from elsewhere within the Amazon basin. Twenty percent came from the adjacent Department of San Martin which includes the eastern foothills and valleys of the Andean range. Only five percent were immigrants from the coastal zone. The principal reasons for coming to the area were in search of new and better lands (34%), to join family members already in the area (25%), for work (21%), and due to dislocation by flooding (6%). Nearly all (97%) plan to stay in the area indefinitely. They are looking for new opportunities and are generally receptive to new technology.

The majority of the farmers (54%) surveyed had between 1 and 20 hectares of land and 97% had 50 ha or less. Almost half (47%) were less than 40-years old. Although most (85%) lived on their farm, exceptions are predominantly those in the sector 2 along the Yurimaguas-Tarapoto highway who lived in Yurimaguas. The farmers differed in the number of years of land use. Forty percent had used their lands for ten years or less; the median for land use was 13 years. Most had legally registered rights to the land (title 43% or special use certificates 23%). The remainder had informal access including loans and unregistered gifts of land. Most (87%) had not expanded their land holdings, but of the 13% who had, 82% had purchased and 86% had selected their land. None indicated they had technical support in the selection of new lands.

The median years of farmer schooling was five years. The sectors 5 (Alto Huallaga) y 1 (Shanusi) had the highest levels of illiteracy (22% each), while sector 3 (Munichis) had an illiteracy rate of only 7%. For those individuals in the age group 16-30, 32% of males and 28% of females had some secondary education.

Land Use

Microvariations in topography, soil color, soil type are apparent in the 17 km radius of Yurimaguas (Table 1). Black soils predominate in all sectors but color is not a good indicator for soil type or quality. Flood plains predominate in sectors 1 (Shanusi). Highly weathered upland landscapes characterize sector 2 (Yuri-Tarapoto Highway); high terraces in sectors 3 (Munichis) and 5 (Bajo Huallaga); flood plain, and high terraces in sectors 4 (Pananapura) and 6 (Alta Huallaga).

Traditional shifting cultivation (swidden agriculture) is the predominant land use system in each of the six sectors, representing 71% of all households (Figure 3). Farmers reported "continuous cultivation" of crops, but their responses to questions about land clearing and fallows reveal that most practice continuous shifting cultivation not continuous permanent cultivation. Irrigated rice is well established in the flood plains of sector 1. Small scale pastures and agroforestry are found distributed throughout all sectors. Many farmers use a combination of management systems because of microvariations in farm topography and the desire to diversify production.

Most households clear a parcel of land each year. Clearing consists first of slashing the small trees and vines, followed by the felling of trees with axes and

machetes, leaving trunks and stumps. After a drying period, the slash is burned, usually between July and September. Due to diminishing access to primary forest, most clearing (80%) involves slashing and burning secondary forest. Median clearing of secondary growth is 2 ha/yr/household. Farmers in sectors 5 and 1 clear more; the others clear less. Only 20% report clearing primary forest each year; of these, the median area of virgin forest cleared is 1.5 ha. Consistent with research recommendations (Alegre, et al., 1986), nearly all (98%) of the farmers clear their lands manually. About half (47%) employed temporary labor to assist with land clearing while 37% used family labor. Farmers report that clearing requires a median of 30 days/ha for primary forest and 20 days/ha for secondary forest.

Most farmers (68%) only plant one or two crops on the newly cleared land before abandoning it. Approximately one-third harvest one crop only, another one-third harvest two crops and one-third harvest three crops. Very few farmers produce more than three consecutive crops on a plot. The reasons given for abandoning land were fertility problems and weed encroachment.

In 1981, farmers reported a median fallow period of five years. Five years later, in 1986, the median fallow period remained five years, but by 1991, the median fallow period had decreased to three years. Fallows are for the most part native vegetation and the shortening of fallows are clearly the result of increased pressure on land use and not attributable to efficiencies achieved through the adoption of improved fallow systems. The short fallow period is a clear signal of the land degradation that is occurring at the present time.

Households also extract numerous products from forest lands (Figure 3). Timber is the primary product taken from primary forest, followed by fruits, firewood, and assorted hunting/gathering products. The secondary forests are used for fallows as well as for firewood, construction materials, and fruits. Product extraction varies somewhat by sector (Table 2). Clearly the mix of farming and forest extraction activities is a consequence of the changing land use patterns and not part of an indigenous tradition of agroforestry that is sustainable. Farming alone does not provide sufficient economic returns to households and therefore continuing reliance on extraction activities is observed.

Allocation of Household Labor

Labor is the principal factor input in local production. In the sparsely populated Amazon basin, labor shortage is also the principal constraint to production. More than half of all survey respondents employed temporary labor to supplement family labor. Payment for day labor is part cash (approximately $1.50/day) and part a daily food ration ($.50/day). At the time of the survey, some farmers had received production loans from the Agrarian Bank which were used principally to hire day labor. However, the Agrarian Bank has since closed and farmers are now left with very limited, if any, access to private credit, making it all the more difficult to manage the labor requirements of their production systems.

Some farmers in the sample (7%) depend upon off-farm employment as a means of obtaining the cash requirements for the household. There is a pool of temporary workers in the area, however, who depend principally on temporary farm labor. The

collapse of the Agrarian Bank, therefore, has consequences not only for borrowers but also on those who benefitted from opportunities of temporary employment as farm workers.

Even when access to credit was available to hire day laborers, many households preferred an informal tradition of labor/barter (chova-chova). "Chova-chova" is a reciprocal arrangement where farm households draw upon their neighbors to help with tasks they cannot manage themselves. With this system, farmers can obtain assistance as needed without having to pay wages. The household, however, is obligated to provide food for the workers.

Family labor includes substantial involvement of school age children in farming activities. Approximately 50% of all male children ages 5-15 years old work on the farm, compared with 19 percent for female children. It is unclear how work may be effecting schooling and vice versa. Most males and females 16 to 30 years old work on the farm. The average number of hours worked is 7.1 hours/day. Use of family labor enables farmers to avoid the reliance on others and to minimize the transaction costs that would be associated with loans or barter arrangements.

The needs for temporary labor vary by sector according to the types of forest and systems of production. In the secondary forest more labor is required in slash-clearing because of the greater density of growth. In the virgin forest more labor is required in felling large trees.

Labor allocations by activity are presented in Figure 5 for shifting cultivation practices. Medians were computed for time devoted to each activity, where time is greater than zero. Not all households report labor in every category. Overall, 78% of households used family labor, 74% chova-chova and 45% day laborers.

Purchased Inputs

Purchased inputs are used sparingly. Forty-two percent purchased seed, mostly in local markets, but most (58%) save seed from previous harvests for future plantings. A minority obtain improved (certified) seed from the government (ECASA-5%; INIAA-4%). Herbicide is used by 24%, insecticides by 11%, and fertilizer (urea) by 7%. Only 15% of farmers reported that purchased inputs were easy to obtain. Access to supplies and high costs were frequently mentioned reasons for not using purchased inputs. Systematic market information is lacking on price and availability of products at periodic intervals. Farmers do not keep records of their expenditures on inputs and attempts to elicit expenditure information by survey workers were problematic and data were unreliable. Prices shown in Table 3 are based on a survey of the Yurimaguas market in July 1991.

Yields

Farmers yields do not approach the yields that have been proven in research plots (Table 4). For purposes of this study 1980 yields represent baseline values. The period 1981-1985 was a time of active SM-CRSP research collaboration with the national agricultural research system (INIAA). It was during this period that the knowledge base for the landscape model was developed and extension recommendations were formulated. By 1985 the national extension system was poised to actively promote improved soil management systems throughout the region. Unfortunately, national economic crisis and political instability during the period 1985-1990 frustrated the effective

transfer of technology. The extension system was reorganized, downsized and demobilized. Consequently, the flows of research findings to the intended user groups were interrupted. As a consequence, farm yields remain far below their potential. The yield reports of farmers indicated differences between the six sectors and differences over time within sectors, but the differences do not fit any clear pattern or interpretation (Table 5). The yields by year and sector are presented for upland rice (Figure 6), corn (Figure 7) and bean (Figure 8).

Some of the variance in farmer reports of crop yields is clearly an artifact of measurement error. Farmer reports of yields are approximations at best. Farmers plots are not surveyed and plot size, therefore, is only estimated. Also the quantity of the product produced is seldom weighed much less weighed using standardized procedures (e.g. adjustments for moisture content). It is stored on the farm site where much of it is consumed by the household or lost due to post-harvest pests and spoilage. Therefore, farmer reports of yields can be no better than the measures from which yield estimates are derived. Farmer record keeping is nonexistent or poor so farmer reports are based on unaided memory.

It is difficult to interpret farmers' reports of changes in yields based on a single survey, but reports suggest that in the last five years farmers have shortened the length of fallow periods from approximately 5 to 3 years. Yields reflect the opposing influences of improved technology, increasing population pressures, and shortened fallow periods. The increased pressure on land with little or no external nutrient inputs is one of the contributing factors holding down the yields in many of the basic crops.

Rates of adoption of new technology are generally less than 10% and, therefore, yield averages are not greatly moved from the baseline (1980). Analyses of the variance (e.g. range) of the yields by farmers in the sectors provide a better indication of adoption in the early phase of technology transfer. Assuming the normal s-shaped diffusion curve, variances in yields will increased in the early period of technology transfer. Descriptive highlights of the differences in average yields and variations (ranges) in crops across time in the six sectors are presented below.

Upland rice: Only sector 1 shows consistent improvement, in upland rice yields. The best yield was obtained in 1985 in sector 6 (Alto Huallaga) of 2.4 t/ha, followed by sector 1 with 2.2 t/ha in 1990. The sector 1 (Shanusi) has an average of 2.5 ha of upland rice per household; Sector 3 (Munichis) has 2.3 ha/household.

Corn: Best yields were consistently found in sector 6 (Alto Huallaga). The average corn yields in sector 6 for the period 1980-1985 was 2.0 t/ha and has since declined to 1.8 t/ha. In sector 5 yields have been 1.7-1.8 t/ha during the period 1980-90. Yields in sector 4 have shown consistent improvement up from 1.4 to 1.8 t/ha over the 10-year period. Sector 6 has an average area of 1.9 ha/household planted in corn, followed by sector 5 (Bajo Huallaga) with 1.8 ha/household.

Banana: Banana is most predominant in sectors 1, 5, and 6. Areas are 1, 0.9, and 0.9 ha/household, respectively. The best yields achieved in sector 5 were 18.6 t/ha in 1980, with declines to 18.3 t/ha in 1985 and 17 t/ha in 1990.

Cassava: Most cassava is planted in sectors 5 and 6 with 1.0 and 1.7 ha/household. Best yields in sector 5 were 23.0 t/ha in 1990 up from 18.0 t/ha in 1980.

Bean: Sectors 5 and 6 are the principal areas of bean cultivation. Plot sizes are typically 0.7 to 0.8 ha/household. Bean yields in sector 6 have dropped from 1.1 to .6 t/ha over the last ten years.

Livestock and poultry: Livestock and poultry are found throughout the region (Table 6). Cattle production is most prominent in sector 4 (Pananapura) and 2 (Yurimaguas-Tarapoto Road). The stocking rates for pastures of the region are .5 to 1 head/ha. Most (76%) report no technical management of their livestock. Of those using technical management 67% used mineral salts and/or veterinary care, 28% report management of feed and 50% improved breeds of cattle. Fourteen percent use technical management of pastures including improved grass-legume associations and rotational grazing.

Home Gardens

Sixty-four percent of the households do not have gardens according to farmer reports. For other households (36%) home gardens constitute an important part of total production. The median garden size is less than 5000 m^2. Gardens are most prominent in Bajo and Alto Huallaga. Gardens are used to support the production of animals, horticuitural products, and other crops for household consumption and sale. Plantain is most frequently mentioned as an important garden product (21%), followed by poultry (19%), cassava (20%), chile pepper (12%), and swine (10%). More isolated farmers in the region, are probably even more reliant on garden production than farmers in this sample taken within a 17 km radius of Yurimaguas.

Production Problems

Limited access to credit and control of weeds and pests are cited by farmers as the most common problems of production (Figure 9). In contrast, problems with soil are cited by relatively few (11.4%). This pattern reveals more about farmer perceptions than about the actual production constraints. Clearly, the problems reported are not independent, but farmers do not perceive the relation between weed problems and good soil management practices. Weed growth is apparent and tangible and consequently it is frequently reported to be a problem, while poor soil conditions are less apparent and less frequently cited by farmers.

Regional variation in the problems reported by farmers are apparent. Farmers in sector 1 (Shanusi) most frequently report the lack of capital. Other problems are weeds, pests, poor transportation infrastructure, scarce and costly temporary labor, disease, bad seed, land constraints, and drought. The principal production problems in sector 2 (Yurimaguas-Tarapoto Road) are weeds, capital constraints, pests, and temporary labor shortage. In sector 3 (Munichis), capital, weeds, pests and transportation are most pressing. In sector 5 (Bajo Huallaga), capital, weeds, labor and transportation predominate. In sector 6 (Alto Huallaga), weeds, capital, flooding, pests and labor are most serious.

Capital was the most cited problem in 1991 and with the demise of the Agrarian Bank it is undoubtedly even more acute now. As previously indicated, farmers want

access to capital, in order to hire temporary labor for land clearing, weeding, and related tasks. From this perspective, the perceived need for capital is a proxy for other problems and constraints on production.

Most farmers interviewed (93%) reported problems with weeds (Table 7). Weeds grow continuously in the humid tropics unlimited by temperature or moisture. The humid conditions also severely restrict tillage, a primary means of controlling weeds. Labor for hand weeding is largely unavailable. The use of herbicides presents other problems: i) their availability is limited, ii) the cost is high, and iii) their safe and effective use requires a high level of farmer education (Mt. Pleasant et al., 1990). Farmers identified 35 different weeds by local name. Of these, the weeds named most frequently by farmers are *Cyperaceaeus* spp., *Paspalum* sp., *Axonopus compressus*, *Rotbellia exaltata* sp., and *Solanum* sp. When asked about weed control, 65% reported using manual weeding. Weeding requires a median of 20 days/ha/crop. The farmer typically is not able to keep up with the weeding demands himself. Day labor may be used, especially if credit is available for contracting. Neighbors may also assist with weeding. In the Shanusi sector 40% of the farmers reported using herbicide to control the weeds *Paspalum* sp. and *Rotbellia exaltata* sp. in irrigated rice. This practice has been assisted by credit from the Agrarian Bank. Use of mulches and other means of weed control were not mentioned. Clearly, weed growth is a problem in all sectors and with all land use options.

Pest and disease problems are reported by 84% of farmers, but few use control measures. In the humid tropics pest and diseases, like weeds, are important constraints toward sustainable development. Pest and diseases named most often were: stem borer in corn (*Diatraea Saccharalis*), "Chamuchina", "Chinche", leaf cutting ants (*Atta cephalotes*), and beetle larva ("Papaso"). Farmers report problems of accessibility and costs of pesticide as the primary constraints. None of the farmers surveyed used biological control or rotations for the purpose of pest control.

Technical Assistance

Few of the farmers sampled reported receiving technical assistance from the Agrarian Bank or the Ministry of Agriculture. However, probing the matter further, 43% reported having been visited by a researcher or extension specialist from the experiment station. A little more than half the farmers have had no on-farm visits from researchers or extension specialists, yet a few farmers have had as many as 15 visits. Of 72 households that had received visits, 39 received specific technical recommendations; of these 39 households, 29 followed the recommendations given (Table 8). Although most farmers followed the technical recommendations given during visits, it is not clear from the data why some farmers did not. The benefits perceived by farmers receiving technical assistance included both improvements in yields and quality of the product. The lack of quality extension services is clearly an impediment to achieving the full potential of social and economic benefits made possible by research.

The level of farmer participation in extension activities is presented in Table 8 and Figure 10. Visits, demonstrations, field days, farmer meetings and radio communications have exposed many farmers to new management practices. However, 49% of farmers report that they have not participated actively or received any extension communications.

Innovations

Research station contacts with farmers are facilitating changes in land use practices. Approximately 17 % of farmers have adopted technical management practices on the basis of direct contacts with the experiment station. Other farmers are benefitted indirectly from information being passed on informally by farmers who have participated in research station activities.

New activities (innovations) adopted by farmers in the last ten years include coca, timber, fruit trees, woodlots, livestock/pastures, fish ponds, and living fences among others (Figure 11). These innovations are the result of a combination of social and economic forces operating in the region. Coca cultivation is a much larger factor than these survey data would indicate. Many of the farmers (63%) not responding to the question about innovations were concealing their involvement with coca; a fact verified by observations at the farm site. Private investors have been driving activities relating to timber and fish ponds. The SM-CRSP in association with the Yurimaguas Research Station has been the principal force for sustainable cropping, pastures, and agroforestry systems. Soil management innovations have been introduced to the region by researchers and have been featured in field-days and other outreach activities of the experiment station. Forty-two percent of farmers reported making improvements in their land. Fruit trees have been adopted more in Alto Huallaga and Shanusi than the other sectors. Improved livestock and pastures also are most evident in the Shanusi sector. Distributions of selected innovations across the sample sectors are shown in Table 9.

The level and variance of innovation adoption in selected soil management practices are described in the following sections.

Improved seed: Nine percent of farmers use improved seed obtained from INIAA or ECASA. Most farmers (58%) produce their own seed and others (33%) purchase seed in the local market or obtain seed from neighbors. The quality of the seed purchased in the local market could not be determined.

Residue management: Very few farmers incorporate any type of crop residues. Only 4% of farmers report recycling rice straw in the Bajo Huallaga and Munichis sectors, 3% recycle corn stover in small quantities in the Bajo Huallaga and Munichis sectors.

Leguminous crop rotations: Cowpea, bean and peanut cultivation have increased in the region. These crops are used in rotation by 39% of farmers. Peanut is produced in upland conditions in sectors 2, 4, 5, and 6 with average plot sizes ranging between 0.4-0.9 ha. Bean is produced in sectors 3 to 6 with average plot sizes between 0.4 and 0.8 ha. Cowpea also is produced in sectors 3 to 6 with average plot sizes ranging between 0.4 and 1.0 ha.

Improved pastures: Farmers (14%) report adopting improved pastures including rotations in grazing, associations of grasses and legumes, burning for weed control and improved management.

Improved fallows: Few farmers use improved fallows. Kudzu fallows are used by only 2%. No data are available on the use of green manures to suppress weed growth.

Agroforestry: In the last five years 21% of farmers have bought or planted seedlings (most often in the sector of Pananapura) despite the fact that seedlings are not readily available for purchase by farmers. The most common tree crops are peach palm (16%), coconut palm (15%), citrus (13%) and cacao (12%). A variety of 13 other crops account for the remaining fraction of tree crops. Seventy-five percent of the farmers have forest or woodlots from which they extract timber, posts, and firewood. Of the 25% not having woodlots, most are in the Pananapura and Munichis sectors. When asked about why they have not purchased or planted tree crops, 82% said the costs were too high. Only 0.3% of the farmers purchased seedlings from INIAA; 14% bought seedlings from private nurseries in Munichis.

Living fences: Five percent of all farmers reported use of living fences. Living fences are used to mark boundaries for their corrals, to protect areas for fruit production, and for firewood and livestock forage. Thirty-three different plants are reported for living fences, but "Amasisa" (Erythrina) is the plant preferred by most farmers (22%); it is most prevalent in the Bajo Huallaga sector. "Ubos" (Spondia sp.) is preferred by 19% of the farmers and is most commonly used in the Alto and Bajo Huallaga sectors. "Mullohuayo" is the other species with high use (13%). Most farmers attribute the origin and use of living fences to traditional practices of the region. Six percent attribute adoption to technical cooperation, especially in the Shanusi sector.

Household Budget

Table 10 presents a breakdown of household income and expenses by category. According to farmer reports, the greatest household costs are field labor (36%), food (19%), education (13%), and health (13%). Families support themselves by a mix of activities including sale of agricultural products (97%), hunting and fishing (30%, especially in the Bajo Huallaga and Alto Huallaga sectors) and off-farm employment (11%).

Product Markets

The product markets in Yurimaguas consist of several actors including the state agricultural supply agency, the state commodity market, the Agrarian Bank, private intermediaries, and retail markets. Prices for most commodities are determined by the market and fluctuate with seasonal supply and demand. Rice, however, enjoys special price supports and market infrastructure established by the government. In most of the sectors, crop production is for household consumption. Surplus production is sold in the local market or to the Agrarian Bank. Survey results suggest that only approximately 20% of the farmers sell their product to intermediaries. Of production from gardens 43% is for consumption and 37% for sale. Similarly, animal production is consumed by the household or sold in the local market. More isolated farmers clearly consume an even greater share and sell less. Forty-six percent of sales are live animals; 23% are animal products.

Transport of products from farm to market is difficult and costly. Farmer reports of transportation costs show tremendous differences. Truck transport prices in Yurimaguas were quoted at US$7.50/t/30 km, but most farmers use other means of transport which vary by sector. The river systems provide market access by river boats,

canoes, and rafts for 61% of producers. Land transport is most often by horse (21%) or foot (17%). Problems of transport were frequently mentioned by farmers (51%), especially cost and timely access. Seventeen percent of the farmers are more than two hours from the local market. The study underestimates the problem of transportation, due to the fact that the sample was limited to households within 17 km of Yurimaguas. More remote areas not surveyed would have greater constraints on transportation. Household production in remote areas is scaled to the capacities of family labor to independently produce and transport products and to the food needs of the household plus a small surplus to protect against crop losses.

Credit Markets

At the time of the survey, 48% of producers indicated that they have access to and/or use credit. However, the large majority of these (91%) were patrons of the Agrarian Bank which has since been closed. It is doubtful that input and product market intermediaries and families which have been minor credit providers will be able to expand credit availability sufficiently to offset the credit losses of the Agrarian Bank. Credit access is necessary for continuous cultivation and larger scales of production, but associated transaction costs (loan interest and fees) are high (approximately one-third of the total costs of production).

Economic Analysis of Land Use Systems

Using production cost data from experiment station plots (Sanchez and Benites, 1987), yield data as reported by farmers, and market prices obtained in Yurimaguas (Table 11) it is possible to make some tentative estimates of economic returns to producers (consumers). However, yield data based on farmer reports should be interpreted with caution. Analyses are based on median values, which minimize the influence of extreme values which may arise from nonrepresentative cases or errors in farmer reports.

A sharp decline in commodity prices since 1984 has changed the economic return for low-input systems of rice and cowpea. Rice, a traditional subsistence crop, when produced in surplus, has a ready cash market with a government price support. Cowpea prices are unregulated. Since June of 1985 the price of rice has been almost halved and the price of cowpea is only 21% of its high value in November 1983 (Table 11). Declining prices for rice are, in part, a result of market-oriented policy reforms of the government and encouraged by international financial institutions. The high market price for cowpea during the period 1983-1984 reflects a temporary market disequilibrium where demand exceeded a restricted supply. More recently cowpea price has approached an equilibrium price as cowpea production has risen.

The rates of economic return to farming systems is sensitive to product prices, input prices, transaction costs, and yields. Economic analyses reported by Sanchez and Benites (1987) were based on market prices for the period January, 1983 to June, 1985. A re-analysis of the economic returns based on updated data on yields and market prices are presented below (Table 12). They show a reduction in the internal rate of return; net present values and internal rates of return which were positive in 1984 are negative in 1991. Low-input systems are still profitable, only if farmers are able to trim production costs, principally by reducing their scale of production to that which can be managed by

family labor and thereby eliminate the transaction costs associated with credit (interest and fees). Smaller cost savings can be obtained by substitution of manual labor or mechanical threshing and reuse of bags for product transport. The availability of credit creates the possibility of increasing the farmer's scale of production by hiring temporary labor, but under present market conditions, expansion of production would not be profitable.

These calculations of benefits and returns are preliminary. They should be fortified with continuing research over a number of years in Yurimaguas and from regional sites. Extrapolation of the benefits from these preliminary analyses to other regions is probably unwarranted. Limitations in the available data do not permit a more complete economic analysis that would enable the development of socio-economic models applicable across sites.

Future Investments

Farmers are looking for alternative land uses and are interested in investing for the future (Figure 12). The most frequently mentioned investment is improved seed (17%), followed by trees (14%), clearing of primary forest land (14%) and clearing of secondary forest land (13%). However, farmers' desires to invest in expansion or improvements of their operations are severely restricted by the access to capital. Changes in terms of credit to promote investment should safeguard that new investments accord with knowledge of soil management. Specifically, any policy or support for new clearing should be conditioned on improved land use practices.

Social and Community Development

Shifting cultivation practiced on marginal lands provides minimum economic returns for support of community infrastructure. However, productive agriculture based on improved and sustainable land use creates the conditions for permanent settlements and the economic surpluses for reinvestment in community projects. Although family labor is the principal constraint to household production, family members participate in community affairs and join in cooperative actions (Figure 13). Community projects attracting the greatest levels of participation are school building (30%), road construction and repair (28%), health center construction (18%) and land improvements (15%). Allocation of time to community projects reflects the importance of social development relative to household production. Unfortunately, data from a single survey cannot reveal whether time allocated to community development is increasing as a consequence of economic surpluses generated by new technology.

Of the school age population, 69 percent attend school regularly (Table 13). In sectors 6 (Alto Huallaga) and 5 (Bajo Huallaga) there is a lower percentage of regular attendance. Eight-eight percent of households report reasonable access to primary schools. For 46%, the schools are within 4 km. Most boys (61%) and girls (67%) between 5-15 have had some schooling. There are no secondary schools in the region except one in the city of Yurimaguas. All 22% of children attending secondary school must go there.

Households bear the costs of school books, uniforms, shoes and supplies. Despite the costs and sacrifices a family makes to support the education of children, households are motivated to provide children with knowledge and useful skills for the

society. Most parents (60%) wish their children will have non-farm careers, while 23% of parents wish their children to continue the family tradition of farming. However, most families in remote areas simply cannot overcome the hardships associated with providing continuing (secondary) educational opportunities to their children.

Health problems contribute to the precarious socioeconomic status of the local population. Subsistence agricultural systems that rely heavily on family labor encourage larger family size. Under conditions of minimum health care access, family social and economic well being is vulnerable to common diseases of the humid tropics. Twenty-three diseases were mentioned by farmers in this sample. The five most common diseases in the area are malaria (21%), influenza (16%), fever (12%), diarrhea (11%), and rheumatism (8%). Households use both pharmaceutical (57%) and indigenous medicines (43%). Fifty-five medicinal plants were identified of which the most important indigenous species are: "malva" (12%), "vervena negra" (11%), lemon (10%), "pinon" (7%), and oregano (6%). An integrated development strategy which promotes improved agriculture and human health practices is suggested.

CONCLUSIONS

1. Multiple forces are driving land use changes in the region. The uncertainty and socioeconomic hardship imposed by political turmoil, terrorism, macroeconomic adjustment programs including the closure of the Agrarian Bank have been the predominating influences in the region during the 1980s. Farmers are adjusting to these difficult conditions as best they can with limited resources. In this context the land use options developed by the SM-CRSP are contributing to incipient innovation and diversification of local production. The program has produced much technical knowledge and contributed to institutional capacity through education, training and outreach activities.
2. The longitudinal research experiments are exemplary of the contributions agricultural science can make toward sustainable development. Knowledge produced has dispelled the myths and admonitions against intensive cultivation in the Amazon basin. It has also identified and sought remedies for emergent problems of soil management over successive cropping cycles. These long-term experiments provide a dynamic analysis of soil-plant relationships that are the foundations of improved farming practice. Acid tolerant germplasm and native species in agroforestry and pasture systems is a centerpiece of the low-input management approach. The suitability of land management options for a particular combination of soil, ecological and socioeconomic conditions requires an extension of the experimental designs to include systematic socioeconomic measurements under conditions where temporal effects are not confounded with spatial variability.
3. Land-use varies between and within sectors in close relation to landscape types. Many farmers are involved in multiple land-use options. New crops and innovative practices are slowly being incorporated into farming systems. Diversification of production fits the circumstances and needs of the local population. Also site

variation requires multiple management options. The research program provides management options for the different topographic and socioeconomic conditions.

4. The future of the region is uncertain. One possible scenario is a continuation of farming practices characterized by shortened fallow periods, weed encroachment, and nutrient losses that degrade the natural resource base of the region and lead to socioeconomic calamity. Another possible scenario is to build off the technical knowledge now available and facilitate appropriate technology transfer using new informational and analytical tools. Under proper management the soils can sustain levels of economic return that are superior to traditional shifting cultivation and at the same time produce environmental and socioeconomic benefits.

5. Application of improved management practices to the small portion of the land (5%) with good soil properties could have a substantial effect on the overall national production with minimum adverse effects on the environmental equilibrium of the tropical rainforest ecosystem. In particular, the paddy rice system offers tremendous potential for production and reducing deforestation. Future development of research tools and extension strategies could provide assistance to both private and public interests in the identification of most suitable lands for paddy systems and promote land tenure in these areas with appropriate technology.

6. Difficult social and economic conditions have adversely affected both researchers and farmers in the region. The national system for technical assistance to farmers has been devastated by budget cuts and losses of technical talent. It is not functioning as an agency of technology transfer. It is also unable to provide the research system systematic information on problems and concerns of farmers. Farmer surveys reveal needs for better coordination between research and local practices in soil management. Better information and feedback systems are needed.

7. Some data were difficult to elicit by surveys of farmers. In particular, questions asking for quantitative estimates produced large variation. Few farmers kept written records of their costs of production, labor inputs, plot sizes and yields. Land areas are not well controlled making conversions to standardize units (e.g. t/ha) problematic. As part of the continuing research workplan, field research teams should be equipped with survey equipment and measures for verification of areas in production and yields. Also, when asked about capital requirements of production, farmers gave responses that were clearly underestimates when compared with recorded production costs at the local experiment station. Probing the matter, it became apparent that farmers were not reporting implicit costs, only obvious cash requirements. A farmer who uses seed saved from the previous harvest, family or bartered labor, and no purchased inputs of fertilizer or herbicide has very minimum cash requirements. Even purchased supplies such as the bags used to haul rice to market are saved and patched as necessary to be reused year after year. Future research needs to work with farmers to set up recording systems for expenditures, production, inventories and related factors.

8. Adequate policies are needed to reinforce market signals and accelerate the use of available technology. Improved access and targeting of credit, reduced transaction costs, increased market information and improved infrastructure for transport, storage and processing would unleash a technological transforation of the region. Information overload is a potential problem. Farmers and extension specialists need assistance in interpreting available research findings and drawing practical implications for specific action plans at the national, regional, community and farm levels. Integration of new information into information systems and models will be a continuing need.
9. The challenges of the next decade will be to continue research that addresses unresolved problems and achieves better synthesis of technical, social and economic factors. Improved informational and analytical tools are needed to facilitate appropriate policy formulation, investment planning, problem diagnosis, technology transfer and socioeconomic impact evaluation. The urgent challenge is to draw from the knowledge and experiences gained from Yurimaguas, Peru and to multiply the benefits of research by extrapolating methods and leveraging land use changes in sites throughout the humid tropics.

REFERENCES

Alegre, J.C., D.K. Cassel, and D.E. Bandy. 1986. Effect of land clearing and subsequent management on soil physical properties. Soil Science Society of America Journal 50:1379-1384.

Bidegaray, P. and R.E. Rhoades. 1985. The farmers of Yurimaguas. Document No. 10, International Potato Center, Lima, Peru.

Chaumiel, J.P. (ed.). 1988. Pablo Maroni. Noticias Autenticas del famoso Rio Maranon (1738). Monumenta Amazonica B4. IIAP - CETA, Iquitos, Peru.

Cochrane, T.T. and P.A. Sanchez. 1982. Land resources, soils and their management in the Amazon region: a state of knowledge report. *In* S.B. Hecht (ed.) Amazonia: Agriculture and land use research. pp.137-209. CIAT, Cali, Colombia.

Diaz, W., L.T. Szott, M. Arcos, L.A. Arevalo, and J.M. Perez. 1993. Analisis y evaluacion economica del pijuayo en sistemas agroforestales. *In* J. Mora-Urpi, L.T. Szott, M. Murillo and V.M. Patino (eds.) La biologia, manejo y utilizacion de Pejibaye (Bactris gasipaes H.B.K.). University of Costa Rica Press, San Jose, Costa Rica.

Ganoza, V. G., G.W. Norton, C. Pomareda, R.E. Evenson, and E. Walters. 1990. Evaluating agricultural research and extension in Peru. *In* R.G. Echeverria (ed.) Methods for diagnosing research system constraints and assessing the impact of agricultural research. International Service for National Agricultural Research, The Hague: ISNAR.

Hecht, S.B. 1982. Agroforestry in the Amazon Basin: practice, theory and limits of a promising land use. *In* S.B. Hecht (ed.) Amazonia: Agriculture and land use research. pp.331-371, CIAT, Cali, Colombia.

Lara, D., C. Castilla, and P.A. Sanchez. 1991. Productividad y persistencia de pasturas asociadas bajo pastoreo en un Ultisol de Yurimaguas. *In* T.J. Smyth, W.R Raun

and F. Bertsch (eds.) Manejo de suelos tropicales en Latinoamerica. North Carolina State Univ., Raleigh, NC.

Mt Pleasant, J., R.E. McCollum, and H.D. Coble. 1990. Weed management in a low-input cropping system in the Peruvian Amazon region. Trop. Agric. 69:250-259.

Rhoades, R.E. 1985. The farmers of Yurimaguas. Report 10, International Potato Center, Lima, Peru.

Rodriguez, M. 1991. Proceso de ocupacion y construccion social del espacio amazonico. *In* F. Barclary, M. Rodriguez, F. Santos, and M. Valcarcel (eds.) Amazonia 1940-1990: el extravio de una ilusion. Terra Nuova, Centro para el Voluntariado y la Cooperacion Internacional, Rome, Italy. pp. 103-159.

Salazar, A. and C.A. Palm. 1987. Screening of leguminous trees for alley cropping on acid soils of the humid tropics. *In* Gliricidia sepium: management and improvement. Spec. Publ. 87-01:61-67. Nitrogen Fixing Tree Assoc. Honolulu.

Sanchez, P. and J.R. Benites. 1987. Low-input cropping for acid soils of the humid tropics. Science 238:1521-1527.

Serrao, E.A.S., I.C. Falesi, J.B. DaVeiga, and J.F. Teixeira. 1979. Productivity of cultivated pastures on low fertility soils of the Amazon of Brazil. *In* P.A. Sanchez and L.E. Tergas (eds.) Pasture production in acid soils of the tropics. pp. 195-225, CIAT, Cali, Colombia.

Szott, L.T., C.A. Palm, and P.A. Sanchez. 1991. Agroforestry in acid soils of the humid tropics. Adv. Agron. 45:275-301.

Villachica, J.H., J.E. Silva, J.R. Peres, and C. Magno da Rocha. 1990. Sustainable agricultural systems in the humid tropics of South America. Soil and Water Conservation Society.

Webb, R. and G.F. Baca. 1990. Peru en numeros 1990. Lima: Cuanto S.A.

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Table 1. Reported land use by farmers based on topography, soil color, soil texture, and type of land management.

DESCRIPTION	SECTORS 1	2	3	4	5	6	TOTAL
	----------number of farmers----------						%
Land Classification							
Topography							
beach	5	0	5	3	3	4	12
low flood plain	14	9	9	13	9	15	42
high flood plain	10	2	4	16	9	15	34
high terraces	9	19	19	12	22	14	57
Soil color							
white	9	0	4	5	0	1	11
black	28	20	14	24	25	24	81
red/yellow	13	20	7	3	0	1	27
gray	15	1	3	7	10	7	26
red	0	0	7	0	5	6	11
Soil texture							
sandy	23	10	14	13	15	5	48
loam	20	2	0	5	4	22	32
clay	24	21	11	14	14	3	52
Type of Management							
Paddy rice	16	1	2	3	0	0	13
Shifting cultivation	22	16	19	17	28	16	71
Low input	14	1	5	8	0	8	22
Pastures	10	9	11	5	4	4	26
Agroforestry	4	6	5	5	6	3	17

Table 2. Products and uses of primary and secondary forests by rural households in the Yurimaguas region.

DESCRIPTION	SECTOR 1	2	3	4	5	6
	----------number of farmers----------					
Primary Forest Products						
Timber	20	4	10	13	16	12
Capirona	4	1	1	3	2	1
Cedro	4	0	0	1	7	0
Espintan	1	0	1	3	2	2
Fruit	13	6	0	4	8	3
Firewood	7	4	0	3	3	6
Posts	3	0	2	2	4	1
Leaves for roofing	0	1	6	9	1	8
Vines (rope)	7	2	3	3	7	4
Animals	0	0	1	1	6	0
Medicinal plants	1	0	1	0	6	2
Secondary Forest Uses and Products						
Fallows	24	20	21	21	24	19
Posts	14	1	5	3	2	3
Firewood	29	20	19	20	20	10
Construction mater.	21	6	8	11	6	8
Medicinal plants	6	2	4	2	0	5
Timber	19	11	10	6	13	11
Fruit	11	8	5	9	20	9
Vines (rope)	10	7	9	6	2	4
Animals	7	6	5	3	1	0

Table 3. Prices for services, materials, and products in July 1991. Exchange rate: US$1.00 = 0.80 Nuevos Soles.

ITEM	UNIT	PRICE	SOURCE[a]
		US$	
Labor	day	4.71	Survey
Transportation	ton/30 km	7.50	Market
Seed			
Rice	kg	0.38	INIAA
Cowpea	kg	1.25	INIAA
Peach palm	kg	5.00	INIAA
Inga	pod	0.13	Market
Araza	kg	10.00	INIAA
Centrosema	kg	23.75	INIAA
Shaina	kg	8.75	Market
Cassava stakes	1000	2.50	Survey
Plantain seedlings	one	0.25	Survey
Urea	kg	0.30	Market
Triple superphosphate	kg	0.45	Market
Magnesium sulfate	kg	5.00	Market
Paraquat	l	15.00	Market
Sevin	kg	33.75	Market
Mirex	kg	10.00	Market
Plastic threat	ball	0.80	Market
Bags	one	0.63	Market
Machete	one	10.00	Market
Post-hole digger	one	50.00	Market
Sprayer	one	150.00	Market
String	m	0.35	Market
Brown thread	m	1.00	Market

Table 3. (continued)

ITEM	UNIT	PRICE	SOURCE[a]
		US$	
Shovel	one	18.75	Market
Bucket	one	2.50	Market
Watering pan	one	5.00	Market
Plastic bags	1000	30.00	Market
Ax	one	15.00	Market
Saw dust	kg	0.06	Market
Wood for nursery	m	0.20	Survey
Winch & belt	one	12.50	Market
Gloves	pair	8.75	Market
Wood crate	one	0.63	Market
Products			
Rice	ton	150.00	Market
Cowpea	ton	300.00	Market
Cassava	ton	125.00	Market
Plantain	ton	250.00	Market
Araza	ton	312.50	Market
Peach palm fruit	ton	156.25	Market
Inga fruit	pod	0.13	Market
Inga firewood	m^3	6.25	Market
Shaina wood	m^3	5.00	Market

[a] Survey = rural household survey; market = city of Yurimaguas; INIAA = Yurimaguas Experiment Station.

Table 4. Comparison of yields for the principal agricultural products in the region of Yurimaguas, Peru.

PRODUCT	NATIONAL AVERAGE[a]	DEMONSTRATIONS IN FARMERS FIELDS[b]	RESEARCH STATION PLOTS[b]
		----------kg/ha----------	
Traditional Food Crops			
Upland rice	1200	--	2750
Paddy rice	2500	--	4500
Corn	2767	4076	4500
Soybean	1000	--	2500
Cassava	10,000	18,000	25,000
Cowpea	500	--	1200
Export/Nontraditional Crops			
Plantain	7,000	--	30,000
Coffee	540	--	2750
Cacao	450	--	800
Araza	5,000	12,000	20,000
Brazil nut	--	--	31,000
Camu camu	--	--	6,000
Peach palm (fruit)	--	--	20,000
Peach palm (stems)	--	--	1,000
Peach palm (oil)	--	--	6,000
Animal Production			
Milk (kg/day)	3	8	9
Beef (kg/carcass)	130	180	200

Sources: [a] Peru in Number, 1990; [b] INIAA, 1992.

Table 5. Average household yields and area planted to crops in each sector of the Yurimaguas survey.

	SECTOR											
	1				2				3			
		YIELD				YIELD				YIELD		
CROP	AREA	1990	1985	1980	AREA	1990	1985	1980	AREA	1990	1985	1980
	ha	---t/ha---			ha	---t/ha---			ha	---t/ha---		
Upland rice	2.5	2.2	2.1	1.7	1.3	1.2	1.3	1.5	2.3	1.6	1.6	1.6
Paddy rice	5.0	4.2	3.9	4.4	--	--	--	--	--	--	--	--
Corn	1.5	1.0	1.6	1.8	1.1	1.5	1.3	1.6	1.4	1.5	1.8	1.8
Cassava	0.5	14.6	5.0	--	0.5	4.2	--	--	0.7	11.3	11.8	11.8
Plantain	1.0	15.8	2.5	--	0.5	8.3	9.0	8.0	0.7	9.8	8.7	8.7
Peanut	--	--	--	--	0.5	0.5	--	--	--	--	--	--
Bean	--	--	--	--	--	--	--	--	0.5	0.6	0.6	0.5
Cowpea	--	--	--	--	--	--	--	--	--	--	--	--
Watermelon	--	--	--	--	--	--	--	--	--	--	--	--
Pineapple	0.7	4.0	--	--	--	--	--	--	--	--	--	--
Sugar cane	1.0	2.0	1.0	--	--	--	--	--	--	--	--	--
Coffee	0.5	--	1.6	--	--	--	--	--	--	--	--	--
Cacao	0.8	0.7	--	--	--	--	--	--	--	--	--	--
Peach palm	--	--	--	--	--	--	--	--	0.8	--	--	--
Sweet potato	--	--	--	--	--	--	--	--	--	--	--	--
Potato	--	--	--	--	--	--	--	--	--	--	--	--

Table 5. (continued)

CROP	SECTOR 4 AREA	4 YIELD 1990	4 YIELD 1985	4 YIELD 1980	SECTOR 5 AREA	5 YIELD 1990	5 YIELD 1985	5 YIELD 1980	SECTOR 6 AREA	6 YIELD 1990	6 YIELD 1985	6 YIELD 1980
	ha	---t/ha---			ha	---t/ha---			ha	---t/ha---		
Upland rice	1.6	1.3	1.5	1.4	1.6	1.4	1.3	1.7	1.4	1.6	2.4	2.3
Paddy rice	--	--	--	--	--	--	--	--	--	--	--	--
Corn	1.5	1.8	1.7	1.4	1.8	1.7	1.7	1.8	1.9	1.8	2.0	2.0
Cassava	0.6	12.0	12.4	9.5	1.0	23.0	23.0	18.0	1.7	15.0	19.0	20.0
Plantain	0.7	8.5	10.0	7.8	0.9	17.0	18.3	18.6	0.9	9.4	11.7	11.0
Peanut	0.4	0.8	1.0	1.3	1.0	0.5	--	--	0.9	0.5	0.9	0.9
Bean	0.4	0.6	0.5	--	0.7	0.5	0.5	0.4	0.8	0.6	1.0	1.1
Cowpea	0.4	0.3	0.4	--	0.8	0.5	--	--	1.0	0.5	0.5	0.5
Watermelon	--	--	--	--	--	--	--	--	0.5	3.3	2.0	--
Pineapple	--	--	--	--	--	--	--	--	--	--	--	--
Sugar cane	0.5	--	--	--	--	--	--	--	4.0	--	--	--
Coffee	--	--	--	--	--	--	--	--	--	--	--	--
Cacao	--	--	--	--	--	--	--	--	--	--	--	--
Peach palm	--	--	--	--	--	--	--	--	--	--	--	--
Sweet potato	--	--	--	--	2.0	5.0	--	--	--	--	--	--
Potato	--	--	--	--	0.5	5.0	--	--	--	--	--	--

Table 6. Farmer practices with livestock and poultry among sectors of the Yurimaguas rural household survey.

DESCRIPTION	SECTOR 1	2	3	4	5	6	MEAN
			number				number/farm
Kinds of Animals							
Chickens	519	307	420	318	747	461	16.7
Swine	80	39	29	26	80	83	2.0
Cattle	50	115	99	169	33	94	3.4
Horses	19	8	7	8	15	13	0.4
Guinea pigs/rabbits	35	0	2	6	0	34	0.5
None	16	13	0	0	0	0	0.2
Area in Pasture (ha)	34	75	53	105	23	50	7.9
Use of Improved Management							%
Yes	8	3	1	2	2	2	11
No	21	22	20	13	26	25	76
Not known/no response	4	2	4	11	0	0	13
Kind of Improvement							
Veterinary	6	2	0	1	2	1	67
Feed	1	1	0	1	0	2	28
Animal selection	2	0	0	1	0	0	17
Improved breed	5	2	1	1	0	0	50
Use of Improved Pastures							
Yes	9	4	5	3	2	1	14
No	21	21	15	12	26	26	73
Not known/no response	3	2	5	11	0	0	13
Kind of Improvement							
Pastures	5	4	5	0	2	1	71
Burn	1	1	2	0	0	0	17
Grazing rotation	5	0	2	0	0	0	29
Legumes	5	0	0	2	0	0	29
Cut forage	1	0	0	0	0	0	4

Table 6. (continued)

DESCRIPTION	SECTOR 1	2	3	4	5	6	MEAN
			number				%
Household Consumption of Animal Products							
Yes	27	20	21	12	24	21	75
No	0	2	1	5	4	6	11
Not known/no response	6	5	3	9	0	0	14
Kind of Product							
Poultry	5	2	2	4	21	16	40
Meat	19	12	15	13	3	5	54
Milk	3	6	8	5	2	5	23
Eggs	24	18	19	13	21	18	90
Other (dairy, leather)	0	0	0	2	1	5	8
Sale of Animals							
Yes	9	17	10	14	15	11	46
No	8	2	4	6	6	14	24
Not known/no response	16	8	11	5	8	2	30
Sale of Animal Products							
Yes	9	11	11	0	0	8	23
No	8	8	3	0	0	0	11
Not known/no response	16	8	11	26	28	19	65

Table 7. Weed, pest and disease constraints to agricultural production as reported by farmers in each sector of the Yurimaguas survey.

PROBLEMS/MANAGEMENT	SECTOR 1	2	3	4	5	6	TOTAL
	number of farmers						%
Problem with Weeds							
Yes	33	26	18	24	28	25	93
No	0	1	7	2	0	2	7
Type of weed							
Paspalum sp.	17	16	4	6	1	0	10
Cyperaceae spp.	12	8	9	9	0	4	10
Axonopus compressus	8	4	11	8	4	6	9
Rottboelia exaltata	17	13	0	0	1	1	8
Solanum sp.	5	2	3	3	6	8	6
Others	27	3	65	50	44	58	57
Type of Weed Control							
Herbicides	17	6	7	1	6	3	24
Manual weeding	10	14	18	19	22	24	65
Not known/no response	6	7	0	6	0	0	11
Who Does the Weeding?							
Farmer	10	5	8	7	1	11	25
Day laborer	10	9	6	4	6	3	23
Family laborers	3	4	5	8	6	10	22
Neighbor	0	1	6	7	6	3	14
Not known/no response	10	8	0	0	9	0	16
Problems with Pests and Diseases							
Yes	27	23	21	24	22	23	84
No	3	3	1	2	6	4	12
Not known/no response	3	1	3	0	0	0	4
Type of Pest Disease							
Diatraea sacharalis	0	0	7	9	13	6	27
"Chamuchina"	0	0	5	6	3	7	16
"Chinche"	0	0	6	5	5	5	16
Atta cephalotes	0	0	8	5	2	5	15
"Papaso"	0	0	0	2	3	4	7
Others	0	0	2	6	10	6	19
Type of Pest Control							
Wait for rain	7	0	0	0	4	2	8
Insecticides	12	12	3	1	18	5	31
No control	14	15	22	25	6	20	61

Table 8. Farmer participation in extension and technical assistance activities.

DESCRIPTION	SECTOR 1	2	3	4	5	6	TOTAL
	number of farmers						%
Source of Technical Assistance							
Agrarian Bank	0	0	0	0	2	0	1
Ministry of Agriculture	4	0	0	2	3	0	5
Others (neighbors, friends)	2	0	0	0	0	0	1
None	18	18	23	15	21	27	73
Not known/no response	9	19	3	9	2	0	25
Researcher and Extension Specialist Visits							
Yes	15	5	10	11	15	16	43
No	18	22	15	16	13	10	57
Received Recommendation from Extension Specialist							
Yes	11	3	3	7	4	11	23
No	22	24	22	19	11	15	68
Agricultural practices	11	0	4	3	5	12	69
Pest control	2	2	1	4	1	6	31
Others							8
Follow Up on Recommendations							
Yes	11	2	0	4	5	6	17
No	22	25	25	21	22	20	83
Increase in yield	6	2	0	1	1	1	38
Improved product quality	5	0	0	3	0	5	45
Others	22	25	0	0	2	0	49
Farmer Participation							
Extension visits	8	2	4	6	4	7	19
Demonstrations	3	3	1	0	2	2	7
Demonstration plots	6	2	1	1	2	2	8
Field days	10	3	1	1	1	1	10
Farmer meetings	14	7	5	0	7	11	27
Radio communications	2	3	1	1	8	3	11
Printed materials	1	1	0	0	0	1	2
None	11	15	13	17	11	15	49

Table 9. Distribution across sampling sectors of innovations adopted by farmers during the last ten years.

DESCRIPTION	SECTOR 1	2	3	4	5	6	TOTAL
	number of farmers						%
New Activities in the Last 10 Years							
Coca	0	0	0	1	5	0	4
Timber	5	2	1	1	0	0	5
Fruit trees/firewood	6	1	0	3	2	7	12
Livestock/pastures	6	4	2	2	0	1	9
Fish ponds	0	1	3	3	0	0	4
Others (poultry, sugarcane)	2	1	0	1	1	0	3
Not known/no response	14	18	19	15	20	19	63
Improvements in Land Use							
Yes	17	9	12	13	11	7	42
No	16	18	13	13	17	20	58
Planted fruit trees	16	8	8	8	4	6	30
Planted timber species	5	3	3	2	2	4	11
Planted for firewood	5	4	7	1	0	1	11
Living fences	2	2	0	0	3	1	5
Fish pond	0	1	3	3	0	0	4
Rotation of Crops							
Yes	3	8	5	18	15	15	39
No	30	18	16	4	13	12	56
Not known/no response	0	1	4	4	0	0	5
Improved Seed							
Saved from last harvest	21	18	15	18	13	13	58
ECASA	6	1	0	0	0	2	5
INIAA	5	1	0	0	0	1	4
Others (marked, neighbors)	6	7	9	8	15	11	33
Use of Factor Inputs							
Herbicides	22	14	21	16	17	9	60
Insecticides	11	0	1	4	2	4	13
Fertilizers	10	0	0	2	0	2	8
None	9	12	3	9	11	15	36
Use of Off-Field Residues							
Yes	2	0	2	1	1	1	4
No	28	26	21	24	16	25	84
Not known/no response	3	1	2	1	11	1	12
Type of Residues Used							
Kudzu	2	0	1	0	0	0	2
Rice straw	1	0	2	0	3	1	4
Corn straw	1	0	1	0	2	1	3
Cassava	1	0	0	0	1	0	1
Other (pineapple, guaba and sugar cane)	1	0	1	1	0	0	2
Not known/no response	27	27	20	25	22	25	88

61

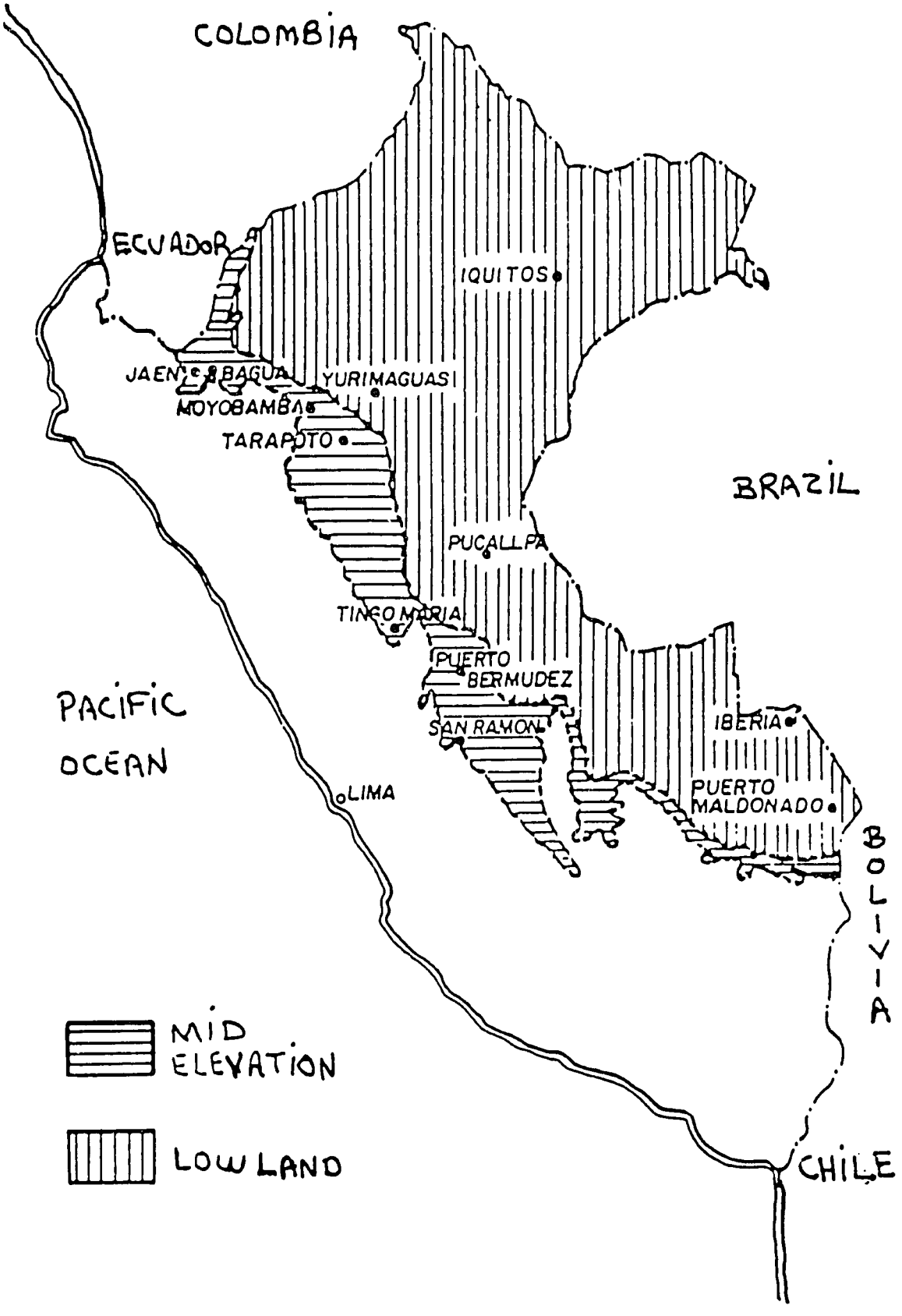
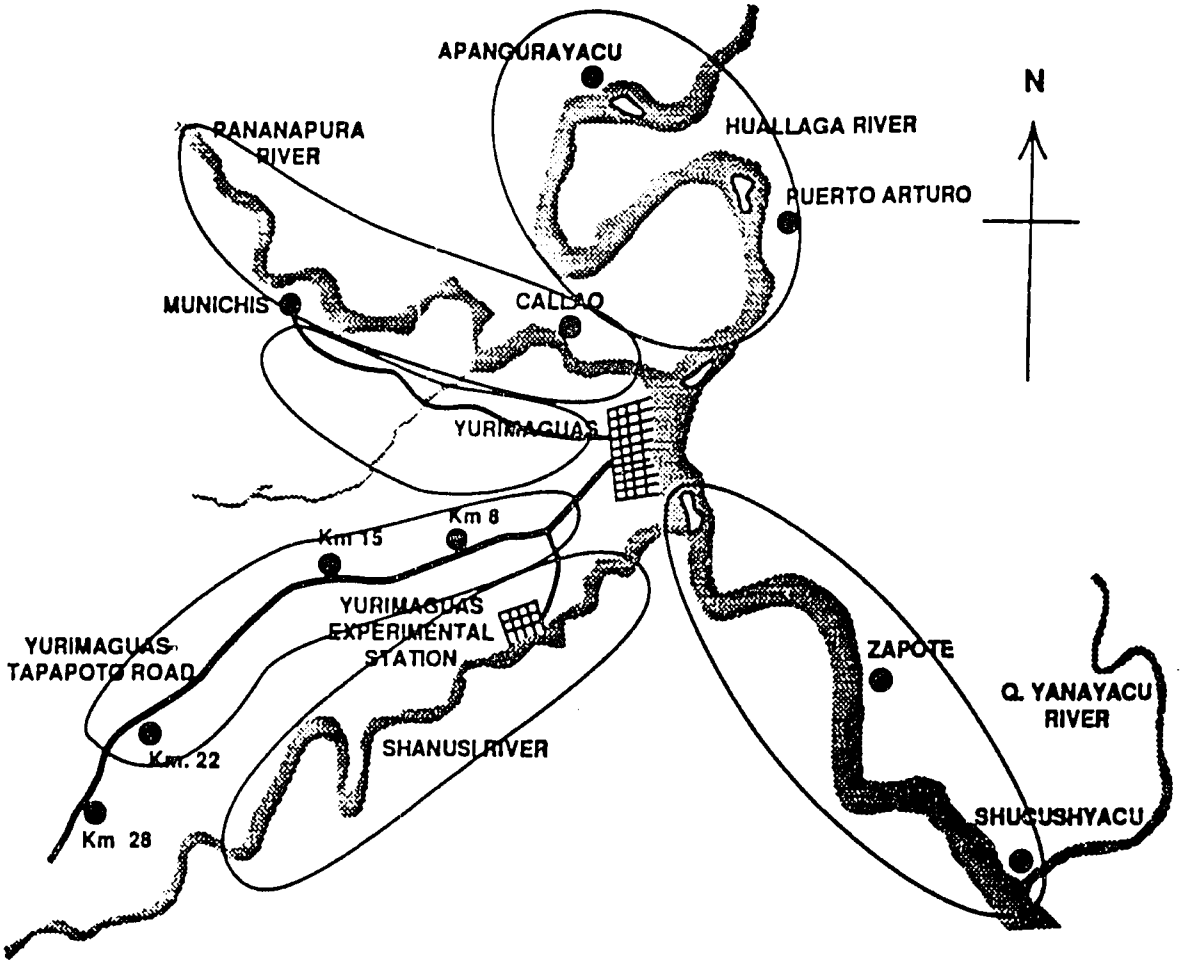

COLOMBIA
ECUADOR
IQUITOS
JAEN
BAGUA
YURIMAGUAS
MOYOBAMBA
TARAPOTO
BRAZIL
PUCALLPA
TINGO MARIA
PUERTO BERMUDEZ
SAN RAMON
IBERIA
PACIFIC OCEAN
LIMA
PUERTO MALDONADO
BOLIVIA
MID ELEVATION
LOW LAND
CHILE

Figure 2. Map of the Yurimaguas area



Sample Sectors:

1. Shanusi
2. Yurimaguas-Tarapoto Road
3. Munichis
4. Paranapura
5. Baja Huallaga
6. Alto Huallaga

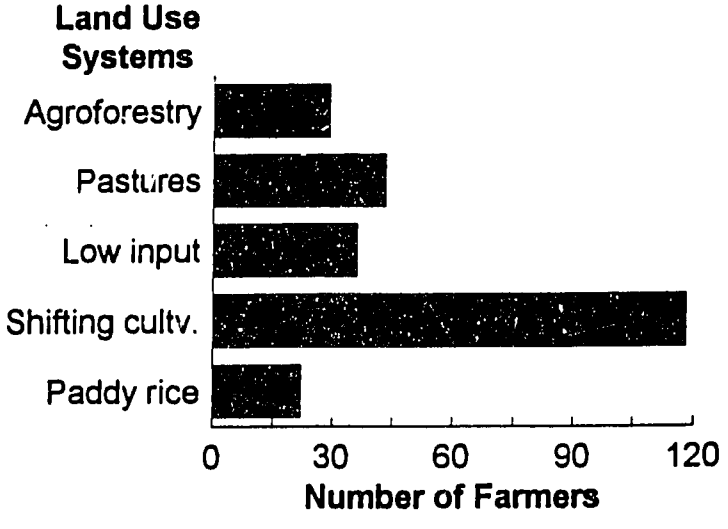

Land Use Systems
Agroforestry
Pastures
Low input
Shifting cultv.
Paddy rice
0
30
60
90
120
Number of Farmers

Fig 3

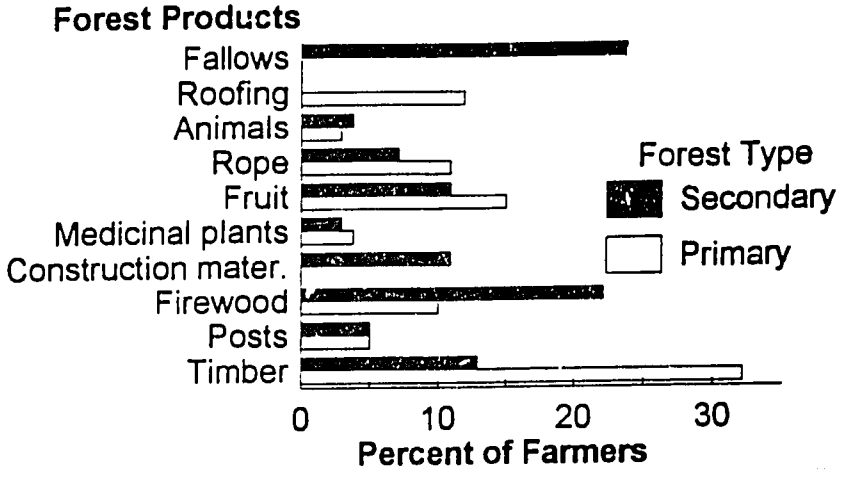

Forest Products
Fallows
Roofing
Animals
Rope
Fruit
Medicinal plants
Construction mater.
Firewood
Posts
Timber
0
10
20
30
Percent of Farmers
Forest Type
Secondary
Primary

Fig 4

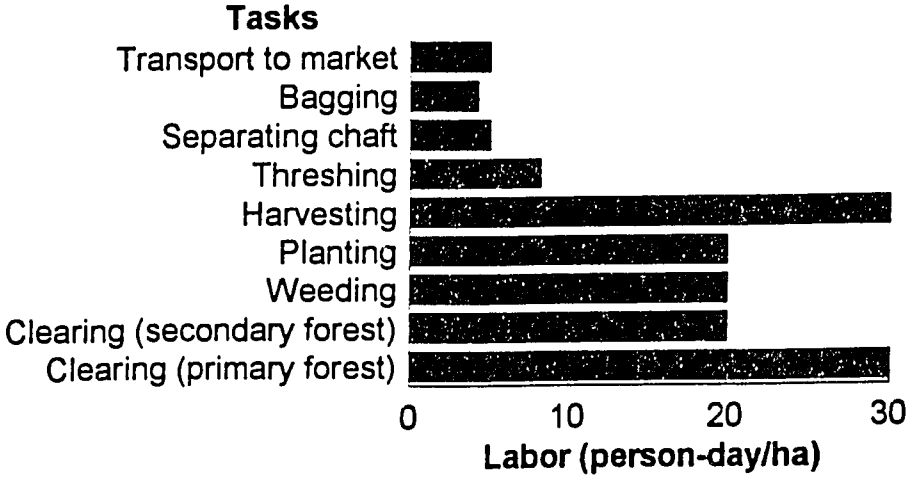

Tasks
Transport to market
Bagging
Separating chaft
Threshing
Harvesting
Planting
Weeding
Clearing (secondary forest)
Clearing (primary forest)
0
10
20
30
Labor (person-day/ha)

Fig 5

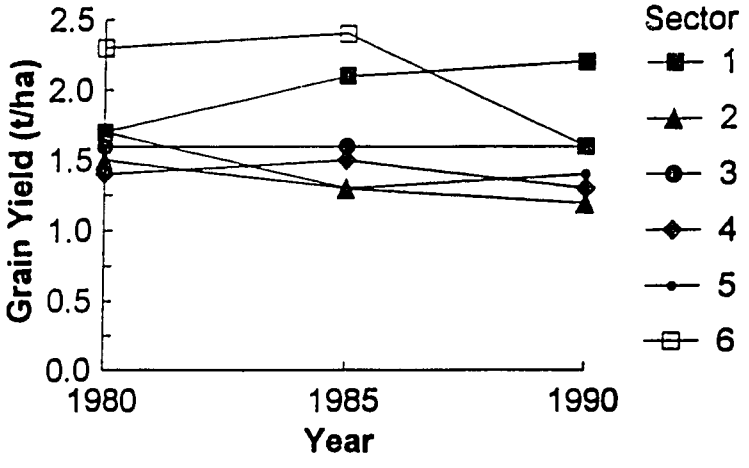
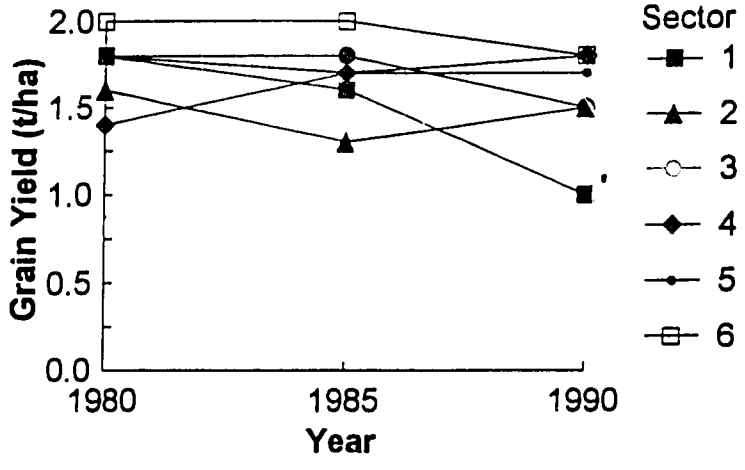

Grain Yield (t/ha)
2.5
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
Year
Sector
1
2
3
4
5
6

Fig 6


Grain Yield (t/ha)
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
Year
Sector
1
2
3
4
5
6

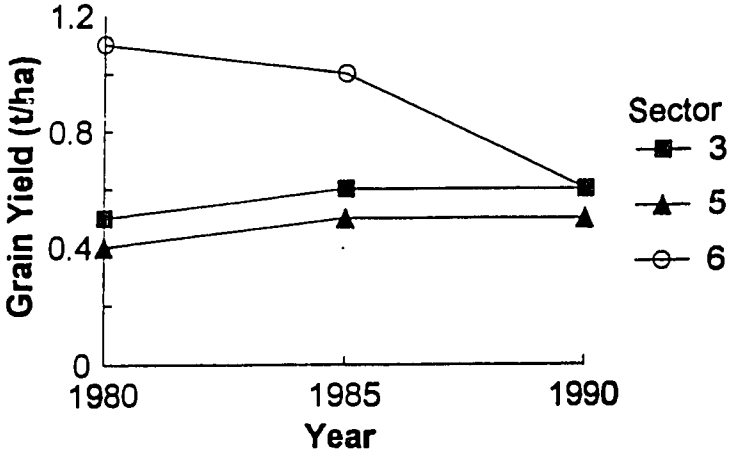


Fig F

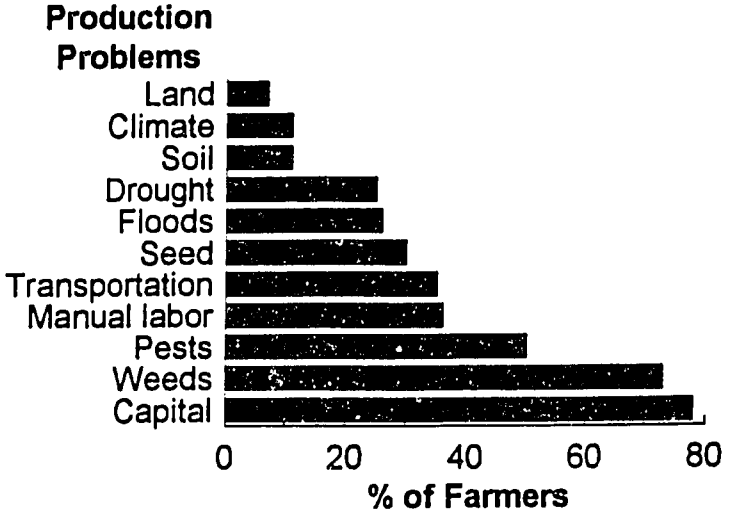

Production Problems
Land
Climate
Soil
Drought
Floods
Seed
Transportation
Manual labor
Pests
Weeds
Capital
0
20
40
60
80
% of Farmers

Fig 9

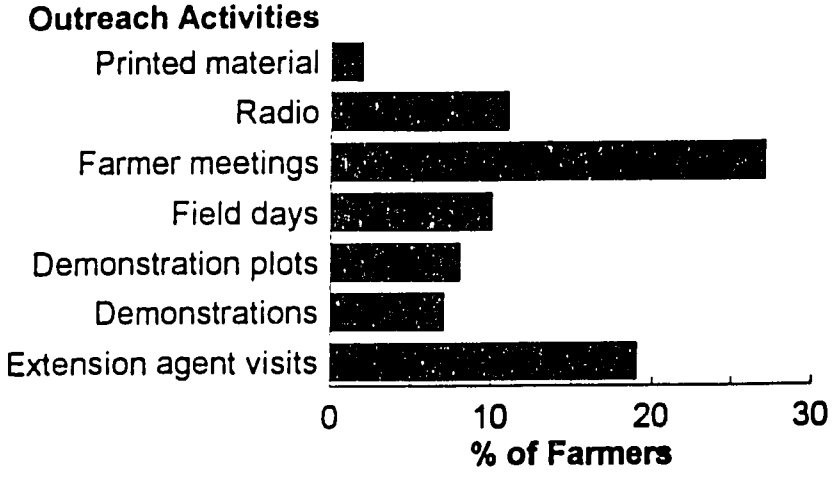

Outreach Activities
Printed material
Radio
Farmer meetings
Field days
Demonstration plots
Demonstrations
Extension agent visits
0
10
20
30
% of Farmers

Fig 10

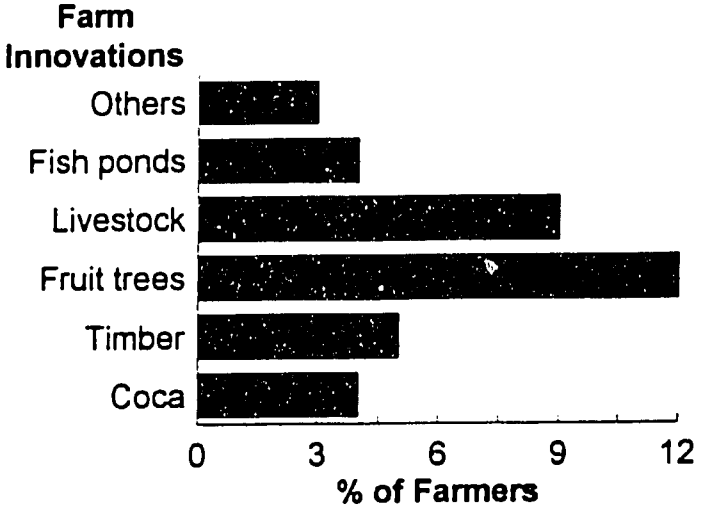

Farm Innovations
Others
Fish ponds
Livestock
Fruit trees
Timber
Coca
0
3
6
9
12
% of Farmers

Fig 11

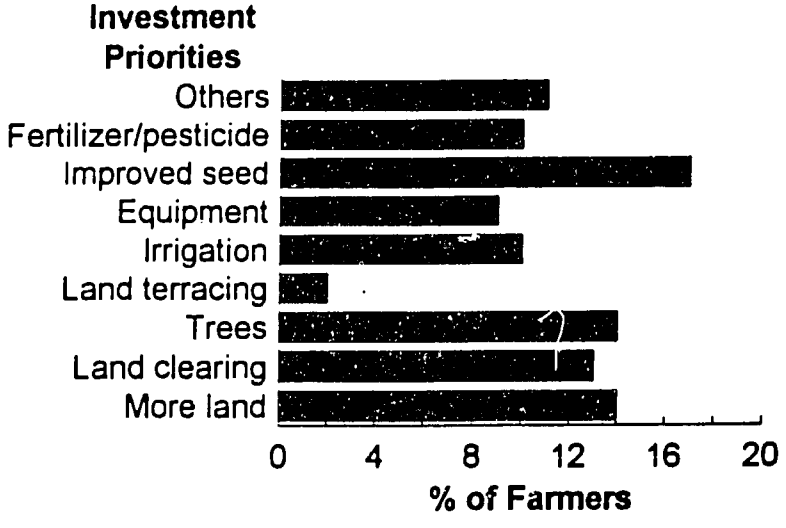

Investment Priorities
Others
Fertilizer/pesticide
Improved seed
Equipment
Irrigation
Land terracing
Trees
Land clearing
More land
0
4
8
12
16
20
% of Farmers

Fig 12

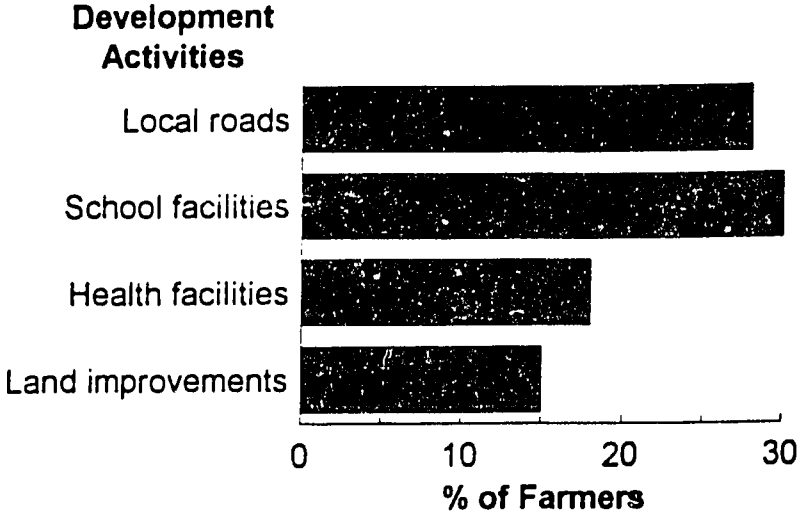

Development Activities
Local roads
School facilities
Health facilities
Land improvements
0
10
20
30
% of Farmers

Fig 13

Table 10 Breakdown of household income and expenses across sampling sectors.

DESCRIPTION	SECTOR 1	2	3	4	5	6	TOTAL
	number of farmers						%
Distance to Product Market (hrs)							
0-2	28	23	16	19	23	25	81
3-4	5	4	8	4	1	1	14
5 or more	0	0	0	1	4	0	3
Transportation							
Truck	3	1	11	0	0	0	9
Horse	12	4	10	1	5	3	21
Boat	6	13	11	16	28	28	61
Walking	9	8	4	7	0	0	17
Not known/no response	3	1	0	4	0	0	5
Problems with Product Transport							
Yes	20	11	20	12	10	12	51
No	10	15	4	12	18	14	44
Not known/no response	3	1	1	2	0	1	5
Expense	2	0	0	0	10	11	27
Availability	9	2	4	0	0	1	19
Others	7	7	0	1	0	0	18
Availability and Use of Credit							
Yes	14	3	10	21	22	10	48
No	19	24	15	4	6	17	51
Not known/no response	0	0	0	1	0	0	1
Agrarian Bank	14	3	10	16	22	8	91
Others (intermediaries)	0	0	0	7	0	0	9
Household Income							
Sale of products	33	27	22	25	28	26	97
Off-farm employment	0	3	5	2	1	7	11
Hunting/fishing	4	4	9	6	13	13	30
Other	11	3	15	3	6	6	27
Principal Expenditures							
Education	4	4	0	5	7	8	13
Labor	8	8	24	10	5	21	36
Food	9	4	3	8	12	5	19
Health care	6	1	2	3	12	3	13
Transportation	1	2	0	0	5	4	6
Others (tools, animal feed, seed, no response)	5	8	6	1	2	6	13
Record Keeping							
Expenses	7	3	2	5	3	3	15
Sale of products	7	5	2	4	9	0	17
Yields	1	5	3	3	4	0	10
Others	4	0	0	0	2	1	4
Not known/no response	4	14	18	14	10	23	53

Table 11. Market price in Yurimaguas of rice and cowpea during the period of 1983 to 1991.

TIME	RICE	COWPEA
	----------US$/ton----------	
January, 1983	321	--
June, 1983	281	--
November, 1983	--	1420
April, 1984	305	--
July, 1984	--	1127
January, 1985	265	--
June, 1985	274	--
July, 1991	150	300

Table 12. Comparison of economic estimates of returns for experimental and farmer conditions in Yurimaguas, Peru.

SCENARIO	COSTS CAPITAL	COSTS LABOR	COSTS TOTAL	TOTAL BENEFITS	YIELD RICE	YIELD COWPEA	MARKET PRICE RICE	MARKET PRICE COWPEA	NET PRESENT VALUE[a]	INTERNAL RATE OF RETURN
	US$				t/ha		US$/t		US$	%
Experimental[b]	1684	1159	2843	6275	2.3	1.1	290	1275	1025.25	609
Experimental[c]	1684	1159	2843	2421	2.3	1.1	150	300	(223.49)	-73
Farmer (no credit or transport)	488	1262	1750	2421	1.8	0.5	150	300	155.55	99
Farmer (with credit)	1338	1262	2600	2421	1.8	0.5	150	300	(135.15)	-38
Farmer (with transport)	672	1262	1934	2421	1.8	0.5	150	300	127.81	93
Farmer (with credit and transport)	1522	1262	2784	2421	1.8	0.5	150	300	(125.08)	-48

[a] Based on median net present value, assuming 15% interest rate and US$=600 nuevos Intis in March, 1991.
[b] 1984-1985 market prices.
[c] July 1991 market prices.

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Table 13. Education and health characteristics of the sampling sectors in the Yurimaguas survey.

DESCRIPTION	SECTOR 1	2	3	4	5	6	TOTAL
	number of households						%
Primary School Access							
Yes	23	19	24	24	28	26	88
No	5	2	1	2	0	1	6
Not known/no response	5	6	0	0	0	0	6
Daily School Attendance							
Yes	19	16	18	18	22	22	69
No	8	5	1	8	5	5	19
Not known/no response	6	6	6	0	1	0	12
Want Children to Become Farmers?							
Yes	3	5	7	6	6	12	23
No	22	12	12	17	21	15	60
Not known/no response	8	10	6	3	1	0	17
If no, why?							
Want them to do better	22	12	12	17	21	15	–
Principal Health Problems							
Malaria	26	19	24	25	13	12	21
Influenza	14	3	18	16	14	23	16
Fever	7	10	8	12	15	16	12
Diarrhea	7	3	17	8	15	14	11
Rheumatism/Arthritis	19	2	2	1	8	11	8
Others (23)	51	14	17	14	35	44	32
Health Care Treatments							
Pharmaceuticals	29	24	21	14	26	24	57
Indigenous plants	17	5	6	23	26	26	43
What Indigenous Plants?							
Malva	13	11	11	9	18	15	12
Verbena negra	11	17	8	18	6	15	11
Lemon	11	14	10	14	5	11	10
Pinon	10	5	10	6	7	6	7
Oregano	6	5	6	3	16	3	6
Others (55)	71	29	41	32	79	94	54

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Bolivian Farmers and Alternative Crops: Some Insights into Innovation Adoption*

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Abstract — The Bolivian Institute for Agricultural Technology, with financial and technical backing from USAID/Bolivia, has recently intensified its efforts to develop and promote cropping systems to serve as alternatives to coca cultivation in the Chapare region of Bolivia. A study was conducted in which 85 farmers were visited and interviewed in order to identify problems faced by farmers of the Chapare, understand the farming practices of the region, and determine the attributes of the new crops that were contributing to their adoption or rejection. Interviews were conducted in an informal manner using an interview guide consisting primarily of open-ended questions. The results of this study indicate that the capital outlay required and the expected profitability, both economic and otherwise, are the attributes of the new crops which most strongly influenced farmers' initial adoption/rejection decisions. The major obstacle to innovation adoption in the Chapare seems to be new crops whose adoption presents unacceptably high levels of risk coupled with low anticipated profitability. Recommendations for the development of the alternative crops program and the Chapare region conclude the paper.

1. Introduction

Bolivia is currently the world's second-largest producer of the coca leaf, the raw material from which cocaine is derived. The majority of Bolivia's coca which is eventually processed into cocaine is grown in the lowland tropical region of Bolivia, the Chapare (Labrousse, 1990; Painter and Rasnake, 1989). The United States and Bolivian governments have been promoting the establishment of alternative cropping systems in the Chapare since approximately 1975. With the implementation of the 1988 Ley del Regimen de la Coca y Sustancias Controladas (Coca and Controlled Substances Regulation Law), coca cultivation in the Chapare was to be phased out over a period of 10 years (Painter and Rasnake, 1989). Coca growers were promised technical assistance in switching to alternative crops, and the Bolivian Institute for Agricultural Technology (IBTA) became the main entity responsible for delivering that assistance. With technical and financial backing from USAID/Bolivia, IBTA has recently intensified its efforts to develop and promote cropping systems to serve as alternatives to coca cultivation.

The purpose of this study, the result of a nine-week stay in the Chapare during which 85 farmers were visited and interviewed, was two-fold: (1) to gain a better understanding of farmers' reasons for either trying out or rejecting the alternative crops, and (2) to identify opportunities for future development of the alternative crops program and the Chapare region.

Drawing on previous studies concerning innovation adoption (Katz, 1963; Rogers, 1983), the authors hypothesized that a number of factors are instrumental in farmers' decisions to adopt or reject the new crops promoted in the Chapare. These include:

- an innovation's relative advantage
- the possibility of loss (risk)
- compatability with existing needs and values
- complexity
- trialability
- observability.

2. The setting

The Chapare settlement area comprises approximately 532,403 hectares and lies in the very humid, subtropical forested area of north–central Bolivia (IBTA/Chapare, 1990). The Chapare lies between

*A summary of the major findings in the M.S. thesis of the principal author at North Carolina State University, Department of Forestry.

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16 and 18°S latitude and is bordered by the Eastern Andes in the south, the Secure River to the west and north, and the Ichilo and Mamore Rivers on the east (Tolisano *et al.*, 1989).

Beginning in the mid- to late-1970s, Bolivians flooded into the Chapare as a result of rising unemployment throughout the country, which reached 35% by 1988, and the expanding economic opportunities offered by the coca industry (Labrousse, 1990). Cultivation of the coca plant increased from 2650 hectares in 1970 to 30,750 hectares in 1984, an increase of 1160%. Yet the cultivation of rice, bananas, and cassava, three of the most important crops in the region, increased by only 300, 164, and 232%, respectively, during that same time period (CIDRE, 1989). By 1990, an estimated 51,000 hectares of coca were planted in the Chapare, and 10% of the Bolivian population earned their livings from coca-related activities (Labrousse, 1990).

The colonists of the Chapare, who usually arrived in groups of families belonging to the same Indian community or village, have organized themselves into sindicatos or farmers' unions which act as local bodies of government. It is estimated that 62% of the settlers arrived spontaneously and 38% as participants in a government-sponsored resettlement program (Painter and Rasnake, 1989). Within the Chapare settlement region, there are 657 sindicatos accounting for a total of 38,377 associated members (CIDRE, 1989). IBTA works with those sindicatos that have expressed interest in establishing production systems which can serve as alternatives to coca cultivation. Although IBTA is also promoting animal systems, the plant systems will be the focus of this study.

IBTA has targeted an estimated 96,994 hectares of the Chapare as being suitable for the establishment of pastures and cropping systems in the form of low-, medium- and high-input agroforestry systems (IBTA/Chapere, 1990). IBTA promotes the alternative crops by working directly with community promoters, representatives elected by their sindicatos who are responsible for learning and teaching the alternative cropping systems to their neighbors. Promoters establish 0.5–1 hectare demonstration parcels on their farms to help neighbors become familiar with the new crops. The number of demonstration parcels in the Chapare has increased from 44 in 1989 to over 90 in 1991, which suggests that a growing number of sindicatos are exploring alternatives to coca cultivation (Majia, 1991, pers. comm.).

IBTA has divided the project area into seven ecological subregions which are in turn divided into micro-regions. Different combinations of alternative systems are promoted in each. Within the project area, six Holdridge life zones (Holdridge, 1982) are represented: wet subtropical forest and wet tropical forest transitional to subtropical, moist subtropical forest, subtropical rainforest, lower montane subtropical rainforest, and montane subtropical forest. Soils orders are predominantly ultisols, entisols, and inceptisols. The soils of the alluvial plains, represented by entisols and inceptisols with moderate fertility and acidity ranging from pH 5 to 5.5, are among the best in the region, although a few areas experience occasional flooding. The majority of the soils, however, are ultisols with low native fertility and elevated levels of acidity and aluminum toxicity (IBTA/Chapare, 1990). The heavy rainfall experienced throughout the Chapare (up to 4800 mm/year) (Tosi, 1983) is likely to make lime and fertilizer management problematic (Monteith, 1992, pers. comm.).

With the implementation of the 1988 Ley del Regimen de la Coca y Sustancias Controladas, no coca would be forcibly eradicated in the Chapare, but it would be illegal to plant new areas to coca (Painter and Rasnake, 1989). In addition to technical assistance in switching to alternative crops, other incentives have included promises of community development projects such as schools, hospitals and potable water, readily available credit, and a payment of U.S.$ 2000.00 to farmers for every hectare of coca uprooted. Furthermore, the price of coca has fallen from an average of U.S.$ 700.00 per 100 lb. of dried leaves in 1985 to approximately U.S.$ 30.00 in 1991, which may be the most powerful factor encouraging farmers to look for alternatives to coca production (Salinas, 1991, pers. comm.).

Nevertheless, coca cultivation is still attractive to farmers for a variety of reasons. While in rural areas an individual's average annual income is $150.00, a coca leaf crusher earns between $7.00 and $15.00 per day (Labrousse, 1990). Coca is the ideal commercial crop since it has an established market, provides three–four good harvests per year, is easy to transport, and grows well with minimal inputs (Chapare farmers, pers. comm.). Finally, the coca leaf has been used for social, medicinal, and religious purposes by Andean peoples for centuries (Weil, 1986). Clearly, the incentives for and against coca cultivation form an influential backdrop against which this study was conducted.

3. Methodology and limitations of study

The principal author collected the data used in this study during a nine-week stay in the Chapare during

which 85 farmers were visited and interviewed. The purpose of the interviews was to identify problems facing farmers, understand the farming practices of the region, and determine the attributes of the new crops that were contributing to their adoption or rejection.

Before beginning the field work the principal author spent approximately five days becoming familiar with the alternative cropping systems, meeting with key IBTA personnel, and planning the work schedule with IBTA extensionists.

The principal author conducted the interviews in an informal manner (Rhoades, 1982), and an average of two–three were completed per day in five of the seven ecological subregions of the Chapare (IBTA/Chapare, 1990) where acid, infertile soils predominate. The author rented a four-wheel drive jeep to reach remote areas, and Fig. 1 indicates the communities visited. An interview guide was used which consisted of a list of primarily open-ended questions dealing with farmer-perceived problems, farming practices, and farmers' reasons for trying out or rejecting the new crops. The open-ended format was used in order to encourage farmers to direct the conversation toward the topics/issues which interested them the most (Chambers, 1985; Garrett *et al.*, 1987). IBTA extensionists critically reviewed the contents, wording, and vocabulary used in the interview guide and contributed valuable suggestions for its improvement.

Visits to farmers began with an explanation of the purpose of the study, and farmers were assured that their participation was voluntary. The principal author first requested a walking tour of the farm-site in order to become familiar with the farmer's land-use patterns and farming problems (Rhoades, 1982; Raintree, 1987). After walking around the farm, the author, her driver, who often served as a Spanish/Quechua translator, the farmer, and an IBTA extension worker returned to the farmer's home where the interview was completed. During the interview the author recorded detailed notes and took photographs with the farmer's permission (Rhoades, 1982; USAID, 1990). The author avoided asking questions about coca cultivation in order to reassure farmers that coca was not the focus of the visit. Farmers who had their pictures taken were sent copies of the photographs with a note thanking them for their participation in the study (Rhoades, 1982).

Respondents were chosen by probability sampling. Since the Chapare covers a wide geographical area, two-stage cluster sampling was judged to be the most time- and cost-effective sampling method (USAID, 1990). IBTA extension workers chose individual communities to visit (primary clusters) within the subregions based on the technologies being promoted and safety considerations. The extensionists then chose the promoters (secondary clusters) who were the most active and experienced, since the objective of the study was to conduct interviews with farmers who were already familiar with the alternative crops program. Promoters generated lists of adopters and non-adopters from which the principal author randomly selected respondents. For the purposes of this study, an 'adopter' is defined as someone who is trying out at least one new, alternative crop. In the event that a woman appeared on a list, she was automatically chosen in

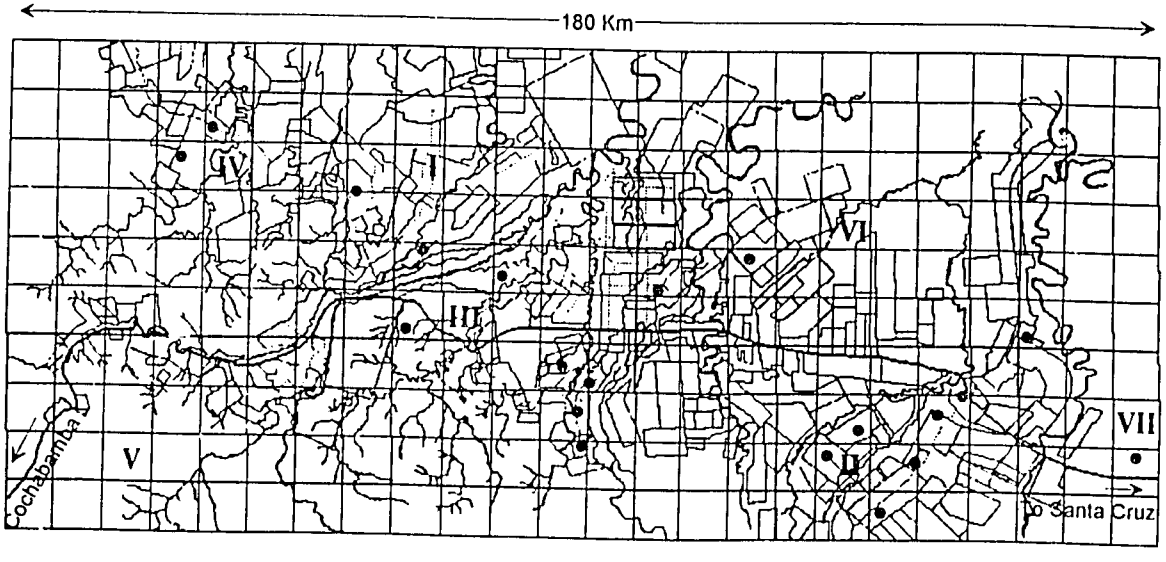

Figure 1. Map of the Chapare with location (solid circles) of communities visited. Roman numerals indicate subregions. Three communities were visited in subregion VII, which does not appear on the map.

order to ensure that women were included in the study. Promoters were the first farmers visited and interviewed in each new community and were considered adopters.

In addition to interviews with farmers, the authors gathered information from key informants, including the director of a school, the doctor of a community health clinic, and a laborer employer by IBTA (Rhoades, 1982; Chambers, 1985). The principal author also attended a meeting between farmers and representatives of PL480, the credit mechanism for the alternative crops program, and talked with five members of the Association of Maracuya (Passion Fruit) Growers.

The inductive method was used for coding the open-ended questions of the interview; that is, the responses were recorded in as much detail as possible and were later divided into categories and coded. The deductive method, which uses a predetermined classification scheme, was used for the closed-ended questions (USAID, 1990).

It is important to point out that this study investigated farmers' reactions to the new crops only at one point in time, while innovation adoption is actually a continual process over time (Rogers and Shoemaker, 1971). The majority of the farmers classified as 'adopters' in this study emphasized that they were in the trial stage and were experimenting with the new crops to see which ones worked best. Thus, depending on the outcome of this initial trial period, it is possible that some of the 'adopters', defined as farmers who are trying out at least one new crop, will eventually become 'rejecters', and that some 'rejecters' will eventually become 'adopters'.

Among the limitations of the study is the fact that the principal author was in the region for only nine weeks; thus it is possible that some important issues were overlooked. By the end of the seventh week in the field, however, no new issues were surfacing, and the author was reasonably confident that she had obtained an adequately sized sample. Due to the author's limited amount of time in the region, farmers were unable to get to know the interviewer well, and as a result may not have been as candid as was hoped. The interview techniques used, however, should have countered this problem to some degree.

The viewpoints of non-adopters may have been under-represented in this study since it was more difficult to locate and interview non-adopters than adopters. Promoters were often hesitant in giving out the names of non-adopters for fear of angering their neighbors. When promoters did identify non-adopters, they were often not at home when the interviewer arrived. Since many non-adopters tended to rely heavily on coca production, they may have feared retribution if it were known that they were not yet working with the alternative crops. Many non-adopters may also have been part-time residents of the Chapare. As a result of these constraints, more adopters and fewer non-adopters were interviewed than had been planned.

Other limitations of the study include the possibility that IBTA extension workers promoted some of the alternative cropping systems more frequently or more enthusiastically than others. Furthermore, the new crops were introduced at different times, and some crops are promoted in more subregions than others. Thus, based on the data presented in this study, it is difficult to state conclusively which of the new crops were the most popular.

The presence of the coca eradication program in the region increased tensions and handicapped the principal author's ability to conduct this study. During an evacuation early in the study, for example, several interview days were lost. The author avoided staying in the communities after dark, which made it impossible to interview farmers at home in the evening, which may have been the most convenient time for them to talk. Finally, certain communities had to be avoided altogether because of safety considerations.

4. Results and discussion

Of the farmers interviewed, 46 (54%) were 'adopters', that is farmers who were trying out at least one new crop, while 27 (32%) were 'rejecters'. Twelve farmers (14%) were from subregion VIIB where improved pastures, rather than new crops, were being promoted and therefore fell into a third category.

When farmers were asked to identify their most pressing farming-related problems, the three most common responses given by farmers were: (1) agronomic problems; (2) a lack of markets/low prices for their products; and (3) transportation difficulties (see Table 1).

Agronomic problems included plants plagued by diseases, infertile soils, tenacious weeds, and problems with soil compaction and poor growth of pastures. Transportation difficulties ranged from the high cost of transportation, to roads that were impassable during much of the year, to a total lack of available transportation. Several farmers commented that they had lost truckloads of oranges

Table 1. Farmer-perceived problems

Problems	Percent
1. Agronomic problems	30.9
2. Lack of markets/low prices	29.6
3. No major problems	22.2
4. Transportation	21.0
5. Credit-related problems	7.4
6. Flooding/standing water	7.4

(1) Includes responses that were given by more than 5% of the farmers who responded to this question.
(2) Each farmer could give from one to four responses.
(3) Sample size = 81.

because vehicles could not reach their communities during periods of heavy rain. Finally, an equal number of farmers mentioned problems with credit, including difficulties acquiring credit or paying back loans, and flooding or standing water as being among their most serious farming-related problems.

It is interesting to note that 22% of the farmers responded that there were no major problems. Most of these were farmers for whom coca (38.9%), bananas (22.2%), or improved citrus (11.1%) was their most important product.

New crops evaluated, in decreasing order of popularity among farmers included in this study, were pineapple, improved citrus, bean, coconut, pepper, passion fruit, peach palm, and macadamia (Fig. 2).

Farmers' reasons for planting alternative crops are shown in Table 2. In contrast, Table 3 lists farmers' reasons for *not* planting the new crops. By comparing farmers' reasons for adopting versus rejecting the alternative crops, one can begin to understand which attributes of the new crops are contributing to their adoption or rejection.

The most common reason given for planting alternative crops was a belief in the market potential of the new crop. Farmer decisions were based on the knowledge that a market for the product currently exists or a belief that the product would become industrialized in the near future. Several farmers suggested the need for processing plants to process fruits for export in order to provide buyers for farmers' products and to increase employment opportunities in the region. The second reason given was that since the future of coca appeared dismal, it was necessary to look for alternatives to coca production. The third most common reason farmers planted alternative crops was to improve the nutritional status of their families.

Further understanding of the attributes of alternative crops which promote their adoption can be gained by studying the characteristics of the most popular of the new crops. From Fig. 2, one can see that pineapple, improved citrus, and bean were the three most popular of the alternative crops among the farmers interviewed. Pineapple has an international as well as a domestic market, produce within a relatively short amount of time, and is among the most ecologically well-adapted crops. In addition, farmers can easily try out pineapple on a

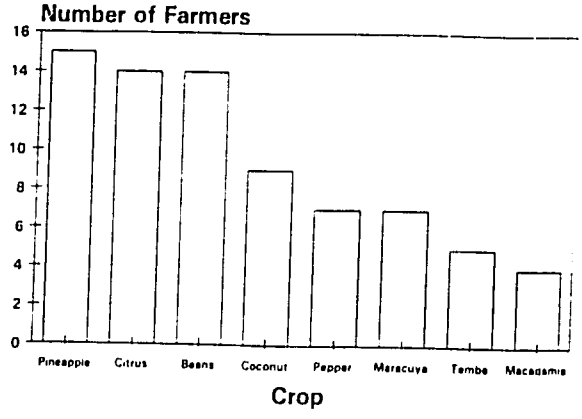

Figure 2. Alternative crops planted by farmers. Only crops planted by at least 3% of interviewed farmers are included in the figure.

Table 2. Farmers' reasons for adopting alternative crops

Reason	Percent
1. Belief in market potential	55.3
2. Problems with coca	26.3
3. Nutrition of family	23.7
4. Improved citrus are superior	15.8
5. Crop diversification	10.5
6. Recommendation of IBTA	10.5

(1) The above table includes reasons that were given by more than 10% of the farmers who responded to this question.
(2) Each farmer gave from one to three responses.
(3) Sample size = 38.

Table 3. Farmers' reasons for rejecting alternative crops

Reason	Percent
1. Large investment required (plants/chemicals)	48.8
2. Plants will not grow well	34.2
3. Lack of markets	24.4
4. Lengthy production time	14.6
5. Not familiar with plants	12.2
6. Other (five responses)	12.2

(1) The above table includes reasons given by more than 2.5% of the farmers who responded to this question.
(2) Each farmer gave from one to four responses.
(3) Sample size = 41.
(4) Note: responses of both 'rejecters' and 'adopters' who were not planting some of the new crops for specific reasons are included in this table.

Table 4. Price list for plant propagules

Common name (English)	Common name (Spanish)	Scientific name	Unit	Price (U.S.$)
		Perennial crops		
Bixa dye	Achiote	*Bixa orellana*	Plant	0.15
Improved citrus	Cítricos mejorados	*Citricos* sp.	Plant	1.50
Coconut	Coco	*Cocus nucifera*	Plant	3.50
Coffee	Café	*Coffea arabica*	Plant	0.06
Cocoa	Cacao	*Theobroma cacao*	Plant	0.50
Star fruit	Carambola	*Averrhoa carambola*	Plant	0.50
Sour sop	Guanábana	*Annona muricata*	Plant	0.60
Macadamia	Macadamia	*Macadamia integrifolia*	Plant	13.00
Black pepper	Pimienta	*Piper nigrum*	Plant	1.47
Pineapple	Piña	*Annas comosus*	Sprout	0.14
Peach palm	Tembe	*Bactris gasipaes*	Plant	0.30
Passion fruit	Maracuya	*Pasiflora edulis*	Plant	0.16
		Annual crops (seeds)		
Rice	Arroz	*Oryza sativa*	11.36 kg	5.00
Beans	Frijol	*Faseolus vulgaris*	kg	0.70
Peanut	Maní	*Arachis ipogea*	kg	1.00
Corn	Maíz	*Zea mays*	kg	0.55
		Tree crops		
Several species			Plant	0.08

Source: La Jota Experiment Station, IBTA/Chapare, Bolivia (1991).

small scale with the least investment, since the cost of each propagule is minimal (Table 4). In regions where pineapples were being promoted, farmers actually reported a shortage of plantlets.

Improved citrus share many of the above-mentioned attributes of pineapples. In addition, improved citrus have clear advantages over the natural citrus, which over one-half of the citrus growers were already cultivating. Farmers stated that improved citrus produce a higher quality fruit than the natural citrus, produce fruit at a time of year when natural citrus do not, command a higher price at the marketplace, and produce fruit within three years as compared to eight years for the natural citrus. Finally, beans, also one of the most popular alternative crops, can be produced inexpensively, seem to grow well, and produce their first crop within a short amount of time. Most importantly, farmers stated that beans have high nutritional value for both people and animals.

In this study bananas are not considered to be a part of the alternative crops program because farmers cultivated them on a commercial scale before IBTA's involvement in the region. In fact, coca has played a much less important role where banana farming has been successful. The author purposely avoided sampling in predominantly banana-growing regions since the study was examining innovation adoption. However, it would be interesting to study whether or not farmers are following IBTA's recommendations for improved cultural practices and packaging of bananas, which are intended to increase their international competitiveness. Bolivia exports bananas to Chile and Argentina, and trucks visit on a regular schedule to purchase farmers' bananas. On the basis of superficial observations made by the author and conversations with extension workers and farmers, it seems that the banana improvement project is enjoying high levels of farmer participation.

Improved pastures is an innovation that has been adopted by an overwhelming majority of cattle owners in the Chapare. Of the 27 current or prospective cattle owners interviewed, 23 (85%) stated they were using improved pastures. Their reasons for doing so were clear-cut: 90% of farmers indicated that the improved pastures provide superior growth and/or nutritional value relative to native pastures. Most of the cattle owners, however, had prior experience with improved pastures when they came to the Chapare. Certainly the positive prior experiences of farmers and the clarity of benefits demonstrated in the Chapare encouraged people to use the improved pastures.

As shown in Table 3, the most common reason farmers gave for *not* planting some or all of the alternative crops was the large investment required in order to purchase and maintain the new plants. The second reason stated by farmers was the belief that the plants would not grow well. The third

reason was the lack of markets for the alternative products and doubts about their future market potential. The fourth most common reason given for not planting alternative crops was the lengthy period of time required for the plants to reach production age. Finally, five farmers stated that they had not planted the alternative crops because they were not yet familiar with them. Each of the first four reasons will be discussed in turn.

1. *Large investment required*

Nearly half of the farmers who identified their reasons for rejecting some or all of the alternative crops mentioned the high cost of establishing the new plants due to the cost of the propagules. When the price of the propagules (Table 4) is considered in relation to the daily wage of a rural laborer at 10 bolivianos or 2.86 U.S. dollars (1991), it is clear that buying even a few propagules represents a substantial investment to many farmers. Farmers were also quick to point out that if the plants die, the farmer is not reimbursed but simply loses his or her money.

In addition to the initial cost of the plants, farmers stressed that the total cost is elevated by the agrochemicals required by the new plants. At the time the study was being conducted, 34 out of the 41 people questioned stated that they were not using granular fertilizers. Of these 34, seven were promoters. At the price of $35.00–40.00 for a 46 kilogram sack of fertilizer, it is not surprising that the high cost of fertilizers was the most common reason given for not using them (Table 5).

It is important to point out that although farmers rarely used granular fertilizers, they commonly used foliar fertilizers for their coca plants. It would be interesting to investigate whether foliar fertilizers were less expensive or more available than the granular variety, or whether farmers believed that returns per unit input were justified for coca but not for other crops.

Table 5. Reasons for not using (granular) fertilizers

Reason	Percent
1. Too much expense involved	42.4
2. Not necessary	33.3
3. Do not know how to use them	18.2
4. Harmful to use them	6.1
5. Benefit might not outweigh cost	6.1

(1) A total of 41 farmers were asked whether or not they used fertilizers; 34 people (82.9%) responded that they did not. Of these 34, 33 were asked *why* they did not use fertilizers, and all of their repsonses are shown above.
(2) Two other farmers stated that it was harmful to use agrochemicals, but these were not included in the above tallies since the author was unable to determine whether or not the farmers were referring specifically to fertilizers.

In addition to the expense involved, farmers, including three promoters, stated they did not use fertilizers because they did not know how to use them. It is interesting to note that nearly one-third of the farmers not using fertilizers, including two promoters, stated that they were unnecessary because farmers produced fertilizer naturally when they burned primary or secondary forest. Finally, slightly over 6% of farmers stated that the benefits of using fertilizers might not outweigh the costs, while another 6% stated that chemical fertilizers were damaging to the soil system. Clearly, farmers require more assistance in the area of agrochemicals, in terms of technical as well as financial assistance, in order to carry out the cultural practices recommended for the alternative crops.

Although PL480 loans were intended to ease the financial difficulties of establishing the alternative crops, farmers stated that there were serious problems associated with the agricultural loan system. Of the farmers interviewed, 32% stated that loans were difficult to obtain, primarily because they lacked official title to their land. Of the 26 farmers interviewed who did have PL480 loans, 10 stated that it was difficult to pay back the loans with money generated from the project for which the loan was taken. A major difficulty farmers identified was that it takes at least three years for many of the new crops and cattle to produce a return, while the 13% annual interest is due at the completion of the first year. Furthermore, several farmers stated that interest payments were problematic because one had to pay in U.S. dollars which were continually increasing in value relative to bolivianos. These concerns, in addition to farmers' doubts as to whether the alternative crops would actually grow well or yield products for which there are markets, made nearly 24% of the farmers interviewed reluctant to take out loans.

2. *Plants will not grow well*

While farmers agreed that the new crops seemed to be growing well at the experimental stations, they commonly doubted that they would grow equally well on their own farms due to different soil conditions and their lack of technical expertise. Furthermore, farmers had seen the new crops growing poorly or suffering from diseases on neighbors' or promoters' farms. Although the poor performance of the plants may have been partially due to farmers' improper use of agrochemicals, the farmers' observations were nevertheless consistent

with Tosi's predictions that, because of the climatic conditions prevalent in the bulk of the Chapare, truly tropical perennials, which require year-round uniform temperatures and photoperiods, are likely not to grow well (Tosi, 1983). Nevertheless, since there is much inter-varietal variation in climatic tolerances within a species, it is possible that certain varieties of alternative crop species could be identified that do grow well. It is unfortunate that many of the new crops were taken to farmers' and promoters' fields before sufficient research was done to indicate whether or not the varieties being used would actually grow well in the regions where they are promoted.

Over half of the farmers interviewed reported that they made their decisions as to what to plant based on the results of their own experiments on their own land. This information has important implications for strategies designed to promote the planting of alternative crops.

3. *Lack of markets*

Farmers' doubts about the market potential of the alternative crops were another factor that discouraged adoption. An additional concern expressed by farmers was that if everyone started planting alternative crops and there were only domestic markets for their products, the markets would soon become saturated and prices would fall. Again it is interesting to note that the most popular alternative crop, pineapple, and banana, a popular traditional crop, were among the few crops which had an international as well as a domestic market.

4. *Length of production time*

Given the fact that the interest on agricultural loans was due at the end of the first year and farmers were expected to reduce their coca cultivation *before* their alternative crops had time to produce an economic return, it is not surprising that the lengthy production time required by the majority of the alternative crops was an additional factor discouraging their adoption. Farmers pointed out that without an outside source of income, it would be impossible for them to support their families, buy the agrochemicals needed by the new plants, and repay the interest on the agricultural loans while waiting for the new crops to begin producing an economic return.

In previous studies, education and farm size have often been cited as socio-economic characteristics distinguishing adopters from non-adopters (Feder *et al.*, 1985; Rogers, 1983). In contrast, there was not enough evidence in the data from this study to support the existence of a significant relationship between years of formal education or land-holding size and innovation adoption (Table 6). This result may be explained by the fact that a variety of alternative crops were being promoted. Wealthier farmers would be the first to adopt if innovation adoption required a large investment of capital, as has usually been the case in previous studies examining characteristics of adopter categories. In this study, however, some of the innovations, such as beans, require little investment and could be adopted by poorer and wealthier farmers with equal facility. In fact, poorer farmers would be more likely to adopt beans since they would be less able to afford meat in their diets. An additional consideration is that larger, wealthier farmers may have already been working with successful alternatives to coca, such as bananas, and may have had less of a need to try out the new alternative crops than small farmers entirely dependent on coca. Furthermore, since educational opportunities are usually positively correlated with wealth, it is not surprising that in past studies adoption of innovations has been positively correlated with formal education. In this study, however, the data did not present enough evidence to suggest a significant difference in the average educational level of adopters as compared to non-adopters.

The data from this study did, however, suggest a significant relationship between age and adoption, with younger farmers more likely to adopt than older farmers. This result may be a consequence of the fact that older farmers were involved in economically successful endeavors before the coca boom and were never as dependent on coca for their livelihoods. Thus, their need to explore alternatives to coca cultivation would not be as great. Furthermore, many of the younger farmers probably migrated into the Chapare during the coca boom and had little experience with anything else. Perhaps younger farmers, lacking experience of their own on which to depend, were more open to outside advice and new ideas.

5. Conclusions

The results of this study indicate that capital requirements and expected profitability are the attributes of the new crops that most strongly influenced farmers' initial adoption and rejection decisions.

The three alternative crops most often planted by the farmers interviewed were pineapple, improved citrus, and bean. Pineapple and bean were among

Table 6. *T*-test results for education, landholdings, and age vs adoption

For education vs adoption:

Adopt	*N*	Mean	Std dev.	Variances	*T*	*p*-value
0	26	4.0	3.34	Unequal	−1.37	0.177
1	43	5.2	3.74	Equal	−1.33	**0.188**

For H_0: variances are equal, *F*-value = 0.551. (*F*-value is not significant; therefore, do not reject H_0 and use *p*-value shown in bold above.)

For landholdings vs adoption:

Adopt	*N*	Mean	Std dev.	Variances	*T*	*p*-value
0	22	15.2	11.97	Unequal	−1.17	**0.247**
1	41	20.1	21.19	Equal	−1.00	0.323

For H_0: variances are equal, *F*-value = 0.007. (*F*-value is not significant; therefore, reject H_0 and use *p*-value shown in bold above.)

For age vs adoption:

Adopt	*N*	Mean	Std dev.	Variances	*T*	*p*-value
0	26	41.7	13.86	Unequal	1.83	**0.074**
1	43	36.0	10.18	Equal	1.97	**0.053**

For H_0: variances are equal, *F*-value = 0.076. (*F*-value is borderline; therefore, it is debateable which *p*-value should be used.)

(1) Alpha level used for *p*-values = 0.100; therefore *p*-values equal to or less than 0.100 are considered significant, and *p*-values greater than 0.100 are considered not significant.
(2) Alpha level used for *F*-values = 0.05.

the crops that could be tried out on a small scale with the least investment. These crops also offered the clearest benefits. Farmers planted beans for their high nutritional value, pineapple and improved citrus had good market potential, and improved citrus had clear advantages over the natural citrus which more than half of the citrus growers were already using. There was a promising export market for bananas, a population traditional crop whose production and marketing IBTA were working to improve. Finally, among the crops tested, pineapple, bean, improved citrus, and banana were also among the crops most well-suited to the climate and soil conditions prevalent in the Chapare.

Because farmers were aware that the future of coca was problematic, and there were government incentives in place to encourage the establishment of alternative production systems, the alternative crops were compatible with farmers' needs to look for alternatives to coca cultivation. However, farmers rejected alternative crops for a combination of reasons.

The relatively large capital investment required due to the initial cost of some of the plants and the expensive agrochemicals required for their maintenance discouraged farmers. The unfamiliar agrochemicals were also incompatible with farmers' current practices. From the farmers' perspective, anticipated profitability was low due to farmers' doubts about the new crops' market potential and ecological suitability to the region. Finally, a loan system that demands payments before crops mature and does not forgive loans in the case of crop failure makes the risk involved in the adoption of alternative crops unacceptable for the majority of farmers.

Although previous studies concerning the adoption of agricultural innovations have found farm size and educational level to be predictors of adoption behavior, the present study suggests that these factors are secondary to a farmer's weighing of costs, risks, and expected benefits *vis-à-vis* his individual situation.

There was strong evidence that farmers of the Chapare are not in general averse to change. Farmers overwhelmingly adopted the practice of using improved pastures and there were actually shortages of some alternative crops — pineapple plantlets, for instance. In this study, the major obstacle to innovation adoption seems to be new

crops whose adoption presents unacceptably high levels of risk coupled with low anticipated profitability.

6. Recommendations

Based on the results of this study, the authors offer the following recommendations for the development of the alternative crops program and the Chapare region:

1. Strategies to lower prices of the plant propagules, such as IBTA's recently offered two-for-one repayment option for pepper plants, would encourage more farmers to try out the alternative crops. In the long-term, propagules could be produced in community nurseries, with farmers' contributions of labor counting toward their purchase of propagules. Insurance costs should be built into the price of the plants sold so that if a farmer purchases a plant propagule and the plant dies, a farmer will be reimbursed or will receive a replacement plant.

2. Transportation of fertilizers and lime into the Chapare, both from other countries and from other regions within Bolivia, is largely responsible for their elevated cost. These costs could possibly be lowered by taking advantage of natural lime deposits within the region. The feasibility of developing small-scale lime processing centers throughout the Chapare therefore warrants further study.

3. Since there is much inter-varietal variation within a species with respect to climatic tolerances, it is advisable to identify and concentrate on varieties and seed sources of the alternative crop species which grow in environments most similar to those of the Chapare. Promising varieties should be grown in the Chapare on an experimental basis to see which ones do the best. The most vigorous individuals of the most suitable varieties could then serve as seed sources.

4. Unless farmers see that the new crops actually grow well on their farms, they cannot be expected to purchase or plant them. Therefore, once promising varieties and seed sources have been identified, greater emphasis should be placed on performing on-farm research in co-ordination with farmers. Not only would farmers become more involved in the development of the alternative crops program, but they would be further capacitated in basic plant research techniques. Research involving substantial risks of failure, however, should not be done in farmers' fields.

5. The PL480 loan system needs to be restructured so that repayments are scheduled to correspond to the first harvest and sale of plant products.

6. Market information needs to be developed and made available to farmers in order to increase perceived (and real) benefits to farmers.

7. Clearly, farmers require more assistance in the use of agrochemicals in order to be able to carry out the cultural practices recommended for the alternative crops. Promoters or para-professionals could be trained to provide basic education to all farmers in this area, and integrated pest management should be included in the curriculum.

8. Training courses should be as practical and 'hands-on' as possible, conducted in farmers' fields with the instructor and the students going through the lesson together step-by-step. Since over one-half of the farmers interviewed said they would like to know more about their soils and what to plant where, showing farmers how to recognize different types of soils and how to judge where to plant their new crops would help them to feel more confident about working with the new plants. Implementation of a soil testing and fertilizer recommendation program within IBTA would also help farmers feel better prepared to work with alternative crops.

9. Farmers need to have consistent technical backstopping through every stage of the process, from the planting to the maintenance to the marketing of the alternative crops.

10. Roads which become impassable during much of the year make the reliable transportation of fruits to market impossible. A feasibility study concerning the establishment of small fruit processing centers throughout the Chapare may be warranted; such centers could enable processed fruit products, rather than fresh fruits, to be shipped out.

11. The development of producer/private sector strategies such as co-operatives could facilitate production, delivery of inputs, transportation, and marketing of alternative crops.

12. Sustainable forestry, such as natural forest management, is a promising development option for the Chapare, especially in regions that prove to be ecologically unsuitable for farming.

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References

Centro de Investigacion y Desarrollo Regional (CIDRE) (1989) *Monografia del Tropico del Departamento de Cochabamba*. Cochambamba, Bolivia.

Chambers, R. (1985) Shortcut methods of gathering social information for rural development projects. In *Putting People First: Sociological Variables in Rural Development*, Cernea, M.M. (ed.). World Bank, Washington, D.C.

Feder, G., Just, R.E. and Zilberman, D. (1985) Adoption of agricultural innovations in developing countries: a survey. *Economic Development and Cultural Change* **33**, 255–298.

Garrett, P., Uquillas, J. and Campbell, C. (1987) Interview guide for the regional analysis of farming systems. Cornell International Agriculture Mimeograph 113. Program in International Agriculture, New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, New York.

Holdridge, L.R. (1982) *Ecologia Basada en Zonas de Vida*. Instituto Interamericano de Cooperacion para la Agricultura, San Jose, Costa Rica.

IBTA Chapare (1990) *Propuesta de Sisemas de Produccion por Subregion para el Tropico Húmedo del Departamento de Cochabamba*. Programa de Desarrollo Alternativo Regional, Cochabamba, Bolivia.

Katz, E., Levin, M.L. and Hamilton, H. (1963) Traditions of research on the diffusion of innovation. *American Sociological Review* **28**, 237–252.

Labrousse, A. (1990) Dependence on drugs: unemployment, migration and an alternative path to development in Bolivia. *International Labour Review* **129**, 333–348.

Painter, M. and Rasnake, R. (1989) Human rights dimensions of the war on drugs. *Development Anthropology Network* **7**, 8–16.

Raintree, J.B. (1987) *D & D User's Manual: an Introduction to Agroforestry Diagnosis and Design*. The International Council for Research in Agroforestry (ICRAF), Nairobi.

Rhoades, R.E. (1982) *The Art of the Informal Agricultural Survey*. International Potato Center (CIP), Lima, Peru.

Rogers, E.M. (1983) *Diffusion of Innovations* (3rd Edn). The Free Press, New York.

Rogers, E.M. and Shoemaker, F. (1971) *Communication of Innovations* (2nd Edn). The Free Press, New York.

Tolisano, J. *et al.* (1989) *Environmental Assessment of the Chapare Regional Development Project, Bolivia*. Prepared for USAID: PDC-5315-I-21-8101-00. Development Alternatives, Inc., Washington, D.C.

Tost, J.A. (1983) Analisis Ecológico y Capacidad de Uso de la Tierra en el Area del Proyecto Chapare. Informe para USAID/Bolivia:511-000-C-00. Traducción: Ing. Juan Carlos Quiroga M. La Paz, Bolivia.

United States Agency for International Development (USAID) (1990) *Conducting Mini-surveys in Developing Countries*. USAID, Washington, D.C.

Weil, J. (1986) Beyond the mystique of cocaine: coca in Andean cultural perspective. In *Plants in Indigenous Medicine and Diet: Biobehavioral Approaches*, Etkin, N.L. (ed.). Redgrave, New York.

5. TECHNICAL ASSISTANCE FOR THE TRANSMIGRANT AND INDIGENOUS FARMERS OF INDONESIA: SOCIO-ECONOMIC FACTORS IN SOIL MANAGEMENT[1]

Frank J. Smith, Khariah and Russell S. Yost

This paper examines one example of Indonesia's attempt to promote agricultural settlements in the islands outside of Java and the technical support role of collaborating U.S. universities. The purpose of this study was to obtain new information based on field studies of the population of transmigrant and indigenous farmers in Sitiung, Sumatra. The research questions were the following:

1. How is research changing (improving) farming practices?
2. What are the principal constraints to innovation and change?
3. What are the social and economic returns to four basic farming systems?

BACKGROUND

Indonesia is striving for self-sufficiency in basic food supplies. The domestic production of rice has increased to exceed self sufficiency. However, the country remains a net importer of a number of food grains. Between 1985 and 1986, for instance, Indonesia imported 33,000 mt of rice(*Orysa sativa*), 50,000 mt of corn (*Zea mays*), 17,000 mt of peanut (*Arachis hypogea*), 350,000 mt of soybean (*Glycine max*), and 1,000 mt of mungbean (*Vigna radiata*) (Tabor et.al., 1988). Forecasts suggest that through the remainder of this decade, the following average annual rate of growth in demand for selected commodities: corn (2.6%), cassava (*Manihot esculenta*) (2.6%), soybean (2.9%), peanut (4.1%), and mungbean (7.0%).

In response to increasing population pressures and the need to increase agriculturerel production the Government of Indonesia has opened new areas for agriculture and promoted transmigration to the islands of Sumatra, Kalimantan, Sulawesi, and Irian Jaya. Transmigration is one of the most important national programs in Indonesia. By the year 2000, an estimated 10 million families are expected to be moved from Java and Bali to and settled in the outer islands. Under the transmigration program, each family is given 2 ha of land. By this program alone an additional 20 million ha of approximately 191 million ha of total land area or 120 million ha of forest and woodland will be cleared for cultivation by the end of the century.

The most common use of the newly-opened areas is for traditional food production. Unfortunately, most of the newly-settled areas have predominantly acid,

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nutrient-poor soils. Research and experience over the past 10 years has shown that realization of the potential of these soils will require a sustained program of soil management and fertilization. This presents a difficult challenge to resource poor farmers.

Sumatra is one of the islands where large areas have been opened to settle transmigrant families. Soil related constraints are the major limitation to sustainable food crop production. Problems of acidity, aluminum (Al) toxicity and infertility have been extensively studied and soil management remedies are known (Wade et al., 1989). However, soil management that is sustainable, feasible, farmer-acceptable and environmentally safe are not generally practiced.

Sitiung, West Sumatra (2°S, 101°E) is a transmigration site in the center of Sumatra, straddling Jambi and West Sumatra provinces (Figure 1). The Sitiung transmigration area covers about 100,000 hectares. Between 1976 and 1986 , the area absorbed some 6000 transmigrant families from Java in addition to 1500 indigenous families. Since 1983 it has been a primary research site of the Soil Management Collaborative Research Support Program (SM-CRSP). The location was selected as representative of Indonesian transmigration sites in Kalimantan, Sulawesi, and Sumatra (Colfer, 1991).

Until the late 1970s the area was covered by lush tropical rainforest, interspersed with small settlements of the indigenous Minangkabau. Annual rainfall is approximately 3000mm and the wettest months are September-May. The mean annual temperature is 26 °C and ranges between 21 and 31 °C. Land use is in gradual transition to rubber plantation and subsistence farming. The topography is moderately undulating to steep with slopes ranging from 5 to 25%. Moderately fertile Inceptisols on river banks join with highly leached and impoverished Oxisols and Ultisols in the dissected peneplain. Most of the soils are highly acidic and exhibit a high degree of Al saturation limiting growth of most annual crops. Phosphorus (P) and potassium (K) are the most significant limiting nutrients. Annual crops frequently suffer water stress because the clayey soils form aggregates and behave as sandy soils, allowing the ample rainfall to dissipate rapidly.

The indigenous peoples of the area, the Minangkabau, had a sustainable system that included small, permanent, wet-rice plots and shifting cultivation of upland rice, rubber, and other assorted tree crops within the forest. The shifting cultivation consists of slash/burn and no-till farming techniques.

Land for the early settlements of transmigrants (Sitiung 1 in 1974 and Sitiung 2 in 1976) had been cleared by bulldozer leaving even more acid, infertile subsoils exposed. A modest home, 1.25 hectares of recently cleared land, and a year's supply of food, fuel, and other essentials such as seed and fertilizer were given to each family upon arrival. Land for later settlements (Sitiung 3 in 1978; Sitiung 4 in 1980; and Sitiung 5 in 1982) were cleared manually.

The transmigrant farming system is sedentary. Field work is mostly done by hand. They produce one or two crops per year of rice, rice with soybean, or peanut; on fixed, 1-ha plots of land per family. Home gardens are an important part of total production and include vegetables, fruits, field and tree crops, medicinal plants, and ornamentals (Colfer, 1991). Agricultural pests--wild pigs, monkeys, insects, and disease--are recurring threats, frequently wiping out entire crops. Restoration of degraded lands and development of

sustainable agricultural alternatives poses important technical and social challenges to the multidisciplinary team of the SM-CRSP.

Prior research has shown that farmers have some knowledge of the value of lime, fertilizers, and pest control chemicals, but few can afford them. The gap between yields obtained under research conditions and those obtained by farmers in the area remains large (Table 1). Also previous research has revealed qualitative differences between farmers and researcher in terms of perceived constraints to productivity. Researchers tend to perceive technical factors as the primary constraints (e.g. poor soil fertility, acidity, moisture stress, poor genetic stock and seed quality). Farmers perceptions give greater weight to social and economic factors (e.g. inadequate labor, credit, marketing problems, poor extension service, government policies). Therefore, further analysis of constraints to technology transfer were planned and implemented to clarify and quantify factors of production.

RAPID APPRAISAL SURVEY

Four villages in the Sawahlunto Sijunjung district of West Sumatra, Indonesia were selected as representative sites for the study of four different farming systems (paddy rice: upland, low-input; alley cropping; and agroforestry). Each village is within the vicinity of the Sukarami regional agricultural research station which was the base of operations for the SM-CRSP in Indonesia (Figure 2). The sample of 108 households was drawn using a stratified-random design. Random selections of 27 farm households were made within each of the four villages. Unfortunately the data for one of the households in the upland system was lost, reducing the total sample to 107. Interviews were conducted with both male and female heads of households. The Tiumang village includes both indigenous and transmigrant households. The farmers of the Tiumang village are representative of the low-land (paddy rice) farming practice in the region. The farmers of the village of Piruko are representative of transmigrant food crop cultivators in upland conditions. Transmigrant farmers of the village of Muaro Timpeh are participating in a government sponsored experiment in alley cropping. Finally Koto Padang is a settlement of indigenous farmers involved principally in agroforestry. Table 2 presents basic characteristics of the four farming systems.

The survey was planned with collaboration of personnel from the Sukarami Research Institute for Food Crops (SARIF) in Sitiung, Andalas University in Padang and the SM-CRSP. The survey was conducted during the period of January to March, 1992.

An informal interview method (Rhoads, 1982; Chambers, 1985) was used to elicit information from farmers about their household demographics, land use, farming practices, participation in extension activities, costs of production, yields, product consumption and profits. All interviews were conducted at the farm site over an 8-week period by the second author in the local dialect. A walking tour of the farm provided opportunities for monitoring land uses, problems and partial confirmation of information obtained through interviews.

Secondary information and briefings were provided by the central office staff of the Centre for soil and Agroclimate Research (CSAR) in Bogor. The Sitiung regional

extension office shared information on programs, areas under various production systems, and regional production aggregates.

RESULTS

Demographic Profile of the Survey Sample

Fifty-eight percent of the respondents were male. Ages ranged from 18 to 65 with an average of 38.9 years. The sample includes transmigrants from Java (42.1%), transmigrants from other parts of Sumatra (7.5%) and indigenous families (48.6%). In most of the households (92.5%) a spouse was present. The average number of dependent children for households was 2.3. The level of schooling of the adult respondents ranged from 0 to 12 years.

Land Use

Most of the farmers in the sample owned small parcels of land averaging 1.6 ha in size. Land in use was somewhat less, averaging 1.23 ha (Table 3). Lands of another family member accounted for a small fraction of land in use (0.32 ha) and land rental was essentially zero (0.03 ha).

Land tenure in the transmigration areas of Sumatra is not an issue as in many other regions of the humid tropics. Households typically have clearly established titles to small plots ranging from 0.5 to 2 hectares. Expansion or shifting cultivation outside the fixed plots, however, is restricted. Land clearing tends to be more complete (including removal of logs and stumps) than in traditional shifting cultivation. In the upland areas, indigenous populations are less restricted in their use of forest land and traditional slash and burn practices predominate.

Rice is the basic food commodity in the region. One or two crops of rice or rice/soybean are produced by farmers each year. Rice and soybean are grown in rotation by 50 percent of farmers in the uplands (Table 4). Soybean is produced and prepared as a bean curd. It is a traditional part of the Javanese diet. However, soybean has a relatively low tolerance for Al saturation (15%) and yields are consequently low. Mungbean, another traditional crop, has a near zero percent tolerance to Al saturation. Corn and peanut have greater tolerance to Al saturation (30% and 40% respectively) and have been promoted with some success as alternatives to a second crop of rice (Wade et al., 1989). Home gardens are also an important part of family production. Gardens supplement the basic grain (rice) production and contribute to diversity of food for home consumption.

Paddy rice Sitiung is not a major area for irrigated rice and the research and extension system does not give much emphasis to it. However, lowland flooded areas are cultivated and constitute an important part of regional production. Farmers attributed increases in production to use of fertilizer. Decreases in production were attributed to seasonal drought, pests including wild pigs, and unavailability of fertilizer.

Upland cropping systems The most common upland food crops are rice, maize, cassava, peanut, soybean, and sweet potato. Tillage is generally carried out using hand tools. Only a few farmers use animals or machines. Other practices include fertilization, plant protection, weeding, and hilling for some crops. Weeding is generally carried out three weeks to one month after planting but may be delayed due to shortages of labor.

Farmers hill corn 1 to 1.5 months after planting. Planting time for upland rice is generally the onset of the rainy season and may vary from August to October. Other food crops are planted year round to fulfill the subsistence needs. Fertilizers are applied, but not in the amounts researchers have found to be optimum. Peanut and soybean receive more fertilizers than cassava and sweet potato. Use of farmyard manure is very limited. No farmers practice green manuring. Pesticides are applied to rice, maize, peanut, and soybean, probably because of their higher market value.

Upland rice production is constrained by a combination of biological and social problems. Increases in production were strongly attributed to fertilizer or new land; decreases to pigs, disease, pests, water stress and unknown factors.

Alley cropping The agricultural extension system is promoting an alley cropping system within the transmigration areas for small-scale upland conditions. Seed and technical assistance have been provided by the government since 1989. There are 200 ha of land in Muaro Timpeh under alley cropping systems. In our sample most farmers were using Flemengia with local varieties of rice or peanut. Less than ten percent of farmers were trying Flemengia with corn (cv. "Arjuna") or soybean (cv. "Willis"). Farmers were initiating work with alley cropping systems and consequently, production data are preliminary and only indicative of the establishment period.

Rice/Rubber System Rubber extraction has been an alternative use of the land, especially for small indigenous producers and larger, well-capitalized producers. The agricultural extension system has recently promoted small-scale agroforestry systems for indigenous populations. In Koto Padang 1,827 ha are under an agroforestry system consisting of interplanting rubber and upland rice during the first 2 to 3 years. Another system of some prominence is the interplanting of rambutan and upland rice. In both systems the land is first cleared using traditional practices of slash and burn. Rice and rubber are planted in association. Seed is obtained by collection or from other farmers in the area. Farmers attributed losses in rice production to pigs and monkeys, pests and dry seasons.

Labor

Farming is a family activity. Hired labor supplements family labor, principally in activities of land preparation, planting, harvesting and processing. A previous study has provided a detailed qualitative analysis of family labor (Colfer, 1991). Table 5 provides a quantitative analysis of labor as a factor input in four production systems.

Factor Inputs

Although many of the farmers have applied lime to their soil, most did so only under a government program which subsidized the costs to farmers. In 1983-84 the government provided 3 t/ha; in 1986-87 2 t/ha. Only two farmers applied lime in the last year. Use of pesticides and fertilizers is more common (Table 6). In the low-input upland system 65 percent applied pesticides and 69 percent applied small amounts of granular fertilizers. Research has shown that P fertilization without lime is less effective than with lime. Responses to potassium are significant. Upland rice, corn, and peanut require 60 kg K/ha/crop. Mungbean and cowpea require about 80 kg K/ha. Soybean requirement for K is about 40 kg/ha. Potassium fertilizer additions can be substantially reduced by returning the crop residue to the soil. The severity of rice blast as well as grain discoloration is also reduced with potassium fertilizer. Potassium leaches rapidly from the

root zone. It is unclear whether nutrient supplements and pest management practices are well managed. Median input dosages for K are near recommended levels. Dosages and use of pesticides were not evaluated but future research will need to establish appropriate units of measure for pesticide inputs.

Technical Innovation, Technical Assistance and Outreach

New technology is slowly being incorporated into production systems of the region. Most farmers mix elements of traditional and new technology in their farming systems. The quality of technical assistance available to farmers is difficult to evaluate. Personal communications with regional extension directors indicates that most extension agents are young with little field experience and only secondary schooling. The frequency of contacts between extension agents and farmers is relatively good except in the case of the indigenous agroforesters of Koto Padang (Table 7). Forty percent of upland farmers and 59% of alley croppers have been visited by an extension agent in the last year. These same groups have relatively high rates of participation in demonstration plots under extension supervision. However, it is unclear that these contacts have much effect on farming practices. With the exception of the farmers involved in the government alley cropping program, most farmers continue to rely principally on informal processes between farmers and the extended family for information and advise on farming practices.

In order to strengthen the extension system and provide direct benefits to the region, the SM-CRSP has assisted in a variety of outreach activities. Beginning in 1989, outreach plots were established in selected farm sites for purposes of technology validation and technology transfer. The outreach plots provided an in-the-field setting for training extension workers about soil management practices. Workshops were held providing in-class instruction and supervised field visits for 90 extension staff. Field days enabled farmers, extension staff and others to observe demonstration plots. Finally several limited studies of farmer practices were done. They used surveys and focus group methods to elicit information from farmers and extension staff with a emphasis on lime and fertilization practices.

On-farm results evidence a high degree of variability. An expert system has been developed to identify and solve soil acidity constraints on crop production. Intended for extension services and government planners the system is a tool for diagnosis and prescriptive action. The expert system incorporates a partial budget analysis that considers the cost of lime, transportation to the farmer's home and his field, and the costs of spreading and incorporation. This enables users to make more accurate soil management decisions with respect to acidity, lime requirement and fertilizer needs. A user's guide has been prepared but no data is available on its distribution or use in the field.

There remains a large gap between the yields obtained by farmers and yields demonstrated by experimental plots. In the period 1982-1989 upland rice yields in the area have fluctuated in a range from 1.6 to 2 t/ha. Approximately 60% of farmers survey reported an increase in production over the past 5 years, but a significant group, approximately 33%, report declines in production over the same period. This variance in results merits further study.

Adoption of improved varieties for paddy rice is well established (Table 8). It is not clear why 22.2% persist in use of local varieties. Price does not appear to be a factor in seed selection as improved varieties sell at the same price as local varieties in the local market. In the other farming systems almost all producers use local varieties. It is unclear whether improved varieties are not available or not well adapted to the upland areas.

For upland conditions extension and research packages consist mainly of inorganic fertilizer and lime recommendations. The survey indicates that use of inorganic fertilizer is an accepted practice, while few apply lime as recommended. Deposits of limestone are found in the area but there has been no attempt to commercialize or organize a cooperative to produce agricultural grade lime. The primary obstacle seems to be the costs of mining and transport to the field site. This is what the government has done in the past. Incorporation of lime into the soil can be done in the normal course of tillage (typically by hand hoe, two times per year). Deep liming neutralizes toxic Al, improves the chemical environment in the soil, and promotes root growth. A deep root system is able to absorb water and nutrients from a larger volume of soil. Thus, effects of drought are alleviated and fertilizer use efficiency is increased. Appropriate technology in the form could include an animal-drawn plow which can incorporate lime to 25 to 30 cm depth. A ridge-furrow system of land management is an alternative method for deep incorporation of lime. In the humid tropics, lime reacts very quickly and crops can be planted a few days after lime is applied.

Because alley cropping is a new activity under government supervision, the family relies on the technical assistance and subsidies provided by the local extension system. Farmers show more willingness to invest labor than cash, thus in principle, adoption based on management of organic material-related technology is appropriate. Research has shown the effectiveness of organic material recycling in alleviating soil fertility problems (e.g. Wade; Sanchez), but organic material is not a substitute of inorganic fertilizers especially P. Several experiments (e.g. Evensen, 1994) have been conducted addressing organic material management and alley cropping. Those experiments were conducted in farmers fields, thus, facilitating direct contact between researchers and farmers. *Calliandra calothyrsus* was most tolerant to soil acidity and frequent pruning.

With regard to agroforestry, Colfer (1988) has suggested that agronomists should look at the indigenous system and extrapolate it in the transmigration area. The survey shows little technical assistance for rubber/rice systems in the region to date.

Several forage legumes and grasses selected from the CIAT germplasm collection have been found to do well in the Sitiung area. Inclusion of native vegetation in the cropping system can be beneficial. Food crop/weed-fallow rotations have shown potential as a means of nutrient recycling and organic material.

The relationship between research and extension in Indonesia is prescribed by a centrally controlled regime. Research findings and recommendations from the field are sent for review to the central authorities in Bogor. The central office attempts to reconcile research findings and recommendations with the government priorities and institutional capacities. The formal structure of extension does not encourage direct collaboration between research and extension at the regional level.

Farmer cooperatives exist in the region but most farmers do not actively participate. It is unclear whether cultural factors impede cooperative activities or whether farmers do not perceive that such activities are worthwhile.

Economic Analysis

Economic calculations are based on farmer reports of input quantities and product yields. Conversions to monetary values were made using unit prices in the local market at the time of survey (Table 9).

All land-use systems with the exception of alley cropping produce positive internal rates of return (IRR) to farmers (Table 10). For subsistence farmers, however, the net present value (NPV) of production is probably more relevant. Net present values were calculated assuming a discount rate of 15%.

On an average, production costs amount to about 21% of the total returns. Most of the costs are for family labor or hired labor. None of the farmers in the sample reported using or having access to credit. Given the constraints on land and capital, the land-use systems are locked into small scales of production that at best yield small benefits for rural families. Most of the production is consumed by the household (78%). The surplus production (22%) is sold or traded in the local market.

Median values of IIR and NPV for lowland rice double cropping were computed separately for indigenous and transmigrant farmers. A relatively small difference in IRR (67% verses 46%) masks a more than three-fold advantage of indigenous NPV ($150.34/ha) over transmigrant NPV ($44.43/ha). Clearly, the large difference is created by the difference in total volume of production per hectare, which is 2.5 t/ha for indigenous farmers and only 1.0 for transmigrant farmers. There is nothing in the current dataset that can account for these large differences. We are generally aware, however, that the indigenous farmers have had first access to the better lowlands and the differences in NPV undoubtedly reflect the differences in sites rather than production systems.

Upland farming in Sumatra is clearly a low input system. Farmers get a good rate of return principally by minimizing inputs. The internal rates of return for three upland systems fall in a narrow range (99 to 116%). Reference to the net present values clearly shows the advantages of improved low-input systems. Traditional upland rice produces a NPV of only $38.71/ha while a rotation of upland rice and soybean with a light treatment of fertilizer produces a NPV of $147.49/ha (more than three times as much).

Alley cropping is labor intensive and the scale of production is small. Consequently, the costs exceed benefits at least in the short-term as revealed by these preliminary data. The benefits of managed organic material and reduced soil erosion are lagged. The long-term economic viability of the alley cropping system is uncertain based on these data.

The analysis of impacts of the agroforestry system are based only on yields of rice during the period of establishment of the rubber trees. Yields are relatively good because the land is new. A family can manage 2.0 ha plot producing a net present value of approximately $215 during the period of establishment of the rubber trees. This compares favorably with the NPVs of other land use systems.

CONCLUSIONS

Farming in the transmigration areas of Sumatra is small-scale and low-input. Most of the production is consumed by the household with the balance sold or traded in the local market. While farming is the principal activity of the household, family labor is also allocated to off-site employment.

Research results are being translated slowly into changes in farming practices. A combination of technical, socioeconomic and institutional factors, including an over-regulated, centralized extension system, constrain adoption.

Budget analyses of farming systems are sensitive to site characteristics and market prices. Systematic recording of on-farm inputs and management practices over time are required in order to arrive at rates of return for different site parameters. Analyses of information from household surveys suggests modest net present value for three farming systems. Internal rates of return are positive for the three farming systems but are probably less determinative of farmer decisions than net present values.

Approximate rates of returns can be estimated for different scenarios of inputs and soil properties by the Acid Decision Support System (ADSS). Refinements in the economic component of ADSS require a continuing commitment to build a data base. Data requirements are the primary limitation to use of more powerful time-series, econometric designs. Development of appropriate measures with in-field verification are a priority.

Ninety percent of lowland technology is based on traditional practices of the family and other farmers in the area. Sitiung is not a major lowland rice area and research and extension services do not give much emphasis to this production system.

Fifty percent of upland farming systems have incorporated soybean in crop rotations, but yields are low due to soybean's low tolerance of Al saturation. Farmer preference for soybean is more a reflection of dietary habits and tradition than its suitability to the region.

Alley cropping may be a long-term solution for sustainable agriculture on eroded slopes. However, the findings from Sitiung clearly suggest that the alley cropping system is not profitable in the short-term. Promising material from research has not been included in government assisted farm trials. Government technical and economic assistance will be required during the establishment period. The relatively high labor requirements of alley cropping, at least in the early years, and the small plot sizes (0.5 ha) will not be competitive for rice production. Future studies should explore the feasibility of higher valued products that are well adapted to intensive management such as multistory, sustainable agroforestry.

Rubber/rice agroforestry systems offer a relatively good net present value during the establishment period. Systematic follow-up is needed to provide a complete analysis of this system.

Production results in the region have been mixed with some farmers reporting positive trends and others negative trends. This is further indication of the variance introduced by unmeasured site factors. Future research must sort out the sources of site variation and build them into future models.

Lime is an under-utilized input. Research has produced tools for diagnosis and prescriptive action for liming. Research has also examined appropriate methods of lime incorporation. What appears to be missing, however, is a system for extracting lime and transporting it to the farm site. Farmers have taken upon themselves the burden of incorporation of lime into the soil when the government has delivered the lime to the farm site. The feasibility of developing a small enterprise or regional cooperative to commercialize lime warrants further study.

Although improved varieties of seed are available in the region at prices comparable to local varieties, farmers typically produce their own seed. One suspects that input requirements combined with the capital constraints on households is holding back the adoption of improved varieties. None of the farmers in the region indicated access to credit.

Household production has modest net present values. Most of the costs and benefits are implicit. The principal cost is family labor and the principal benefit is food for home consumption. In this sense the household has minimum involvement in the regional market. Substantial increases in production resulting from improved soil management would create commodity surpluses that would then raise the need for market infrastructure for product transport, storage and processing. Future development planning should anticipate the need for market development in the region. Farmers already express concerns about market capacities. Market information is not available to farmers or researchers and consequently decision-making is based on excessive uncertainty.

Significant technical and socioeconomic challenges remain. Soil management practices are helping to lay the technical foundations for a sustainable agriculture. Continued multidisciplinary research is needed to develop the analytical tools to facilitate technology transfer, formulate appropriate development policies, reinforce markets and build appropriate information and technical assistance capacities in Sumatra, Kalimantan, Irian Jaya, parts of Sulawesi, and throughout the humid tropics.

REFERENCES

Chambers, R. 1985. Shortcut methods of gathering social information for rural development projects. *In* Cernea, M.M. (ed.) Putting people first: sociological variables in rural development. World Bank, Washington, D.C.

Colfer, C.J. 1991. Toward sustainable agriculture in the humid tropics. TropSoils Bulletin Number 91-02. Soil Management Collaborative Research Support Program, North Carolina State University, Raleigh, NC.

Colfer, C.J., D.W. Gill, and F.Agus. 1988. An indigenous agricultural model from West Sumatra: a source of scientific insight. Agricultural Systems 26:191-209.

Rhoades, R.E. 1982. The art of the informal agricultural survey. International Potato Center (CIP), Lima, Peru.

Soil Management Collaborative Research Support Program (undated manuscript). TropSoils Project. University of Hawaii, Honolulu. Center for Soil and Agroclimate Research, Bogor, Indonesia.

Wade, M.K., D.W. Gill, J. Subagjo, M. Sudjadi, and P.A. Sanchez. 1989. Overcoming soil fertility constraints in a transmigration area of Indonesia. TropSoils Bulletin No. 88-01. Soil Management Collaborative Research Support Program, North Carolina State University, Raleigh, NC.

Table 1. Yield gaps between research and farmer plots for selected crops in the Sitiung region.[1]

CROP	RESEARCH PLOTS	FARM PLOTS
	----------t/ha----------	
Upland rice	5.0	0.7
Corn (monoculture)	6.5	2.0
Corn (corn/rice)	--	0.1
Soybean	2.0	0.3
Peanut	2.0	0.6
Cowpea	1.5	0.6
Mungbean	1.0	0.2

[1] Source: SM-CRSP, 1991

Table 2. Comparison of basic characteristics for four faming systems in the Sitiung region.

	LOWLAND (TIUMANG)		UPLAND (PIRUKO)		ALLEY CROPPING	AGROFORESTRY
ACTIVITY	TRANSMIGRANT	INDIGENOUS	TRANSMIGRANT	INDIGENOUS	(MUARO TIMPEH)	(KOTO PADANG)
Irrigation	Yes	No	No	No	No	No
Lime	No	No	twice/10yr	No	No	No
Land preparation	Plow and harrow	Hoe	Plow and harrow	Slash & burn	Hoe	Slash and burn
Planting	Transplant	Transplant	Dibble	Dibble	Dibble	Dibble
Fertilizing	Yes	No	Yes	No	No	No
Plant protection	Yes	No	Yes	No	No	No
Harvest	Sickle	Sickle	Rice knife	Rice knife	Rice knife	Rice knife
Others					Flemengia hedgerow	Rubber

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Table 3. Median hectares in use by farming system.

	PADDY RICE	UPLANT (LOW INPUT)	ALLEY CROPPING	AGROFORESTRY
	ha			
Own land holdings	1.25[a]	2.00	0.50	2.00
Own land in use	0.75[b]	1.00	0.50	2.00
Family land in use	0.00	0.00	0.00	0.00[c]
Rented land in use	0.00	0.00	0.00	0.00
Fallow land	0.37	0.75	0.00	0.00
Garden	0.13	0.25	**	**

[a] range .125-7.5 ha
[b] range .125-5.0 ha
[c] range .00-12.0 ha
** no data

Table 4. Secondary crops grown by farmers.

CROP	PADDY SYSTEM (N=27)	UPLANT (LOW INPUT) (N=26)	ALLEY CROPPING (N=27)	AGROFORESTRY (N=27)
Soybean	0	13	2	2
Peanut	0	1	4	0
Corn	0	4	1	0
Cassava	0	5	0	0

Table 5. Median family hired labor by activity.

ACTIVITY	PADDY RICE		UPLAND (LOW INPUT)		ALLEY CROPPING		RICE-RUBBER SYSTEM	
	FAMILY	HIRED	FAMILY	HIRED	FAMILY	HIRED	FAMILY	HIRED
	days/ha							
Land preparation	13	9	12	0	36	35	7.5	7.5
Liming	0	0	0	0	0	0	0	0
Planting	1	1	1	1	2	2	0.5	0.5
Weeding	13	0	10	0	20	0	5.0	0
Fertilizing	1	0	1	0	2	0	0	0
Plant protection	4	0	2.5	0	6	0	0	0
Harvesting	1	1	1	1	2	2	0.5	0.5
Processing	1	1	1	0.5	2	2	0.5	0.5
TOTAL	34	12	28.5	2.5	70	41	14	9

Table 6. Number of farmers using inputs and medium input dosages.

Inputs	Paddy Rice		Upland (Low-input)		Alley Cropping		Agroforestry	
	n=27	kg/ha	n=26	kg/ha	n=27	kg/ha	n=27	kg/ha
Lime	1	133	0	--	0	--	1	1000
Urea	16	67	17	50	24	20	2	25
TSP	14	67	18	50	24	20	2	25
KCl	10	50	16	50	19	20	2	25
Manure	5	1067	9	500	1	1000	0	0
Insecticide	18	1	17	1	20	2	8	0
Fungicide	1	1	0	--	0	--	0	--

Table 7. Technical assistance for the four farming systems.

ASSISTANCE	PADDY RICE	UPLAND RICE	ALLEY CROPPING	AGROFORESTRY
	----------% of respondents----------			
Source of Information				
Family	74	69	37	89
Extension service	11	19	63	4
Another farmer	15	12	0	7
Farmer Cooperatives				
Aware exits	48	85	89	41
Meeting participation	26	23	67	4
Farmer/extension Interactions				
Visited by agent in past year	19	40	59	4
Collaborated on a demonstration plot	4	27	48	0
Participated in meetings with other farmers	7	23	59	0
Listened to extension programs on radio	19	23	19	7
Read extension articles in news media	4	4	0	0
Informally discuss problems with other farmers	74	58	70	78

Table 8. Rice varieties used in each farming system.

VARIETY	LOWLAND	UPLAND	ALLEY CROPPING	AGROFORESTRY
	----------% of respondents----------			
Local	22.2	100.0	95.7	96.3
Aries	40.7	0.0	0.0	3.7
IR64	11.1	0.0	4.3	0.0
Kompai	22.2	0.0	0.0	0.0
Cisadane	3.7	0.0	0.0	0.0

Table 9. Unit prices for factor inputs.

ITEM	UNITS	PRICE RANGE	MEDIAN PRICE
		----------US $	----------
Seed			
Rice (local)	kg	0.13-0.21	0.18
Rice (IR42)	kg	0.16-0.19	0.18
Rice (IR64)	kg	0.18	0.18
Rice (Cisadane)	kg	0.18-0.21	0.18
Soybean (Willis)	kg	0.47	0.47
Soybean (Orba)	kg	0.47	0.47
Peanut (Gajah)	kg	0.93-1.04	0.98
Cassava (Addira)	100 band	0.52	0.52
Corn (Arjuna)	kg	0.16-0.93	
Rubber seedlings		0.13-0.32	0.18
Rubber seed		0.01	0.01
Rambutan		0.13	0.13
Flemengia		0.52-2.08	1.04
Fertilizer			
Urea	kg		0.16
TSP	kg	0.13-0.16	
KCL	kg	0.13-0.16	
manure	kg		
Insecticide	tin	4.79	
Labor (per hectare)			
Land preparation	person/day	1.55-1.81	1.81
Planting	person/day	1.29	1.29
Weeding	person/day	1.04-1.29	1.29
Fertilizing	person/day	1.29	1.29
Plant protection	person/day	0.52-0.78	0.78
Harvesting	person/day	1.29	1.29
Processing	person/day	1.29	1.29

[a] US$ = 1932 Rb

Table 10. Economic analysis of land use systems[a]

LAND USE SYSTEM	INPUT COSTS	FAMILY LABOR	CONTRACT LABOR	TOTAL COSTS	TOTAL BENEFITS	TOTAL PRODUCTION	MARKET PRICE	NET PRESENT VALUE	INTERNAL RATE OF RETURN
	----------US		$/ha----------			t/ha	US$/kg	US$	%
Indigenous upland rice	5.43	40.11	0.00	-45.55	90.58	0.50	0.18	38.71	99
Transmigrant upland rice & cassava	8.67	48.91	5.18	-62.76	135.87	0.75	0.18	63.63	116
Transmigrant upland rice & soybean with fertilizer	70.91	86.44	12.94	-170.29	341.61	rice=1.30 soybean=0.30	0.16 0.47	147.49	101
Indigenous lowland rice double cropping[b]	21.48	94.20	155.28	-270.96	452.90	2.50	0.18	150.34	67
Transmigrant lowland rice double cropping	6.34	87.99	29.76	-124.09	181.16	1.00	0.18	44.43	46
Alley cropping (rice or peanut with flemingia)[c]	26.40	196.17	209.63	-432.19	331.26	0.80	0.21	-124.04	-23
Agroforestry (rice & rubber)[d]	11.65	69.01	52.45	-133.11	258.80	1.33	0.19	107.63	94

[a] Based on median net present value and assuming a 15% interest rate (US$=1932 Rb in 1991).
[b] Median plot size in survey was 0.75 ha; estimates adjusted to a 1.0 ha plot size.
[c] Median plot size in survey was 0.50 ha; estimates adjusted to a 1.0 ha plot size.
[d] Median plot size in survey was 2.00 ha; estimates adjusted to a 1.0 ha plot size.

LIST OF FIGURES

Figure 1. Map of Indonesia showing the Sitiung region.

Figure 2. Location of villages surveyed in the Sitiung area. (Source: Colfer, 1991)

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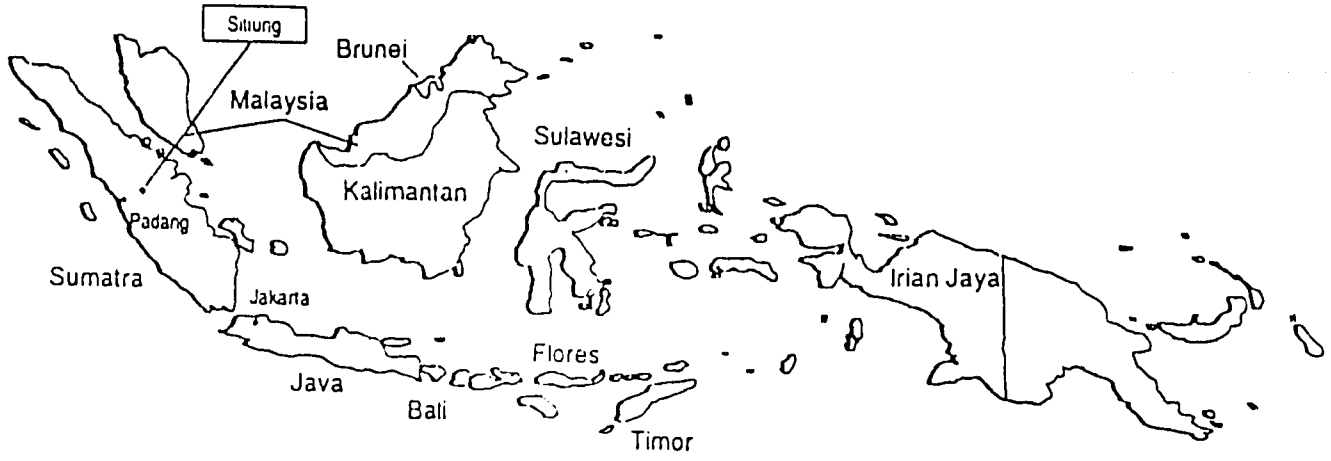

Figure 1. Map of Indonesia showing Sitiung region.

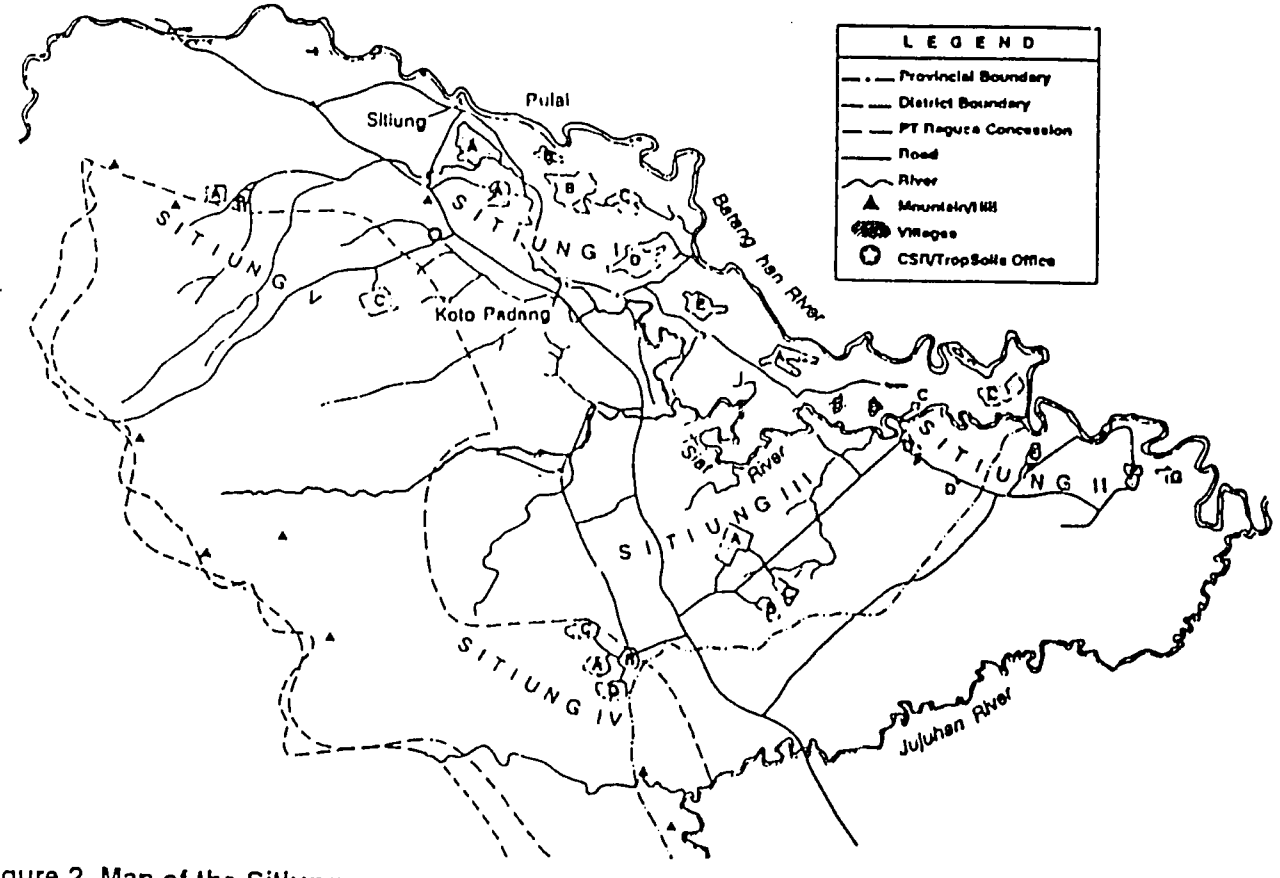

Figure 2. Map of the Sitiung area.

6. EDUCATION FOR DEVELOPMENT: PERSPECTIVES FROM STUDENTS AND ALUMNI[1]

Diane Ursone and Frank J. Smith

Some development experts have suggested that the socio-economic development of a country depends on a national capacity for science and technology (e.g. Singer, 1982; Stewart & James, 1982; Duncan, 1986). They argue that the relative scarcity of scientists and engineers engaged in research and development (R&D) in developing countries is a constraint to growth. The available data (U.N. Statistical Yearbook 1988/89) clearly show the disparity between countries in the number of scientists and engineers in R&D per million population. For example in Japan there are 4979 scientists and engineers per million population, in the U.S. 3225. Germany has 2096, Peru has 224, Indonesia has 180 and Nepal has only 18. The next generation of scientists and engineers are being trained now. Careful development and utilization of this scientific talent will have important implications for future development.

More than 20 years of research demonstrate importance of education for development (Table 1). Most of the research has focused on primary and secondary education. Increasingly, international agricultural research and development strategies are predicated on education (Psacharopoulos & Woodhall, 1985) and human resource development (Jamison & Lau, 1982). The current study examines the processes and outcomes of education for development at the graduate level.

The study focuses on participants in the Soil Management Collaborative Research Support Program (SM-CRSP), a research program with core financial support from the United States Agency for International Development (USAID). Program activities include developing new technologies and training in the principles and practices of soil management through collaborative research, training workshops and research networks. One component in the practical implementation of the CRSP has been graduate-level education for international host-country participants with the goal of strengthening the capacities of national institutions and improving services to local populations. This study is a first attempt to provide an integrated evaluation of the interrelationships between collaborative research and graduate education.

A conceptual model (Figure 1) adapted from the research of Jamison & Lockheed (1987) and Psacharopoulos & Arriagada (1989) delineates relationships between individual student characteristics, educational program characteristics, and post-graduate roles and responsibilities. The model also suggests the kinds of information needed to manage the educational program of the CRSP.

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[1]The authors thank colleagues T. Jot Smyth, Lynne Baker-Ward, Bill Swallow, and John Beghin for their valuable expertise and guidance. Susan Riha at Cornell and Goro Uehara at U. of Hawaii supplied alumni information and Bertha Monar and Milagro Rumble gave excellent office support. This study was supported in part by USAID Grant DAN-1311-600-0039-00 to the Soil Management Collaborative Research Support Program (TropSoils).

Specific questions of interest include the following: What are the demographic and social characteristics of those selected for training? What are the process variables that affect student progress and performance? Are curriculum adjustments necessary? Are the time allocations to theory, laboratory and practice satisfactory? What are the roles and responsibilities of alumni? Is scientific talent being diverted inappropriately into administrative roles? Are graduates of the program prepared for the variety of roles and responsibilities they assume post-graduation? What is the appropriate balance between specialization and breath of knowledge? What are estimates of the graduates productivity? Are linkages maintained between the program and graduates? How do the program graduates contribute to institutional strengthening and development? How can the education component be improved?

This study provides some insights and answers to the above questions. Surveys of students and alumni reveal the subjective views of program participants about their educational and post-educational experiences. The results provide an essential, participant perspective and feedback to program leaders and faculty. Implications for future program planning are discussed.

METHODOLOGY

The study uses a two-group cohort design which combines surveys of current soil science students and former students of the SM-CRSP. The group of current soil science students includes both students associated with the SM-CRSP and those not associated with the CRSP. The rationale for surveying the current group was to examine the interaction and positive-spillover effects from the SM-CRSP on the U.S. institution. The survey provides important descriptive data on the diversity of current students and their activities. In addition, alumni provide retrospective views of their educational experiences and current students comment prospectively on their preparation for future careers (Figure 2).

Using the tracer study methodology developed and widely utilized by the World Bank (Psacharopoulos & Hinchliffe, 1983), a survey was designed and sent to all alumni (N=62) of the TropSoils graduate education programs from N.C. State University, University of Hawaii (U of H) and Cornell University. The individual universities provided last-known addresses for their alumni. A brief cover letter accompanied the survey to explain the project, assure the participants of anonymity and ask for their cooperation in completing the questionnaire. The completed surveys were returned by mail, by facsimile, or carried by persons travelling to N.C. State University. Figure 3 shows the distribution of TropSoils alumni throughout the world.

The survey of current students included all students enrolled in the Soil Science graduate program at North Carolina State University. All U.S. and international students received the cover letter and survey by campus mail. Responses (N=65) were returned also by campus mail.

Survey questionnaires were prepared for both groups. The survey designs included open-ended questions to elicit free responses of a qualitative nature; and closed-ended questions to produce quantitative data. Internal reliability checks were designed-in. The content of the surveys was guided by the conceptual model. A core set of questions

was asked to both groups. Other questions were appropriately targeted to the group in the best position to respond. The enrolled students were the primary source of information about current educational practices. The alumni were uniquely able to provide critical information about how their education prepared them for subsequent roles and responsibilities. Draft versions of the questionnaires were prepared by the authors and reviewed by colleagues in the Department of Soil Science. Revisions were made based on suggestions made.

Analyses of the data served the following research objectives:

1. Profile TropSoils participants in terms of age, gender, citizenship, and family background.
2. Describe the educational process and experience of the TropSoils participants.
3. Describe the alumni's work roles and responsibilities in terms of time allocations, participation, publications, honors and the application and modification of TropSoils- funded research.
4. Describe the alumni's perceptions of both strengths and weaknesses of their graduate education and training.
5. Describe outreach, applications and impacts of TropSoils research.

RESULTS

Twenty-eight alumni and thirty-six students responded to the survey. Of the alumni respondents, 13 (46.4%) graduated from N.C. State, 7 (25%) from U of Hawaii and 6 (21.4%) from Cornell. Twenty-seven (96.4%) completed the program: 5 (17.9%) with an M.S. and 21 (75.0%) with a Ph.D. Soil fertility represents the most frequent specialization with 13 (46.4%) respondents, followed by a combined specialization (25%), soil physics (14.3%), soil chemistry (7.1%) and soil genesis (3.6%).

The following sections present the major results relating to the five objectives of the study.

Demographics

Demographic profiles for the alumni and current student groups are presented in Table 2. Individuals responding to the survey appear to be representative of the alumni population. Most are male, but female participation (27.2%) in the current student group is nearly double that of the alumni group (15.4%). The median age at time of graduate study was comparable for both groups (31-35). Most of the alumni reside in cities of more than 1/4 million population. Alumni and current students have predominantly middle-class backgrounds. Chi square analyses showed no significant differences between the two groups on gender, age at time of graduate study, or measures of socioeconomic status. Only four of the 36 current soil science students had foreign citizenship.

Educational Process

Summary information about coursework of alumni and current students is presented in Table 3. Basic coursework in soil science comprise the core curriculum. Statistics and crop science are the most frequently chosen courses outside the department. A small but growing number of students are selecting coursework in applied areas such as, environmental studies, public policy and economics.

When asked about their experiences with the TropSoils program, 32.1% cited the invaluable opportunity for on-site field research with actual problems in tropical locales and the chance to meet and work with local scientists as a major perceived benefit of the program. Twenty-one percent made direct mention of the openness and supportiveness of the TropSoils personnel and staff during the more personally challenging times of their training. These responses were volunteered without prompting by the survey, and are therefore strong evidence for the positive, perceived benefits of the program.

Research areas of current students are more varied than for alumni (Table 4). Agroforestry, sludge and heavy metal management are emerging areas of research and resource allocation is a topic that engages more current students. The responses of the currently enrolled student group also indicate growing interest in environmental concerns and extension activities. Forty-seven percent (n = 17) of this current group of students expressed career goals in the areas of environment and extension. This may reflect differences in interests between students preparing an overseas versus a domestic career. Students were candid in their responses and comments suggesting the rising importance that students are attributing to coursework involving hands-on applications. The authors regard these comments as further evidence of the increasing student interest in developing direct links between scientists and users.

Career Roles and Responsibilities

Work roles and responsibilities reported by the alumni (Table 5) show that 46.2% are employed by a university, 23.1% by the national government and 23.1% by an international research institute. Regarding current responsibilities, respondents report an average of 51.6% of their time in research, 13% in teaching, 15.4% in administration, 5.45% in extension activities and 3.34% in policy-making. There is little indication that the technical talent produced through SM-CRSP is being diverted or misallocated. Only 8% report allocating more than fifty percent of their working time to administrative duties.

Alumni share their knowledge gained in CRSP programs with co-workers, students, government agencies, farmers and others, which has a multiplying effect on the benefits of the education. Table 4 shows that 84% share the knowledge from their TropSoils education with co-workers, 36% share with other agencies, and 28% share with the local population. Many commented that they taught their acquired skills in the use of the computer, statistical techniques and methods of thinking as well as anecdotes of life in America and interactions with Americans to their colleagues, their students and to local farmers. Forty-four percent of respondents report participation in ongoing training; 72% participate in conferences. Seventy-six percent have published their doctoral research and/or ongoing research.

Perceptions of the Program

Perception of strengthens and weaknesses of the SM-CRSP educational program are presented in Tables 6. SM-CRSP alumni praised the excellent opportunities provided for field research, the program philosophy, and high quality and experience of the faculty. Alumni perceptions of weaknesses were relatively few and related primarily to budgets and difficulties in communications and inter-institutional coordination. The current students in the Soil Science department cited the high quality of the faculty, the presence of the SM-CRSP, and the research and training orientation as principal strengths of their

graduate programs. Although most of the current students are U.S. nationals and are not directly supported or involved in the SM-CRSP program, they clearly see that the program adds value that benefits them indirectly. Perceptions of weaknesses by current students are difficult to interpret because they reflect a diversity of opinions and programs that are unrelated to the SM-CRSP.

Applications and Impacts

Responses regarding the application and impacts of research (Tables 7) indicate that 76% of respondents report refereed journal publication of their doctoral results or ongoing research; 44% of the respondents report a direct application of their doctoral research results in a local environment; 40% report transferring skills that they learned in their graduate education to co-workers, students and/or local farmers; 39.3% report their research was used as a foundation for continuing research; and 21.4% report modification to their doctoral research findings to fit local environmental needs.

IMPLICATIONS FOR FUTURE EDUCATIONAL PROGRAMMING

In general, this study shows that the graduate-level education component of the Soil Management CRSP has been quite successful in terms of both knowledge developed and knowledge applied within national and international institutions. Ninety-six percent of the SM-CRSP program participants completed their degrees. The success rate is exceptionally high and exceeds substantially all norms for U.S. graduate education. This is especially significant in view of the geographic and ethnic diversity of men and women who participate in the program.

The TropSoils educational program has an impressive record of preparing students for important roles and international positions. The data do not indicate that scientific talent is being diverted inappropriately into administration. To the contrary, alumni are teachers, researchers, policy-makers, program leaders and more. These program alumni represent a valuable but under utilized resource for managing change. Better coordination with alumni is needed. The difficulty that the researcher encountered in organizing the initial mailing list of the CRSP alumni indicates that attention needs to be given to record-keeping and systematic follow-up including networking and newsletters.

Soil Management CRSP has developed strong relationships with National Agricultural Research Systems (NARS). National capacities for research and technology transfer have been strengthened through education and training programs. Education opportunities created through the program build life-long bonds between individuals and institutions. The instances of friction within the network of researchers reflect personal or institutional interests and have not seriously threatened the substantive work of the program.

As is evident in the current study, the present cohort of students brings new perspectives and interests to the program. Current students more often come from nonfarm backgrounds. They are interested in the environment, agroforestry, economics and social policy as well as soil management. They want to acquire the relevant skills and experience for problem-oriented research. They don't want to be limited by traditional disciplinary boundaries. On other measures (gender, parents' socioeconomic

status, parents' education) no significant differences were found between the alumni and current student cohorts.

Graduate education represents a substantial investment in future development. In order to obtain the maximum benefits of the investment, the educational activities must be planned and implemented based on the best available information. This study is provides feedback from students which can help guide future educational program planning.

In a context of institutional and social change, program planners (faculty) are especially dependent on information. Program success, will depend on their ability to adapt to new conditions and needs. Therefore, continuing assessment of education and training programs should be an integral part of the Soil Management CRSP program. The program needs to track the changes in participant-perceived needs over time and facilitate their work. Instances of student and alumni dissatisfaction or friction with the program underscore the need for improved monitoring and participatory planning. Continued development of socio-economic databases are needed. Periodic surveys of program participants and clients could provide data with important implications for national agricultural and social policy planning.

Tracer surveys have many inherent limitations and are used mainly to generate information that would not be available in any other way. The limitations associated with cross-sectional designs, the difficulty in sending and receiving surveys and the consequent small number of alumni responding, the validity of retrospective and prospective responses, etc. could be averted by systematically eliciting current information from program participants at regular intervals or as specified milestones are achieved throughout the educational and employment process.

A more systematic approach to collection of human resource information is needed. A first approximation of a human resource data base is suggested in Table 8. Baseline information on gender, age, home country, size of local community, size and composition of family, family education and reasons for choice of university should be established and recorded at time of application and/or entry to the program. At completion of the program, data pertaining to the education program would be collected as part of an exit interview. Information would include choice of coursework, specialization and research area, location of research, perceptions of the research experience, degree obtained, and perceptions of the strengths and weaknesses of the program. Follow-up surveys of program alumni should be conducted at 5-year intervals to track their post-graduate roles and responsibilities. Critical information would include: current employment position and time allocations to teaching, research, extension, administration and policy-making; indicators of productivity such as participation in workshops, training and conferences, number and topics of publications, collaboration with co-workers, contacts with agencies outside of their own, and contacts with local populations for the purpose of technology transfer; current participation in research and research collaboration; and personal perceptions of and recommendations for the CRSP program.

RECOMMENDATIONS

Based on the above, recommendations are made for future program planning, implementation and evaluation.

1. Education should continue as an integral component of the CRSP. Investments in graduate education have long-term benefits for individuals, institutions and society.
2. Alumni represent an under utilized program resource. They occupy important positions and would welcome closer ties and opportunities for collaboration. Consideration should be given to mechanisms for improving communications and collaboration. Networking should take advantage of available communications technology to enhance opportunities for interactions with alumni to understand the problems and constraints that they confront and to formulate collaborative research programs of relevance.
3. Universities and collaborating institutions should reassess periodically education and training programs to assure that they are aligned with program goals and client needs.
4. Curricula should provide more opportunity for elective study of resource management and soil-environment relationships. Students should be encouraged to supplement their basic coursework in Soil Science with courses in other departments. Participation in interdisciplinary seminars, workshops, conferences would provide balance between science and application that alumni report is critical. Interaction and exchange between students and faculty should be facilitated, including informal exchanges around the coffee pot important for faculty and students alike.
5. Continued development of focused programs is needed to create clear incentives for cooperation between the CRSP universities on the full range of soil-related environmental and social problems existing in developing countries. The restructuring process of the SM-CRSP is laying the foundation for improved program coordination.
6. Collaboration among researchers is apparent, however a more systematic and broadly-based collaboration between researchers, policy-makers, NGOs, market agents and producers is needed. The call for improvement in communication, coordination and outreach is evident in the responses of alumni and current students. CRSP alumni and current students recognize the need for increased cooperation among the collaborating universities.
7. A human resource information system should be developed and maintained as part of the on-going work of a restructured and revitalized CRSP.

REFERENCES

Jamison, D. T. & Lau, L. J. (1982). Farmer Education and Farm Efficiency. Baltimore: Johns Hopkins Univ. Press.

Jamison, D. T. & Lockheed, M. E. (1987). Participation in schooling: Determinants and learning outcomes in Nepal. Economic Development and Cultural Change, 35, 279-306.

Psacharopoulos, G. & Arriagada A.M. (1989). The determinants of early age human capital formation: Evidence from Brazil. Economic Development and Cultural Change, 683-708.

Psacharopoulos, G. & Hinchliffe, K. (1983). Tracer Study Guidelines. Washington, D.C.: Education Department, The World Bank.

Psacharopoulos, G. & Loxley, W. (1985). Diversified Secondary Education and Development. Baltimore, MD: Johns Hopkins University Press.

Psacharopoulos, G. & Woodhall, M. (1985). Education for Development: An Analysis of Investment Choices. New York: Oxford University Press.

Sanyal, B. (1982). University Education and the Labour Market in the Arab Republic of Egypt. Oxford: Pergammon Press.

Schiefelbein, E. & Farrell, J.P. (1981). Eight Years of Their Lives: Through Schooling to the Labour Market in Chile. International Development Research Centre, Ottawa, Ontario.

Schiefelbein, E. & Farrell, J.P. (1987). Tracer studies. In G. Psacharopoulos, ed. Economics of Education. New York: Pergamon Press.

Table 1. Empirical studies of productivity and benefit-cost of education for development.

REFERENCE	COUNTRY, DATA COLLECTION DATE; SAMPLE CHARACTERISTICS	RESULTS
Productivity Studies		
Huffman, 1974	U.S., 1959-64; U.S. Dept. of Agriculture	Education to production has allocative & worker effects
Welch, 1970	U.S., 1949-59; U.S. Dept. of Agriculture	Education to production has mainly allocative effects
Griliches, 1964	U.S., 1949-59; U.S. Dept. of Agriculture	Effect of education on agricultural production is positive
Dhakal, Grabowski & Belbase, 1987	Nepal, 1987; 600 farm families	Effect of education on agricultural production & productivity is positive
Jamison & Lau, 1982	Malaysia, 1973 FAO/World Bank survey; sample of 800 rural faming households Korea, 1973 national survey sample of 2254 farms in 9 regions of S. Korea & Thailand, 1972-3; farm households in 22 villages/Chiang Mai Valley	Effect of education on output is positive, significant & quantitatively important
Jamison & Moock, 1984	Nepal, 1977-8 joint World Bank and New ERA of Nepal study; sample of 683 farming households in the Terai	Education has a positive & significant effect on farmer efficiency in wheat production
Moock, 1981	Kenya, 1971; sample of 152 farm households - 101 male farm managers	Education has a positive effect on production
Patrick & Kehrberg, 1973	Brazil, 1969; sample of 620 farms in 5 regions of eastern Brazil	Education's effect is negative in traditional agriculture and positive in modern
Phillips & Marble, 1986	Guatemala, 1974; sample of 1548 small farmers	Educations has a positive & significant effect on productivity
Pudasaini, 1983	Nepal, 1981; sample of 205 Terai (Bara district) farmers & 149 hill region (Gorkha district) farmers	Educations has higher significant positive effect in modern setting than in a traditional one
Ram, 1980	India, 1961 & 1971; sample of 149 (1961) and 151 (1971) farmers throughout India	Education has a positive & significant effect
Wu, 1977	Taiwan, 1964-66; sample of 310 bookkeeping farms in mixed regions of the island	Educations has a positive effect on production of small farms
Benefit-Cost Studies		
Griliches, 1977	U.S., 1966-71; National Longitudinal Survey of Young Men	No significant positive ability bias to earnings
Haveman & Wolfe, 1984	Review of 60 studies of non-market effects	Value of incremental schooling via standard human capital methods underestimates total by half
Psacharopoulos, 1982	UNESCO Statistics, 1975; 58 developing, 18 developed & 7 oil-producing countries	Returns to higher education are higher than returns to physical capital
Psacharopoulos, 1985	Word Bank, 1973-85; rate of return data from 60 countries	Returns to higher education are highest for general curricula in lowest capita income countries

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Table 2. Demographic totals.

	SM-CRSP ALUMNI		CURRENT SOIL SCIENCE STUDENTS	
	number	% of respondents	number	% of respondents
Respondents				
All	26	100	36	100
Male	22	85	26	73
Female	4	15	8	22
Missing	–	–	2	5
Age at Time of Graduate Study (years)				
21-25	2	8	5	14
26-30	4	15	6	17
31-35	11	42	15	42
36-40	6	23	7	20
41-45	0	0	1	3
Missing	3	12	2	4
Population in Current Community				
<1,000	2	8		
1,000-2,499	0	0		
2,500-74,999	5	19		
75,000-249,999	7	27		
≥250,000	12	46		
Current Socio-Economic Status (%)				
Top 10	2	8		
75-89	13	50		
25-74	8	31		
11-24	2	8		
Lower 10	1	3		
Siblings				
0-1	4	15	5	14
2-3	7	32	15	42
4-5	9	35	9	25
6-7	3	12	5	14
8-9	1	4	1	3
≥10	2	2	0	0
Missing	–	–	1	2
Youngest	5	19	9	25
Eldest	16	62	7	20
Only child	0	0	0	0
Other position	5	19	18	50
Parent's Current Socio-Economic Status (%)				
Top 10	1	4	3	8
75-89	6	24	3	8
25-74	14	54	21	59
11-24	4	15	6	17
Lower 10	0	0	3	8

Table 2 (continued)

	SM-CRSP ALUMNI		CURRENT SOIL SCIENCE STUDENTS	
	number	% of respondents	number	% of respondents
Mother's Education				
No school	0	0	3	8
0-4 years	2	8	0	0
Primary	5	19	4	11
Middle	4	15	0	0
Secondary	7	27	12	34
Post-secondary	1	4	6	17
BS/BA	4	15	7	20
MS/MA	2	8	3	8
PhD	1	4	0	0
Missing	–	–	1	2
Father's Education				
No school	0	0	2	6
0-4 years	1	4	0	0
Primary	1	4	4	11
Middle	4	15	3	8
Secondary	10	39	8	22
Post-secondary	4	15	5	14
BS/BA	1	4	7	19
MS/MA	3	12	2	6
PhD	1	4	3	8
Missing	–	–	2	6
Citizenship[1]				
China ($320)	–	–	1	3
Rep. of Guinea ($350)	–	–	1	3
Liberia ($395)	–	–	1	3
Indonesia ($430)	3	12	1	3
Nicaragua ($470)	1	4	–	–
Dom. Republic ($790)	1	4	–	–
Honduras ($890)	–	–	1	3
Jamaica ($1100)	–	–	1	3
Colombia ($1110)	2	8	–	–
Thailand ($1160)	1	4	–	–
Botswana ($1600)	–	–	1	3
Fiji ($1750)	1	4	–	–
Argentina ($2160)	1	4	–	–
Mexico ($2165)	–	–	1	3
Brazil ($2500)	2	8	1	3
Taiwan ($7132)	1	4	–	–
Peru ($8800)	1	4	2	8
Switzerland ($17800)	–	–	1	3
USA ($21974)	10	38	22	81
Germany ($24980)	2	8	1	3
Missing	–	–	1	3

[1] Listed from lowest to highest national per capita income for 1992 (World Almanac, 1992).

Table 3. Retrospective and current perceptions of coursework.

	SM-CRSP ALUMNI		CURRENT SOIL SCIENCE STUDENTS	
	number	% of respondents	number	% of respondents
Most Useful Course Taken				
Soil science	15	57	18	50
Crop science	1	4	7	20
Economics	0	0	0	0
Public policy	1	4	0	0
Statistics	5	19	3	8
Other	0	0	7	20
No response	3	11	1	2
Second Most Useful Course Taken				
Soil science	10	38	16	45
Crop science	2	8	5	17
Economics	2	8	0	0
Public policy	2	8	0	0
Statistics	4	15	5	14
Other	2	8	7	20
No response	4	15	2	4
Most Needed Course NOT Taken				
Soil science	5	19		
Crop science	1	4		
Economics	1	4		
Public policy	1	4		
Statistics	3	11		
Environment	2	8		
Programming	2	8		
Other	3	11		
No response	8	31		
Second Most Needed Course NOT Taken				
Soil science	3	11		
Crop science	1	4		
Economics	1	4		
Public policy	1	4		
Statistics	2	8		
Environment	2	8		
Programming	1	4		
No response	14	57		
Most Frequently Chosen Coursework Outside the Department				
Crop science			12	34
Statistics			12	34
Environment			3	8
Other			6	17
No response			2	7
Second Most Frequently Chosen Coursework Outside the Department				
Crop science			6	17
Economics			1	3
Statistics			14	39
Environment			1	3
Computer			1	3
Other			7	20
No response			6	15
Flexibility to Take Courses Outside the Department				
Yes			35	97
No			1	3

Table 4. Research areas of SM-CRSP alumni and current students and prospective career goals of current soil science students.

	SM-CRSP ALUMNI		CURRENT SOIL SCIENCE STUDENTS	
	number	% of respondents	number	% of respondents
Research Area				
Green manure	10	38	7	19
Resource allocation	2	8	6	17
Water movement	3	11	4	11
Fert. recommendations	3	11	5	14
FCC	1	4	0	0
Low input	2	8	0	0
Clay mineralogy	3	11	5	14
Agroforestry	0	0	4	11
Sludge management	0	0	1	3
Folk taxonomy	0	0	1	3
Heavy metal management	0	0	2	6
Tillage & conservation	0	0	1	3
Current Student's Prospective Career Goals				
Environmental research			8	22
Environmental research & extension			5	14
Extension			4	11
University research & teaching			4	11
Government research			4	11
Private industry/consulting			4	11
Government administration			2	6
Other			5	14

Table 5. Current employment roles and time allocations for SM-CRSP alumni.

	NUMBER	% OF RESPONDENTS
Alumni Employment Roles		
National government	6	23
University	12	46
Private enterprise	1	4
Unemployed	1	4
Other	6	23
Employment Sector		
Agriculture	19	72
Public	1	4
Missing	6	23
Description of Work		
Environment & extension	11	43
University research & teaching	9	36
Government research	2	7
Private industry & consulting	2	7
Missing	2	7
Time Allocated to Teaching (mean = 15%)[1]		
0	10	40
<50	10	40
≥50	5	20
Time Allocated to Research (mean = 55%)		
0	2	8
<50	7	28
≥50	16	64
Time Allocated to Extension (mean = 6%)		
0	14	56
<50	11	44
≥50	0	0
Time Allocated to Adminsitration (mean = 10%)		
0	15	60
<50	8	32
≥50	2	8
Time Allocated to Policy-Development (mean = 3%)		
0	22	88
<50	2	8
≥50	1	4

[1] All figures are based on n = 25 employed and n = 1 unemployed.

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Table 6. Alumni and current student perceptions of the graduate education programs.

	NUMBER[1]	% OF RESPONDENTS
Alumni Perceptions of SM-CRSP Education Program		
Strengths		
Opportunity for field research in host country	9	34
Program philosophy and staff	5	19
Opportunity for an education	2	8
Weaknesses		
Budgetary problems	7	27
High emphasis on research; low emphasis on training	6	23
Weak inter-supporting communications	5	19
CRSP own agenda not well-coordinated with host countrys	2	8
Broader emphasis including environmental and social issues	1	4
Current Student Perceptions of Graduate Education Program		
Strengths		
Qualified and knowledgeable faculty	19	53
SM-CRSP presence	5	14
Current and relevant research	4	11
Scholarly training	2	6
Weaknesses		
Needs new curriculum development	9	25
Needs more fieldwork & labs with classes	7	20
Should encourage extra-departmental coursework	5	14
Office space mixed with lab space	5	14
Professors lack teaching ability	4	11
SM-CRSP too separatist	3	8
Communication on research between faculty & students	3	8
Needs more environmental focus	3	8

[1] Multiple responses given.

Table 7. Alumni applications and impacts of SM-CRSP research.

VARIABLES	NUMBER	% OF RESPONDENTS
Alumni Participation and Productivity[1]		
Shares knowledge with co-workers	21	84
Shares knowledge with other agencies	9	36
Shares knowledge through publications	19	76
Shares knowledge with local population	7	28
Participates in training	11	44
Participates in conferences	18	72
Alumni Publications and Honors		
Publications in refereed journals		
0	5	19
1-5	17	65
6-10	2	8
>15	2	8
Honors		
National (U.S.)	4	15
International (non-U.S.)	4	15
Application and Modification of SM-CRSP Funded Graduate Research[1]		
Publication of doctoral or ongoing research	19	76
Direct application in a local environment	11	44
Transfer of skills learned as a graduate student	10	40
As a foundation for continuing research	8	32
Modification to fit local environment	7	28

[1] All figures based on n=25 employed and n=1 unemployed.

Table 8. Proposed systematic human resource data base for SM-CRSP alumni.

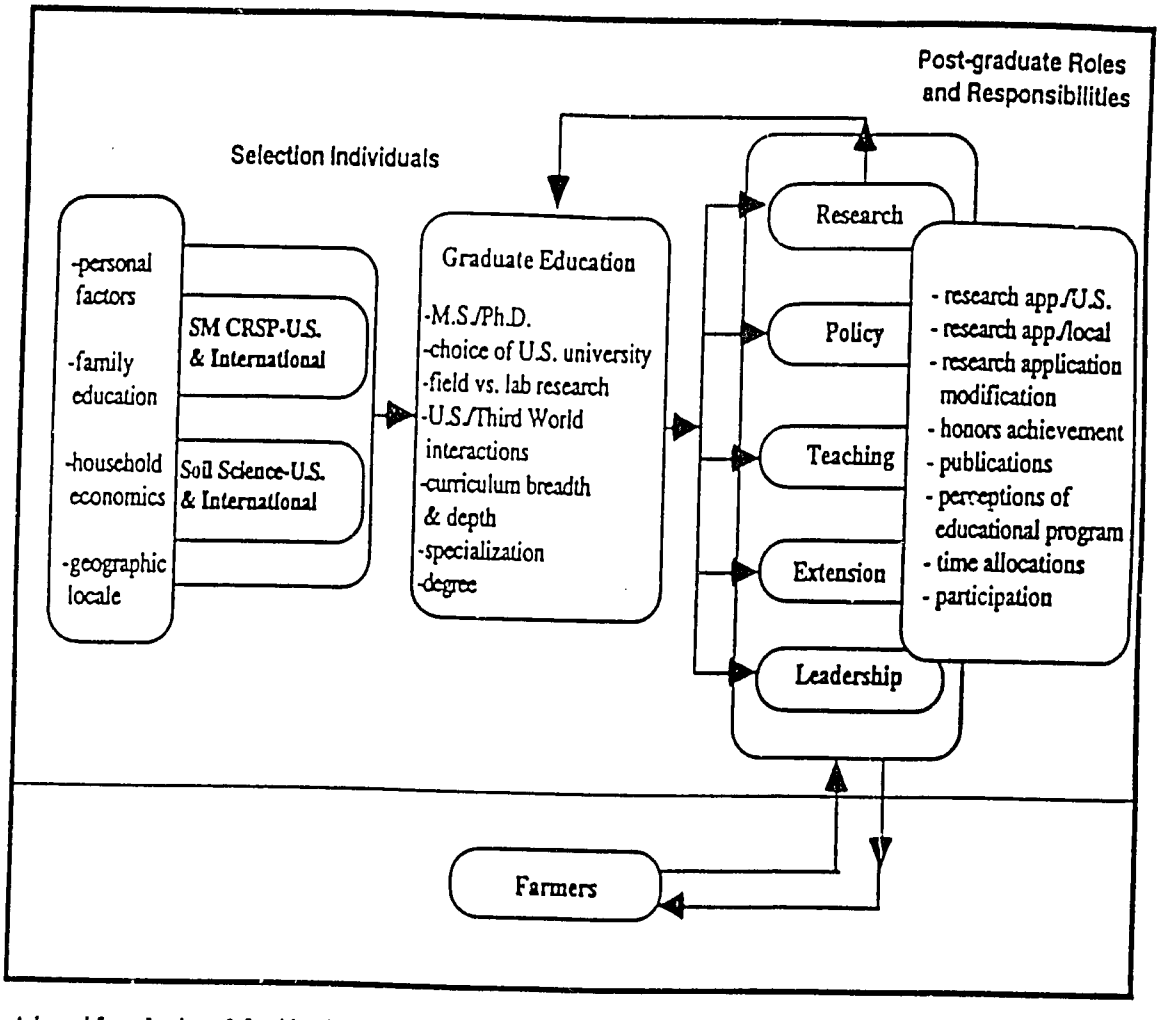
BEGINNING PROGRAM	END OF PROGRAM	5-YR FOLLOWUP
Baseline	Educational Process	Employment Process
Date	Date	Date
Gender	Age	Age
Age	University	Current employment
Home country	Perceptions/courses:	Time allocations:
Size of local community	Most useful	Teaching
Size of family	Changes needed	Research
Composition of family	Specialization	Extension
Family education levels	Research area	Planning
Household economics	Field research location:	Administration
Reasons for university choice	Perceptions/research	Policy development
	Experience	Workshops
	Degree obtained	Conferences
	Perceptions/program:	Publications
	Strengths	Collaboration:
	Weaknesses	Co-workers
		Other agencies
		Local farmers
		Former university
		Current research
		Perceptions/CRSP:
		Strengths
		Weakenesses

LIST OF FIGURES

Figure 1 Conceptual model for the role of SM-CRSP graduates. Adapted from Jamison & Lockheed (1987) and Psacharopoulos & Arriagada (1989).

Figure 2 Sources of retrospective and prospective views of educational experiences in the two-group cohort design.

Figure 3 Worldwide distribution of SM-CRSP alumni which responded to the survey.



Adapted from Jamison & Lockheed (1987) and Psacharopoulos & Arriagad a (1989)

Fig. 1

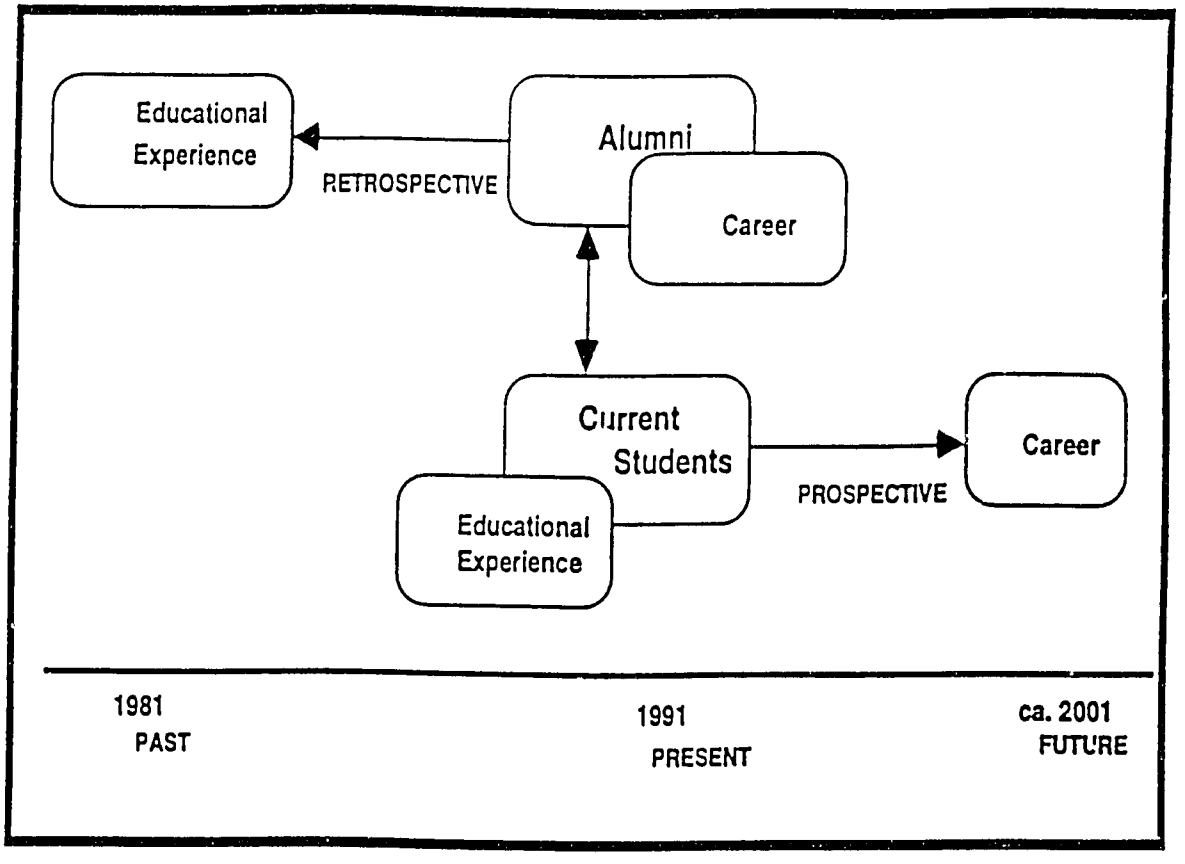

Educational Experience
RETROSPECTIVE
Alumni
Career
Current Students
Educational Experience
PROSPECTIVE
Career
1981
PAST
1991
PRESENT
ca. 2001
FUTURE

Fig 2

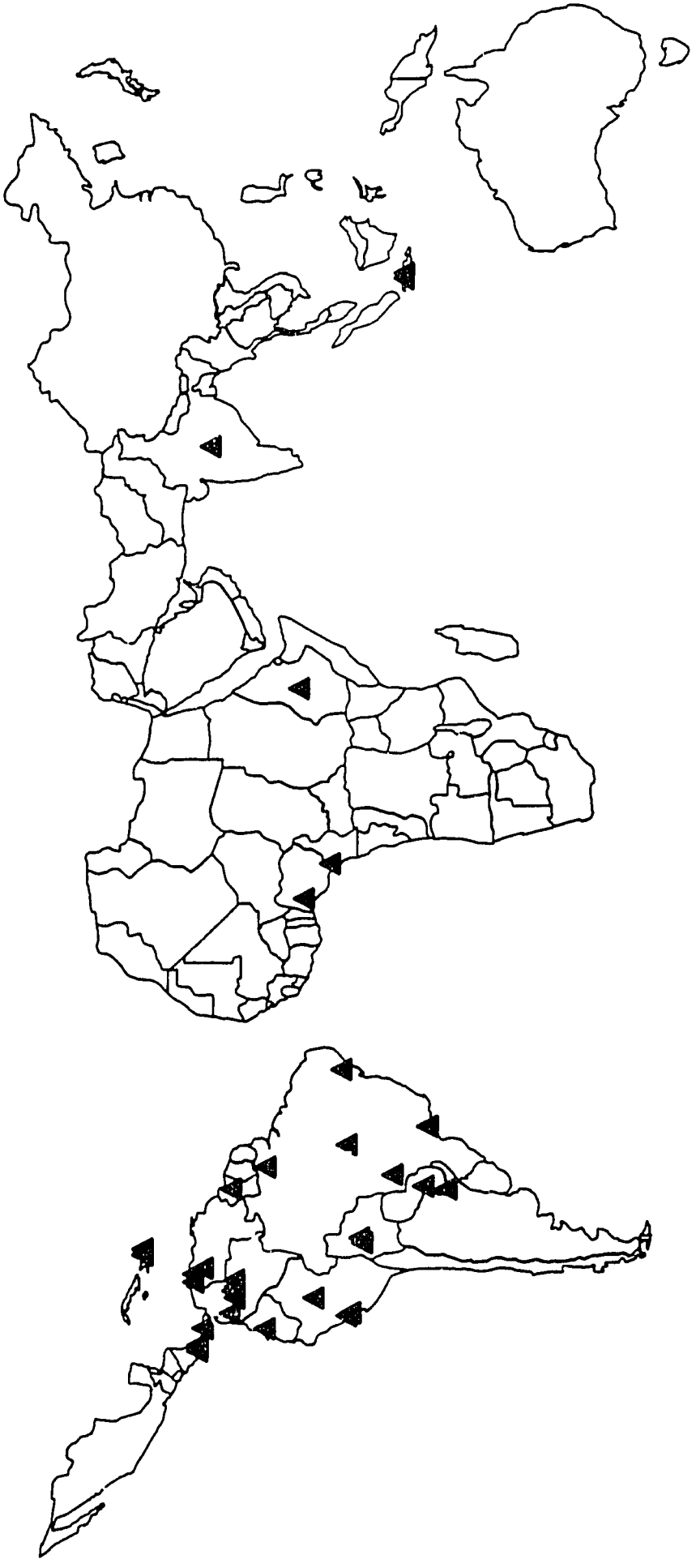


Fig. Ξ

7. OUTREACH FOR SOIL MANAGEMENT: PUBLICATIONS, VISITS AND NETWORKS[1]

Frank J. Smith and T. Jot Smyth

Outreach in the context of the SM-CRSP includes extrapolation, communication, training, networking, and decision-support activities which translate research information into improved applications. Activities involve the participation and collaboration of policy-makers, scientific users, implementors and educators. Figure 1 illustrates the relationship between outreach activities and information users/interpreters.

Outreach activities are designed to overcome the constraints to adoption and application of new management systems (TropSoils, 1989). The four principal constraints to the extrapolation and adoption of improved technologies are 1) the number and diversity of potential users, 2) the site-specificity of soil-management practices, 3) the deficiencies in local expertise and communications, and 4) the gap between new information and useable knowledge.

Every year the SM-CRSP receives numerous visitors and requests for copies of publications. In order to appreciate the level and distribution of program methods and research results, an analysis of the visits and publication requests was made for selected activities. Analyses suggest the amount of interest in various topics and the extent to which the publications have short-term or continuing value.

Demand for research publications is a function of their perceived value and the extent to which persons know they exist and how to request them. The latter is achieved through newsletters, networks, training sessions, conferences and other means to inform individuals about the availability of publications. Requests for publications frequently increase following training sessions and workshops where participants are made aware of the content and availability of publications.

Visits to research sites provides a more intensive form of exposure to the collaborative research activities of the CRSP. Visitors are provided a first-hand view of experiments in the field, and personalized dialogue with field supervisors, researchers and outreach specialists.

Networks provide a structure and synergy for collaborative research on soils of the humid tropics. It strengthens capabilities of personnel at collaborating national research institutions to conduct, interpret and report user-oriented research. Network participation and productivity is reviewed periodically in follow-up workshops.

METHODS

Analyses of the outreach modalities are based on the following: a) analysis of a sample of the publications requested from member institutions; b) analysis of the visitors directory at a primary research site; and c) review of the documentation of the Latin American Tropical Soil Management Network (RISTROP).

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[1]This study was supported in by USAID Grant DAN-1311-600-0039-00 to the Soil Management Collaborative Research Support Program (TropSoils).

Analysis of publication outreach is based on a sample of the publication requests (n=977) made during the period of January, 1990-May, 1993 to the office coordinating North Carolina State University activities in the SM-CRSP. The total collection of research publications numbers 148. All but eighteen of these publications were produced since 1980. They represent a measure of the research output of the NCSU component of the SM-CRSP program since its beginning in 1981 to present. The papers from the period 1973 through 1980 include work sponsored by USAID under a different program, and were instrumental in the planning and eventual implementation of the SM-CRSP.

With help from the Program Coordinator, a categorical system was developed to capture the diversity of content represented in the total collection of publications. Each publication was then assigned a category code best reflecting its content. Following the general framework of the SM-CRSP, the major categories are Natural Resource Management, Sustainable Agriculture, and Outreach. Within each major category are various subcategories defined as follows:

Natural Resource Management
- -Inventories and classifications
- -Watersheds
- -Information systems

Sustainable Agriculture
- -Acidity management
- -Nutrient management
- -Physical constraints
- -Land use options
- -Land reclamation

Outreach
- -Expert systems and models
- -Networks
- -Training

General Program Material

With respect to outreach through hosting visitors, the analysis is based on the 3,180 entries in the visitors log at the INIAA ('Instituto Nacional de Investigacion Agropecuaria y Agroindustrial') research station in Yurimaguas, Peru. The visitors log contains the names of each visitor, their job title/profession, country of residence, and the purpose of the visit for the period 1975 to date. Our analyses are based on the period of 1975 to 1990. The data from the visitors log were coded to summarize the diversity of visitors' professions, place of residence and purpose of the visit as follows:

a) Visitors represented more than fifty different job titles/professions. Professions were grouped into major categories of administrator, researcher, extensionist, farmer, student, government official, international development agency representative, business person, missionary, rancher, forester, media, and others (fisherman, contractor, tourist, lawyer, police, military).

b) Places of residence were coded as Peru, U.S., South America, Central America, Europe, Africa, Asia, and Oceania.

c) Purpose of the visits were coded as training, research, extension, supervision/evaluation, observation, installation/repair, media reporting, obtaining information/assistance, and unspecified.

The outreach activities of the RISTROP network were summarized based on information contained in available reports.

RESULTS

Publication Requests

The distribution of requested publications by their year of publication are presented in Figure 2. Analysis reveals that requests are greatest for the latest publications. Twenty nine percent of the papers requested were published in 1990-1992, the same period that the requests were made. This suggests that many are following with great interest the on-going research program and want the latest results available. It is also important to observe that there is continuing demand for earlier published research dating back to 1973. Clearly the older research studies being requested are perceived to have continuing scientific and applied value.

North Carolina State University has been predominantly focused on the humid tropics of South America. The long-term commitment to collaborative soil management research in the region is evident in the number of publications produced. Therefore, it is expected that there would be substantial demands for publications from South America and, in fact, there were 222 requests representing 22 percent of the total. However, what is striking in the numbers is the extent of the demand from other regions, including the U.S., for publications based on research of predominantly South American origins. The global distribution of publication requests is presented in Figure 3. Clearly, the research publications are regarded as important in Europe, Central America, Africa and elsewhere.

Further analysis of the publication requests provides a measure of the demand for research addressing different topics or problems. Results of publication requests by category during the period 1990-1993 are presented in Figure 4. Publications about land use options and management of soil nutrients were most frequently requested. A two-way analysis of demand (Figure 5) shows general uniformity in the profile of research categories over regions. Papers on land use options and nutrient management were most frequently requested in all regions. These are categories for which the NCSU component has produced the most papers. For example, the absence of requests for papers on SM-CRSP training does not mean that there is no interest in the subject, but rather there are no papers available in the training category. It is useful, therefore, to compute the frequency of requests for each category adjusted for the number of entries in that category. Dividing the frequency of requests by the number of entries gives the adjusted values. These are shown in Figure 6. The adjusted frequencies indicate a relatively high demand for publications about expert systems, networks, land use options, and general program information. They better reflect the breadth of demand across the categories of research.

Visitors

More than 3100 visitors were registered at the Yurimaguas research site during the period 1975 to 1990. Yurimaguas is an out-of-the way destination even for most

Peruvians. It takes special effort to get there, but many have made the effort. The visitors log is a voluntary registration and therefore does not include all who have visited. Outreach to farmers and local businesses is greater than it may appear from registered visitors, because it does not include many who have visited the station as part of demonstrations and field days.

The trend in numbers of visitors at the Yurimaguas site is presented in Figure 7. The period 1981 to 1986 had a consistent growth in the number of visitors. Unfortunately, the worsening security situation affecting Peru has had a dramatic effect in reducing visitation since 1987.

The global representation of visitors is given in Figure 8. Approximately 75% of the visitors were Peruvian. Eleven percent of the visitors were from the U.S. and the remainder were from Europe, South America, Asia, Central America, Africa and Oceania. The purpose of the visits was not specified by many of the registrants. For visitors indicating a specific purpose, research, training and supervision were most frequently cited (Figure 9).

The profession of most visitors was research or administration. Students, professors, and extension specialists were next in order of numbers visiting. The rest included government officials, press, NGOs, farmers, business persons, international agency representatives and others. As with publications, visits to the remote station showed global interest in SM-CRSP research in the humid tropics.

Networks

RISTROP (Red de Investigacion de Suelos Tropicales) was created in 1986 by the 31 scientists from 15 national institutions in ten Latin American countries attending the soil management workshop in Yurimaguas, Peru. By 1990 the network had grown to include 15 Central and South American countries and more than 100 collaborating scientists. The network's primary objective is to help transfer and validate improved soil management technologies throughout tropical Latin America. Network collaborators obtain local support for their research, and the CRSP provides the central coordination and technical backstopping. Network scientists have produced 33 articles and nine special papers after four years of field activities (Smyth *et al.*, 1991).

The locations of ongoing field experiments and the national institutions collaborating with RISTROP are shown in Figure 10. Investigations include local evaluations of the Soil Fertility Capability Classification (FCC) system or validation of technologies in five different soil-management options: low-input cropping with acid-tolerant species, mechanized continuous cropping, agroforestry, improved pastures, and paddy rice.

Strong working linkages have been established with international agricultural research centers (CIP, CIMMYT, CIAT, IRRI, ICRAF) and other international agricultural institutions (TSBF and IBSRAM). Supplementary support has been obtained for training from the Rockefeller Foundation, IRDC (Canada), PPI (Canada), the German Ministry for Economic Cooperation and TSBF.

The link between soil management research in Africa and South America has effectively been established by a training workshop and follow-up activities. Scientists from 16 African countries participated in the Workshop on Acid Tropical Soils

Management and Land Development Practices in Yurimaguas, Peru. Countries and institutions represented at the workshop are shown in Figure 11. The workshop's objectives were to a) acquaint African scientists with the most recent techniques in acid tropical soils management, b) foster the exchange of soil management technologies between South America and Africa, and c) to help IBSRAM-network participants implement experiments to be conducted by their national institutions. The workshop staff of 25 scientists combined a broad range of theoretical and practical experience. They included 10 professors from NCSU, Cornell, Texas A&M, and the University of Hawaii, two IBSRAM coordinators; 10 INIAA scientists; and four NCSU graduate students conducting their thesis research in Yurimaguas.

TSBF and IBSRAM have been established (with African scientists trained in Yurimaguas) in Zimbabwe, Zambia, Madagascar, Uganda, Rwanda, Kenya, Cote d'Ivoire, and Guinea. Continued participation of TropSoils personnel in the TSBF network provides follow-up advice and, in the case of Zimbabwe and Zambia, direct collaborative research.

CONCLUSIONS

Overall, the analysis suggests an interest in the activities of the SM-CRSP. Publication requests and visits are made based on the perception of value and the initiative taken by user groups. There appears to be a reasonable match between the investments in research and the demands for research publications.

The SM-CRSP facilitates transfer of soil management information derived in South America to other regions. Publication requests and site visits indicate that regional CRSP activities have a global relevance. This is a kind of demand-driven CRSP support that leads to new linkages and follow-up activities. Training and outreach activities of the SM-CRSP lead to requests for more information and publications. Responding to requests for publications and information is an essential part of the CRSP outreach function. All institutions of the CRSP respond to such requests for publications. A sample of the publication requests received by one institution suggest the extent of this outreach.

The numerous program papers on land use options and the management of acid, infertile soils have generated the greatest number of requests. Adjusting the number of publication requests in each category by the number of publications available, reveal that the breadth of demand across the various topical areas is quite balanced. Considering the few papers available about expert systems, networks, and general program information, they have generated a relatively high number of requests.

REFERENCES

Anonymous. 1989. TropSoils extension proposal and program plan, 1989-1994. Soil Management Collaborative Research Support Program, North Carolina State University, Raleigh, NC. 156p.

Cordero, A., F. Bertsch, and T.J. Smyth. 1992. Soil researchers pool their experiences. ILEIA Newsletter 8:13-14. Information Centre for Low-External-Input and Sustainable Agriculture (ILEIA), Leusden, Netherlands

Smyth, T.J. 1991. Technical support for research networks in the humid tropics: NC-8. pp. 341-347. *In* T.P. McBride (ed.) TropSoils technical report, 1988-1989. North Carolina State University, Raleigh, NC.

Smyth, T.J., W.R. Raun, and F. Bertsch. 1991. Manejo de suelos tropicales en Latinoamerica. Soil Science Department, North Carolina State University, Raleigh, NC. 310p.

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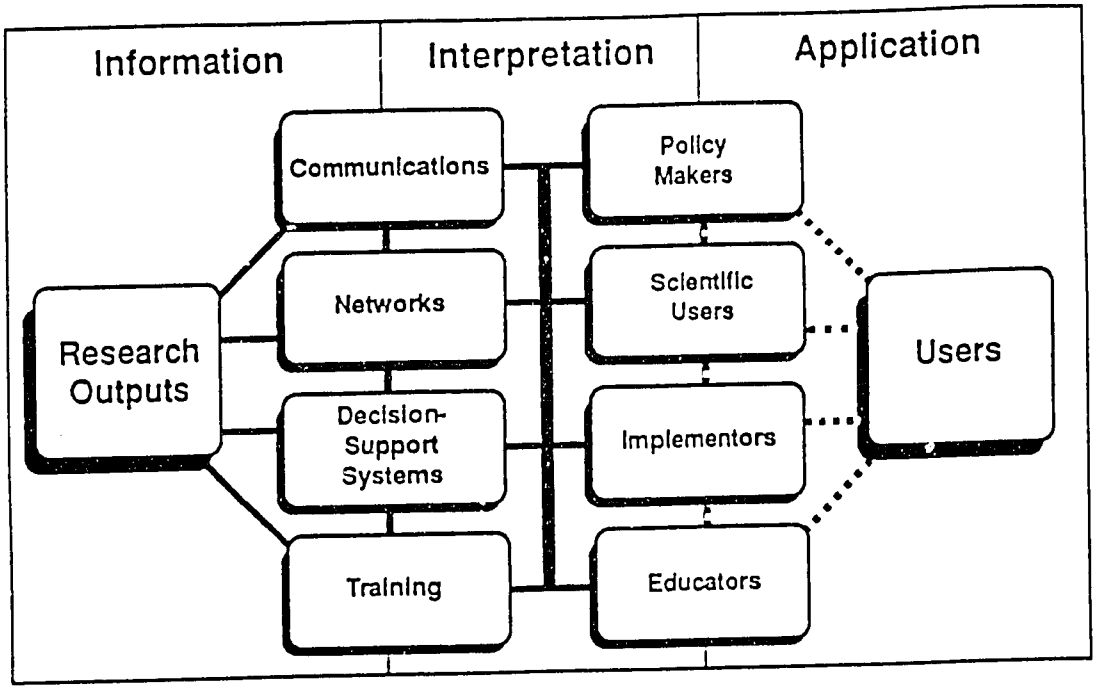
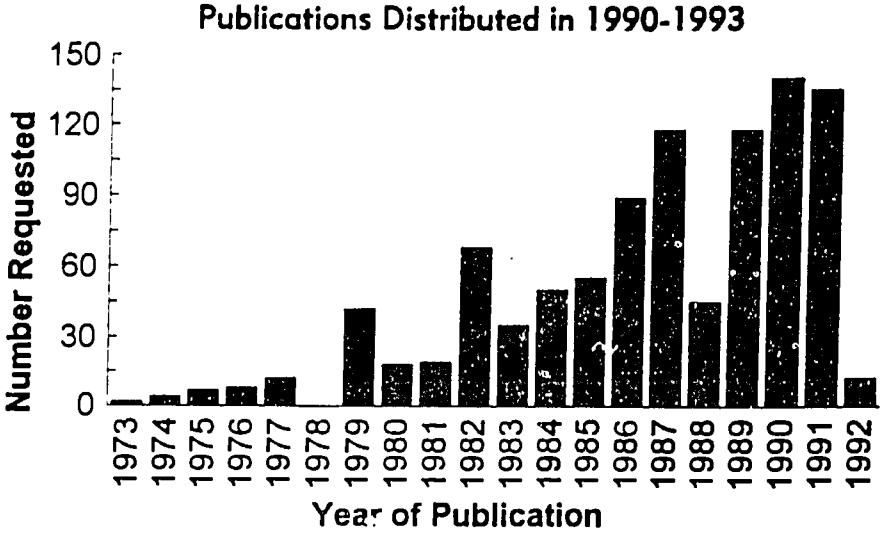

Information
Interpretation
Application
Research Outputs
Communications
Networks
Decision-Support Systems
Training
Policy Makers
Scientific Users
Implementors
Educators
Users

Fig. 1 140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120
90
60
30
0
1973
1974
1975
1976
1977
1978
1979
1980
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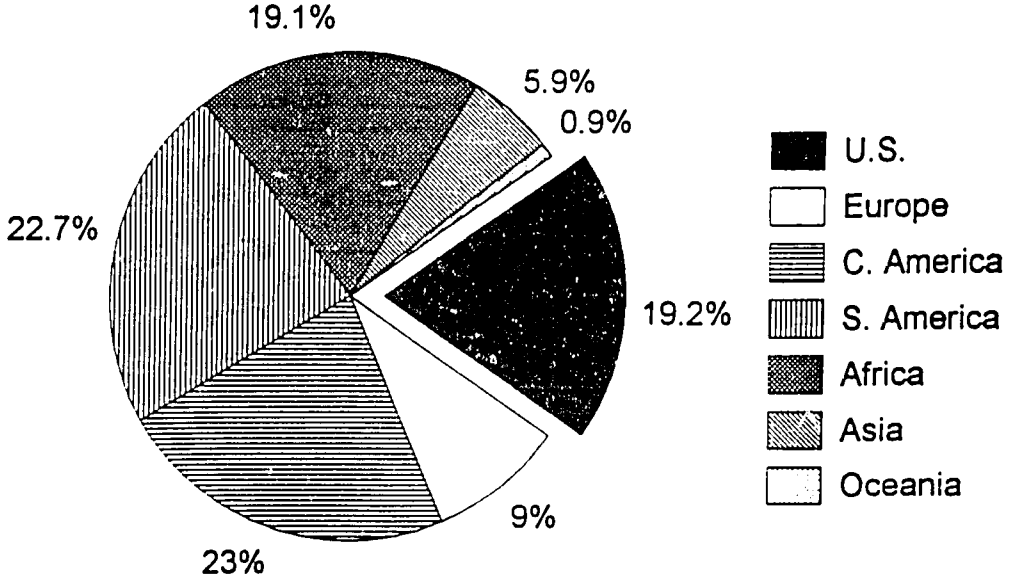
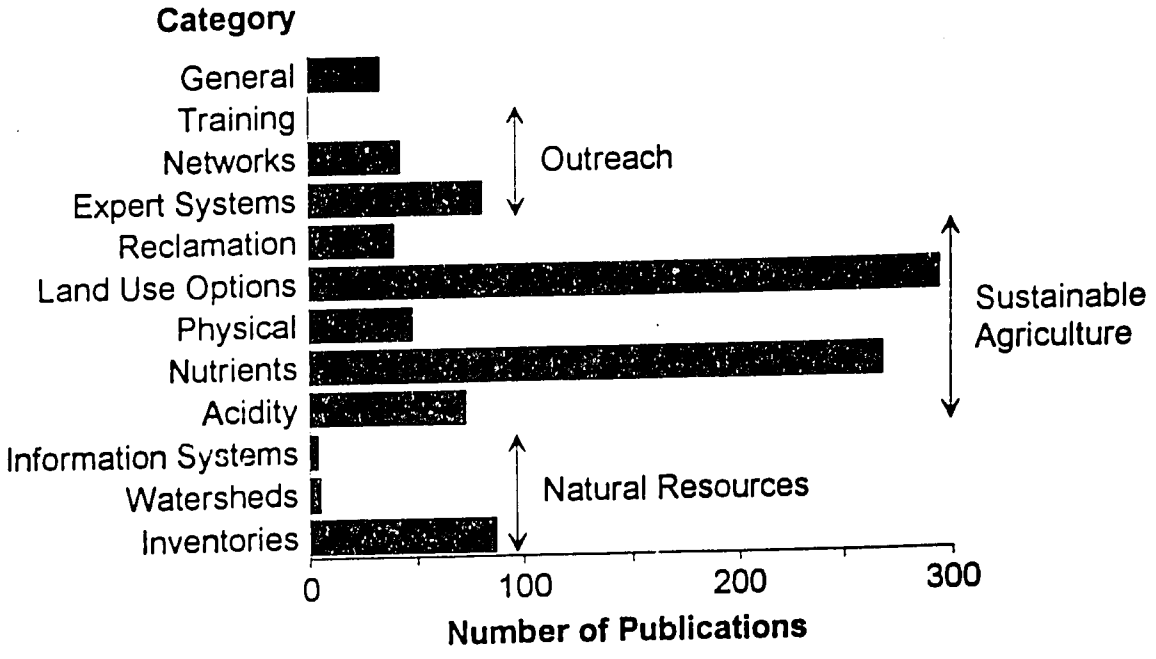
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
Year of Publication

Fig. 141

Global Distribution of Publication Requests

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Expert Systems
Reclamation
Land Use Options
Physical
Nutrients
Acidity
Information Systems
Watersheds
Inventories
Outreach
Sustainable Agriculture
Natural Resources
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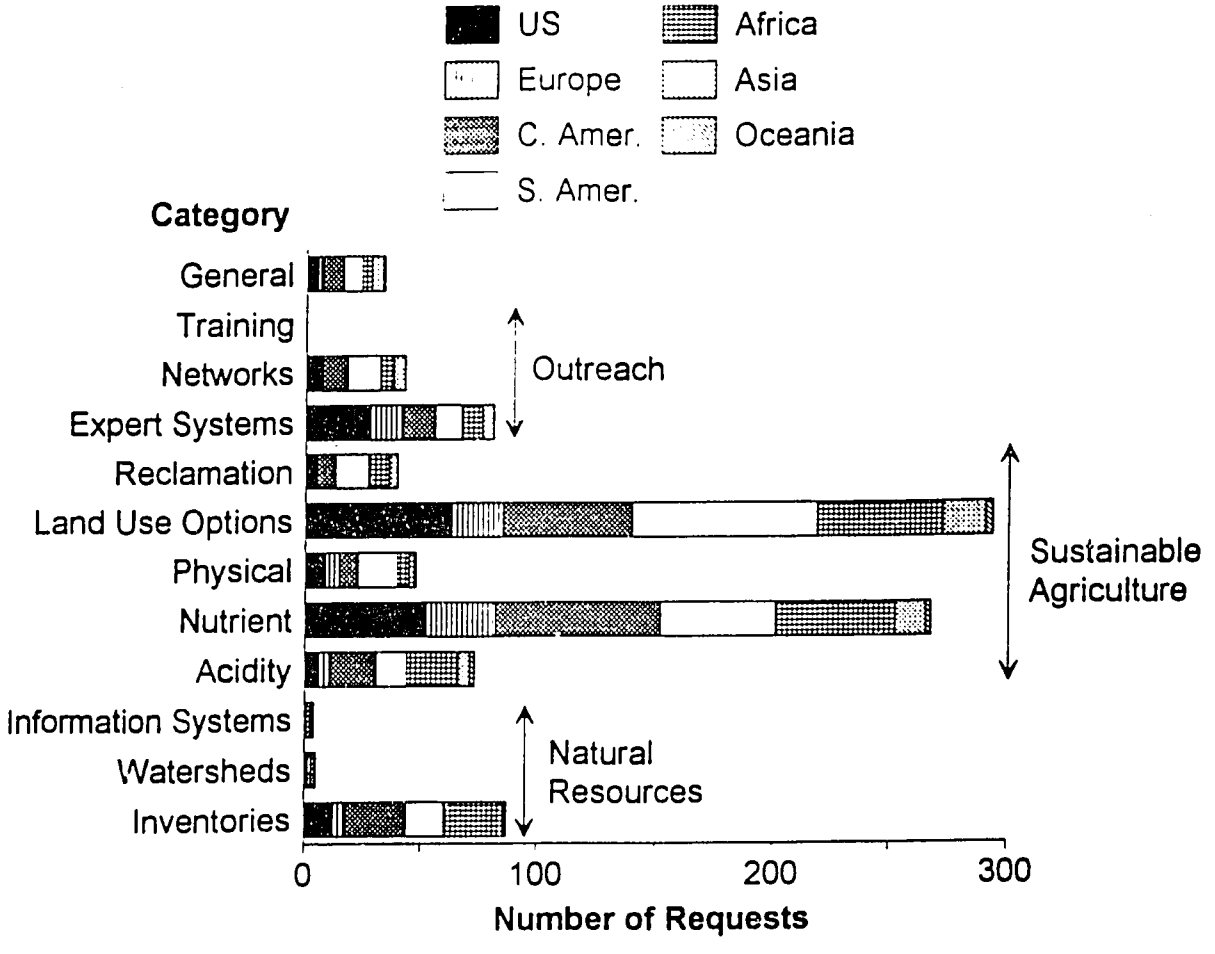
100
200
300
Number of Publications

Fig. 4 143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Africa
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Expert Systems
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Inventories
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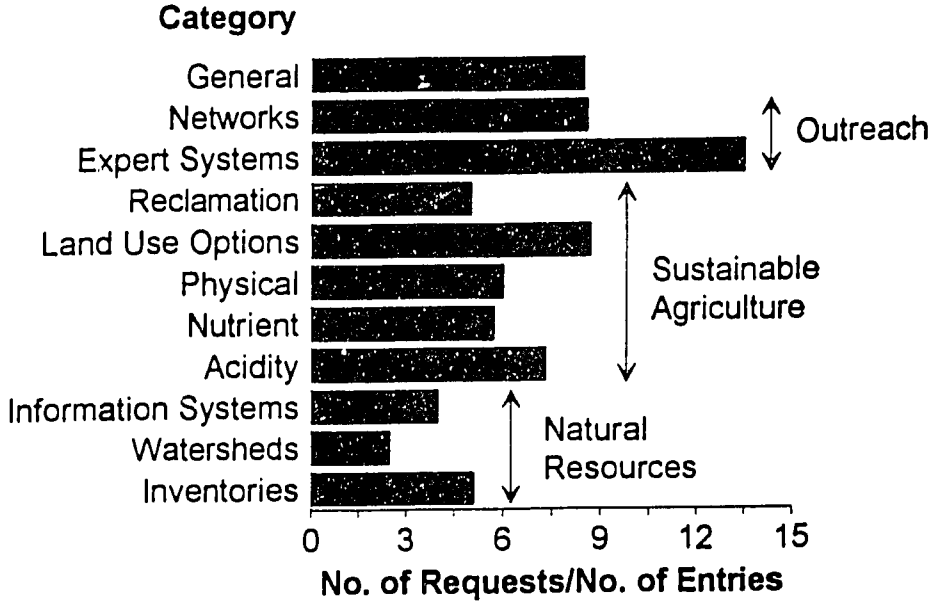
300
Number of Requests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Expert Systems
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Nutrient
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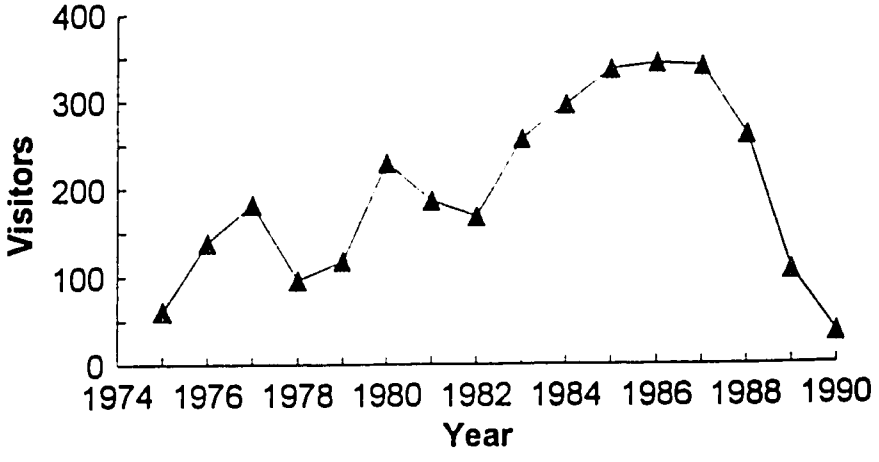
No. of Requests/No. of Entries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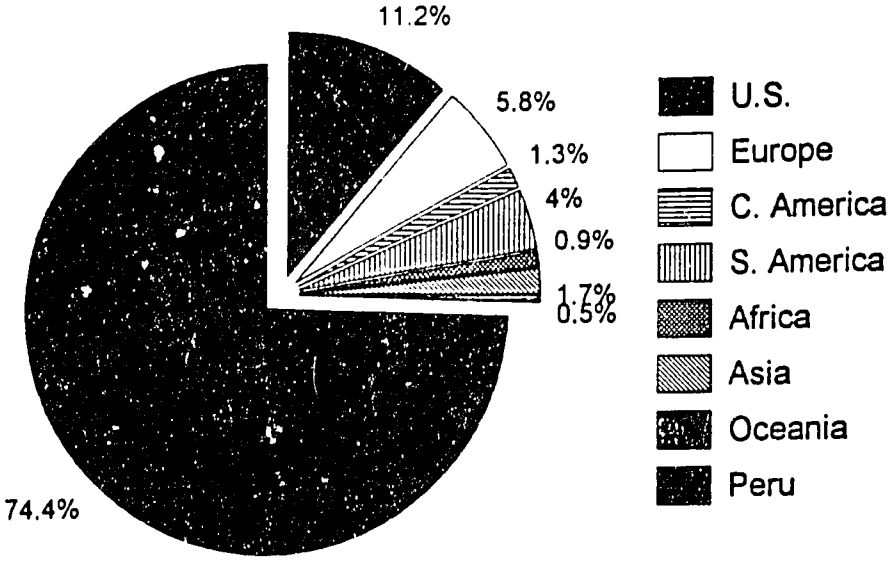
1982
1984
1986
1988
1990
Year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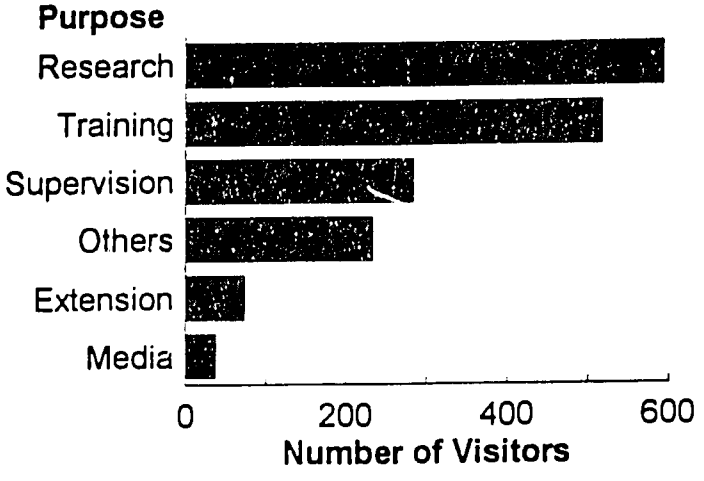
Purpose
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Training
Supervision
Others
Extension
Media
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200
400
600
Number of Visitors

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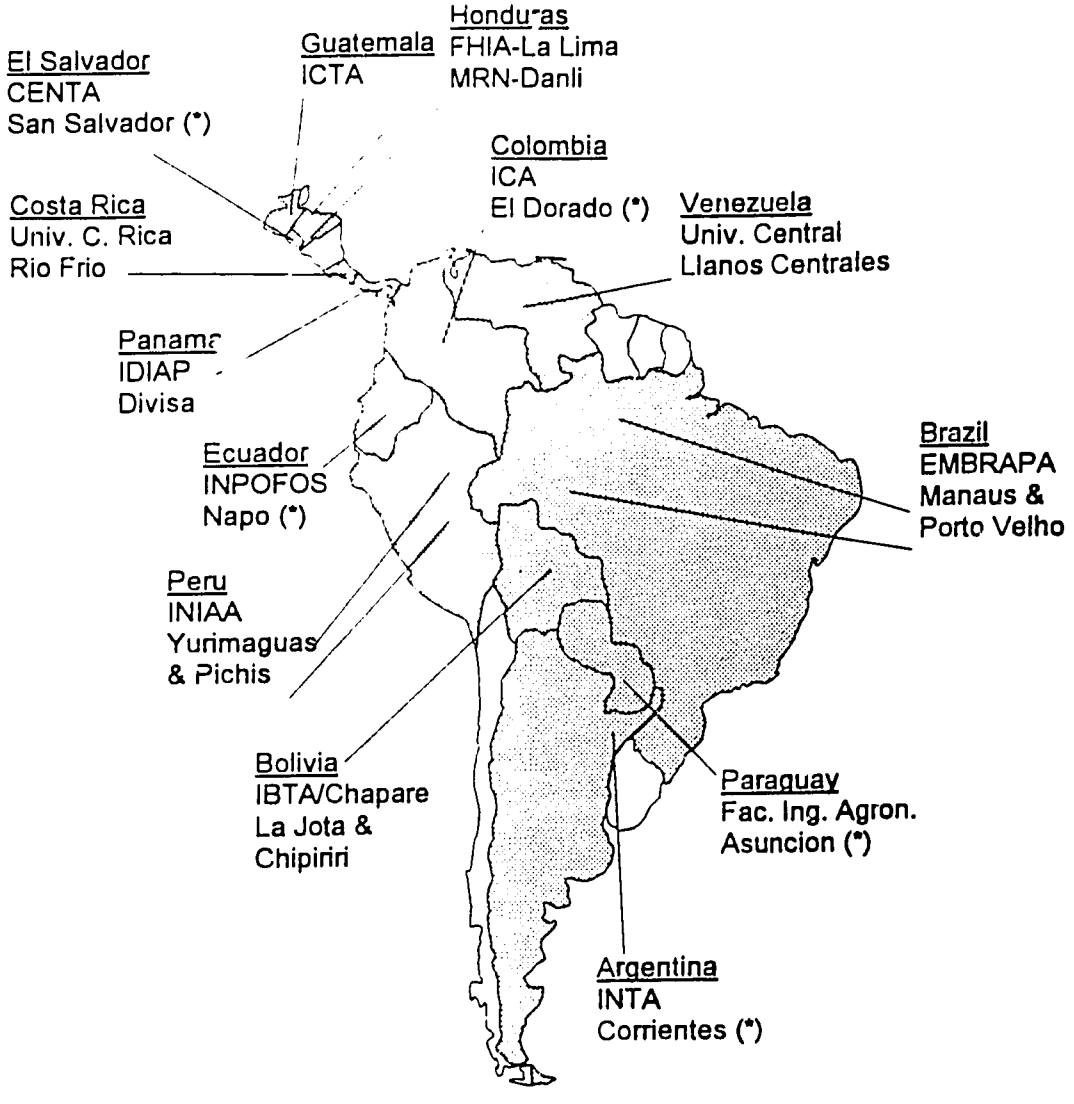
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Llanos Centrales
Costa Rica
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Rio Frio
Panama
IDIAP
Divisa
Ecuador
INPOFOS
Napo (*)
Brazil
EMBRAPA
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& Pichis
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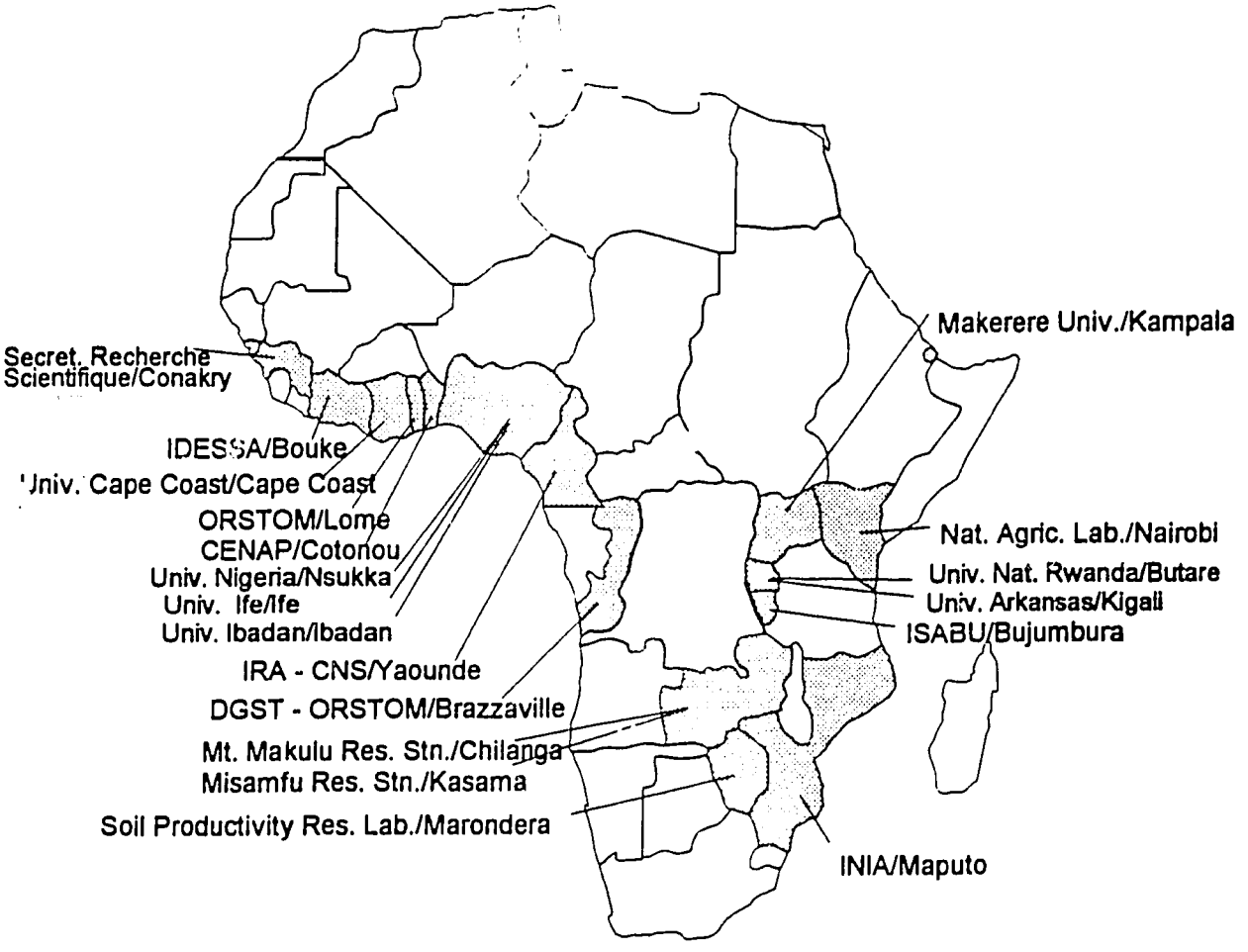
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Univ. Ife/Ife
Univ. Ibadan/Ibadan
IRA - CNS/Yaounde
DGST - ORSTOM/Brazzaville
Mt. Makulu Res. Stn./Chilanga
Misamfu Res. Stn./Kasama
Soil Productivity Res. Lab./Marondera
Nat. Agric. Lab./Nairobi
Univ. Nat. Rwanda/Butare
Univ. Arkansas/Kigali
ISABU/Bujumbura
INIA/Maputo

Fig. 11

8. ACTIVITIES AND IMPACTS OF THE CRSPS IN THE HUMID TROPICS[1]

Frank J. Smith and T. Jot Smyth

In the humid tropics, the contentious trade-offs between agriculture production and environmental protection must be superseded by a technological shift toward sustainable development. Alleviation of poverty and malnutrition pandemic in the region requires both a highly productive agriculture sector and conservation of the natural resource base. Through collaborative research and technology transfer U.S. and international scientists are confronting the technical challenges to sustainable agriculture and natural resource management.

The Collaborative Research Support Programs (CRSPs) of USAID have been structured as independent programs each with its own management entity. The focus of research, training and outreach activities have been guided by participating faculty with concurrence of USAID. The evolution of CRSP programs have lead to a variety of activities in the humid tropical ecosystem, some focusing on specific agricultural commodities and others examining resource management systems. The CRSP council composed of program directors has attempted to harmonize and coordinate research among the CRSPs. This paper is intended to develop information on CRSP activities in the humid tropics so as to identify common themes of research, summarize impacts and facilitate future coordination and collaboration. Figure 1 illustrates the global presence of the CRSPs in the humid tropics.

In order to identify CRSP activities in the humid tropics and lay the foundation for future cross-CRSP collaboration a survey of was conducted in November 1992. Each CRSP director received a mailed questionnaire. They were asked to identify CRSP programs operating in the humid tropical zone. For each activity, they were asked to coordinate a CRSP response to nine questions for each program: 1) activity title; 2) countries involved and duration of the activity; 3) collaborating institutions; 4) descriptive focus of the activity; 5) technologies, developments, and discoveries produced; 6) extent of technology adoption; 7) social, economic, and environmental impacts; 8) other significant results of the activity; and 9) publications produced.

Responses were received from five CRSPs. The Soil Management CRSP has 27 programs operating in the humid tropics; the Bean/Cowpea CRSP identified 5 such programs; Pond Dynamics/Aquaculture identified 4 programs; Small Ruminant CRSP 2 programs; and SANREM-CRSP one program. The following sections summarize the principal activities and impacts of the CRSPs in the humid tropics.

Soil Management CRSP

North Carolina State University, Hawaii, Texas A&M and Cornell in collaboration with national and international institutions are addressing the following problems: a) production-demand pressure, land-clearing pressure, weeds and inadequate resource

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[1]This study was supported by USAID Grant DAN-1311-600-0039-00 to the Soil Management Collaborative Research Support Program (TropSoils).

information in Peru, Indonesia and Bolivia; b) inadequate soil resource information and landscape restrictions in Zaire, Bolivia and Costa Rica; c) inefficient use of water resources and high erosion rates in the Philippines; and d) soil acidity, nutrient deficiency and losses, soil physical limitations, and diversity of potential users in Indonesia, Thailand and Philippines. Fifteen of the activities have reported additional sources and kinds of non-CRSP funding.

1. North Carolina State University, USDA/ERS, CATIE, and INIAA/Peru have joined for comparative agronomic, economic and socio-economic analysis of humid tropical production systems. The activity has produced seven years of production data from a replicated field experiment comparing five management systems in Yurimaguas, Peru. Economic data on all field operations, inputs, and outputs for each treatment and crop during the period from rain forest clearing to the sixth year of cultivation have been compiled into a database and analyses are in progress.

The studies are helping to determine the factors responsible for sustainable production in the principal crop and pasture-based soil management options for the humid tropics as follows: a) low-input, b) mechanized continuous cultivation, c) legume-based pastures, d) paddy rice and e) agroforestry. The later involves collaboration with IDRC, CATIE, ICRAF to determine the suitability of various agroforestry systems for use on acid soils of the humid tropics. Tree components of agrosivicultural systems are being evaluated. Alley cropping research has produced recommendations for suitable tree species (*Cassia reticulata* and *Inga edulis*), optimum alley widths, desirable soil characteristics, and tree pruning frequency during crop production.

2. USDA/SCS, North Carolina State University and IBTA/Bolivia are collaborating on research to determine the absolute soil mineral supplying potential for major soils in perudic ecosystems. This is a continuation of earlier research that produced the Fertility Capability Classification (FCC) system. The FCC provides structured information about the physical and chemical factors within surface soil layers which have a primary influence on plant growth and responsiveness to management. FCC is a valuable tool for land use planners to help select areas for farming.

3. All member institutions have collaborated in the development of two decision support systems. The Acidity Decision Support System (ADSS) and Phosphorus Decision Support System (PDSS) are computer programs for diagnosing and evaluating the impact of soil management. They enable the user to determine what corrective measures are needed and what the estimated economic consequences of those measures will be. The ADSS determines how much soil Al needs to be neutralized with limestone in order to reduce Al toxicity to a level tolerated by the selected crop. The PDSS, currently in the prototype stage, estimates how much fertilizer P should be added to correct for P deficiency in selected crops.

4. The program for Nitrogen Fixation in Tropical Agricultural Legumes (NiFTAL) at the University of Hawaii maintains one of the world's most comprehensive repositories of rhizobial strains (1,924) from a wide array of tropical legumes. The collection is an important tool in developing genetic technologies for improvement of the rhizobium-legume symbiosis. NiFTAL has assisted in private sector legume inoculant production by developing and field testing economic, efficient, and reliable fermentors. Production

facilities are now in use in Africa, Asia and the Americas. A small-scale production system that minimizes personnel and facility requirements is being developed on a modular production concept to assure quality products in remote areas or regions with low production demands. An innovative inoculant delivery system has been developed and a patent application for the system was initiated. Methods for monitoring are being developed to improve inoculant quality and efficiency. Data bases and models are being developed to assist extension services and producers to estimate impacts on income due to inoculant use.

NiFTAL is collaborating with national institutes in Thailand to meet regional BNF needs by developing and transferring BNF resources. Training support is also provided to scientists, private volunteer organizations (PVOs), and inoculant producers. During the most recent year (1991-1992) NiFTAL extended BNF technologies through a total of 10 courses, training 209 participants from 53 countries. Modular BNF curricula were developed to suit the needs of specific client groups including extension personnel, PVOs, scientists, inoculant producers and sales persons. Response in Thailand to this program by farmer demand for inoculant led to the transferral of BNF technology to a private producer of inoculant with a 200 t annual production capacity.

5. Reducing the rate of land degradation and rejuvenation of degraded lands are the objectives shared by North Carolina State University, Cornell, Texas A&M, and collaborating national and international institutions in Latin America, Africa and Asia. Research on steep, acid, infertile soils at two sites near Claveria, Mindanao, Philippines evaluated hedgerows of *Gliricidia sepium*, *Pennisetum purpureum*, or a combination of both species planted on slope contours on abatement of runoff and soil loss. Dissertation research evaluating ridge tillage is planned. Experiments on the site of Glidgi are designed to identify the causes or circumstances that may induce preferential flow below crusted soils. Other studies are evaluating the effects of chemical properties on structural stability using Ultisol samples from two different regions of Costa Rica.

6. Applied research is creating the knowledge base for more efficient management of nutrients. Minimizing soil nutrient losses is a way of increasing the use efficiency of soil amendments and can reduce both production costs and environmental costs. By understanding the fate of nutrients contained in soil amendments, management practices that minimize nutrient losses can be developed. North Carolina State University is leading a research activity on the synchrony between soil nutrient availability from organic inputs and plant nutrient uptake. The project was started in 1992 with a research site in the Chapare region in Bolivia. Cornell and the University of Costa Rica initiated two experiments on a slash-mulch system of bean production on an Andisol and an Ultisol in Costa Rica. The primary objectives of these experiments are a) to find ways of improving P availability and b) to determine whether managed legume fallows can replace the traditional three year fallow to allow annual cropping.

7. Outreach activities of participating institutions include training, support services, information systems, and research networks. North Carolina State University is coordinating technical support for research networks in the Latin American humid tropics. The goal is to foster transferral of knowledge of acid soil management practices to national research institutions and provide a bridge between CRSP-sponsored research

and its utilization by national research institutions. RISTROP network activities have had the active participation of more than 100 scientists from 15 countries in Central and South America. Another international network of scientists interested in intercrop modeling has been formed by the University of Hawaii. Seventy-five scientists representing 43 international sites participate. Linkage with existing research networks established by IITA, TSBF and IBSRAM extend the benefits of soil management research.

Soil moisture and temperature regimes are computed for about 15,000 stations around the world by the Soil Management Support Service and collaborators. In 1992 more than fifty countries have received support services, mostly through correspondence and some through on-site visits by USDA/SCS.

USDA-ERS and North Carolina State University are examining the feasibility of overcoming agricultural adoption constraints by having a contractor provide technical, financial and marketing assistance in exchange for a share of improved yields. Data on pineapple production was collected in Bolivia. Results show that a contract service to help farmers produce and market pineapples would benefit both the farmer and the contractor.

Bean/Cowpea CRSP

1. A ten-year project focused on food preparation, nutrition, health, and cowpea storage was completed March 1992. The project involved collaboration of the University of Georgia and the University of Nigeria-Nsukka. The project team developed an appropriate, village-scale, mechanical process for making cowpea meal. The term meal rather than flour is used here because a coarsely ground product (~1 mm) has far superior functional quality compared to a finely ground flour. The cowpea milling technology developed by the project involves moistening dry seeds with water up to 25 percent, tempering (holding) for a short period, drying to a moisture content of <10 percent, removing seed coats and eyes by abrasion or impact, and grinding the cotyledons into a meal. Rice and plate mills which are commonly found in Nigerian villages were incorporated into this process. Simple, diesel-fired dryers were designed and constructed. The wetting/drying step was found to be necessary to achieve acceptable yields.

Cowpea meal made by this process was extensively characterized and demonstrated to produce foods which compared favorably in chemical, physical, sensory and nutritional aspects to those made by traditional techniques. Safety and health aspects of cowpea consumption have been addressed by studies on the microbial quality (pathogen populations, aflatoxin content) of seeds and products, the content and stability of antinutritional factors, and the use of controlled seed germination to eliminate flatulence-causing oligosaccharides. Extensive surveys at the beginning and end of the project have documented the importance of cowpea in Nigeria. Cowpea was found to be an extremely important component of the diet, supplying a significant proportion of protein and B vitamins.

Following training workshops on substituting cowpea meal in traditional dishes, acceptance by village homemakers and market vendors has been reported to be enthusiastic. Village mills were installed and brought into production in two locations.

Cowpea meal has been successfully utilized in many non-traditional baked, griddled, and extruded foods. The use of cowpea meal in acceptable, efficacious weaning foods has been implemented.

Students have been an integral part of this project. At the University of Georgia, 8 M.S. students and 2 Ph.D. students have completed degree programs; two of these students were Nigerian. At the University of Nigeria, 12 M.S. students and 3 Ph.D. students have completed degrees based on project related research. Four B.S. theses have also been produced in Nigeria.

The Nigeria research team and facilities are in place. Project funds enabled the purchase of equipment and supplies at times when the government of Nigeria was unable to adequately support university research. Research publications for this activity include 78 journal articles, 20 technical reports and approximately 130 conference presentations. Project impact in Nigeria will depend on government policies to encourage investment and innovation by small entrepreneurs and cooperatives and stabilization of cowpea prices.

2. Purdue University and Institut de la Recherche Agronomique (Cameroon) joined in a collaborative CRSP project in October 1987 to improve, adapt and evaluate cowpea production and storage technology. Research showed that exposing cowpeas to temperatures around 57 °C for one hour (or 65 °C for a few minutes) killed the cowpea weevil larvae, pupae and adults. A solar heater was designed which could be built by low-resource farmers. Several cowpea cultivars were identified which possess good levels of pod resistance to the cowpea weevil. Germplasm collection, evaluation and preservation have produced numerous new accessions of cowpea.

Social, economic and environmental impacts have not been quantified. It is expected that the project will extend the storage period of cowpea and availability of cowpea as a family food supply. Also farmers will have less need to sell at harvest (when prices are lowest) and buy late in the storage season (when prices are highest). Solar heaters will reduce the use of hazardous chemicals to control storage insects. Cowpea germplasm obtained will be available for breeding and extending knowledge on storage mechanisms.

Publications include 4 journal articles and 9 technical reports (five English and four French). Outreach activities include eight presentations/workshops.

3. The University of Wisconsin, University of Costa Rica and University of West Indies, Jamaica have joined for collaborative research on bean-infecting geminiviruses. The research program, begun in 1988, characterizes bean-infecting geminiviruses, their weed hosts and insect transmission. The development objective is to produce transgenic resistant beans by using virus-derived DNA domains and traditional breeding methods.

Technological advances to date include the first production of a transgenic bean using the particle gun, in conjunction with the private sector. Four bean infecting geminiviruses have been cloned and sequenced. Nucleic acid squash and dot bot hybridization techniques were developed for a general geminivirus DNA probe and for three isolate-specific DNA probes. Over 4,000 accessions were evaluated for golden mosaic virus resistance, and ten black seeded bean lines were identified with moderate resistance. A dry-inoculum technique was developed to provide a simple, rapid and

effective method for inoculating beans for three major diseases: angular leaf spot, anthracnose and common bacterial blight.

Technology adoption of the dry-inoculum technique has enabled plant pathologists and plant breeders in host countries to evaluate germplasm quickly and efficiently. The development of improved pathogen detection methods with DNA probes will be applicable to other pathogens. Also, strategies developed to control the BGMV can be used for other virus pathogens.

Training activities to date include five M.S. degrees. Program scientists have produced 5 journal articles, 8 technical papers and 60 presentations/workshops.

4. A program begun in April, 1992 focuses on methodology for evaluating bean quality, nutritional standards for bean breeders, and addressing constraints to bean utilization in handling, storage, consumption and nutrition. Collaborating institutions are Michigan State University, Purdue University and University of Costa Rica. The project is in the early stages of development. To date there are no reported technological advances, adoption, impacts or publications.

5. In May 1992, the University of Clemson, Auburn University and University of Ghana launched a program of collaborative research to improve the nutritional and economic status of host country populations, especially low-income children and women, by increasing consumption of cowpea. The program also will facilitate the use of cowpea in new U.S. food products. The program will develop baseline information on cowpea utilization in Ghana and related socioeconomic and nutritional information.

Modifications in existing cowpea milling technology are in progress. Investigation of complex traditional food processing technologies is facilitating the fortification of these foods with cowpea flour from improved Ghanian varieties. Composite flours (up to 24 percent cowpea, up to 46 percent defatted peanut) successfully replaced wheat flour in an unleavened bread and composite flours containing cowpea, sorghum, peanut and cassava flours were partially substituted for wheat in muffin formulations. Basic studies of microbiological, physicochemical, and nutritional characteristics of cowpea and its chemical components support applications research. Three U.S. and two Ghanian students have participated in the research program. To date there are no reports of adoption, impacts or publications.

Pond Dynamics/Aquaculture

1. Since 1982, the University of Michigan, Michigan State University and University of Hawaii are collaborating with the Royal Thai Department of Fisheries and the Asian Institute of Technology to develop appropriate aquaculture technologies. In Thailand, researchers work to determine the most efficient level of nutrient input so farmers can manage fertilizer use and ensure optimal fish production without pollution.

CRSP researchers have developed economically efficient fertilizer strategies utilizing organic and inorganic fertilizers, which can produce yields of 18,000 kg/ha per year, the highest annual tilapia production yet reported without supplemental feeds. Recent outreach efforts have resulted in the development of an algal assay kit for use by farmers participating in on-farm testing of CRSP methodologies. In addition, researchers have studied environmentally-induced ovarian development and hatchery techniques for ...

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production of the walking catfish, *Clarius batrachus*, a well-known, highly marketable food fish whose hardiness makes it possible for farmers to stock and grow them at relatively high densities or in oxygen-poor water. The fish can also be marketed live, an important factor to consumers in many regions.

Thailand's acidic soils can make fish ponds difficult to manage. CRSP research determined that diking ponds instead of digging them minimizes the deleterious effects of acid-sulfate soils on pond production. The nitrogen:phosphorus ration model developed by CRSP researchers has received widespread attention, and has been successfully used in several locations, including CRSP sites in the Philippines and Rwanda.

Quantitative data on technology adoption are not being collected, but informal information indicated that approximately 500 small-scale fish pond operators in the Udorn Thani province have adopted the CRSP strategies. Several large farms in the Central plateau near Bangkok have also successfully implemented CRSP technologies.

Twenty-seven journal articles and 36 technical papers have been published based on this research. Also 12 M.S. theses have been produced. Training is an important component of the program with 19 graduate degree programs and 2 nondegree training programs completed. Students include 3 from Bangladesh; 1 from Canada; 4 from China; 2 from Philippines, 1 from Sweden; 7 from Thailand; and 2 from the U.S.

2. A PD/A-CRSP program operating since 1982 in Honduras is developing appropriate aquaculture technologies to increase the availability of food. Collaborating institutions are Auburn University and University of Hawaii, the General Directorate of Fisheries and Aquaculture, Ministry of Natural Resources and Excuela Agricola Panamericana (Zamorano). In Honduras, the focus of research has been to increase fish production and production profitability by small and medium scale commercial producers based on a technology that relies heavily on enhancement of natural pond productivity using locally available nutrient inputs.

Technological advances include four fish production systems developed and evaluated for economic optimization and biological efficiency. The systems are distinguished by type of input. The four systems are: 1) compost, utilizing primarily local green grasses, leaves, and weeds; 2) chemical fertilization, using ammonium phosphate and urea; 3) organic fertilization, using fresh manure or chicken litter; 4) fertilization followed by feed, using chicken litter and urea or 12 weeks, then feeding a commercial pelleted fish feed. All systems use monosexed tilapia and control unwanted tilapia reproduction by stocking 'guapote tigre', which also serves as a pest management technique.

Economic studies indicate that the most economically efficient production method does not always result from the greatest biological production. No hard figures exist to indicate how many farmers have begun aquaculture enterprises as a result of CRSP efforts, nor how many have adopted a PD/A production system. Both the Ministry and the USAID Mission attest to the fact that here has been a sharp increase in the number of small to medium scale fish farms in the northern part of Honduras, and both agencies attribute this growth to the research and outreach efforts of the PD/S CRSP. It is

expected that the export value of aquaculture products will soon eclipse the value of coffee and bananas, which are currently the chief exports of Honduras.

CRSP researchers conduct short courses for farmers, farm managers, Peace Corp trainees, and extensionists, introducing principles of aquaculture, including water quality, pond fertilization, tilapia reproduction, transport of fish, polyculture, soil-water interactions, and development and analysis of enterprise budgets. Two non-governmental agencies support CRSP research efforts: FPX, the association to promote non-traditional export crops, is constructing a demonstration fish farm which will disseminate the fish production systems developed by the CRSP; the private aquaculture association, ANDA, is making in-kind and cash contributions to fund CRSP research on issues of importance to the emerging shrimp industry.

Four Honduran students completed B.S. level training with CRSP support, seven more are in progress toward B.S. degrees. Forty three Hondurans have completed nondegree training programs of the CRSP. Nine M.S. thesis are in preparation or completed. Publications include eight journal articles and 16 technical papers (11 in Spanish). Thirteen papers have been presented at conferences/workshops.

3. During the period 1982-1987, PD/A CRSP was active in Indonesia to develop appropriate aquaculture technologies. Collaborating institutions were Michigan State University and Institut Pertanian Bogor (IPB). The research focused on enhancing the yields of tilapia in subsistence, semi-intensive pond aquaculture through efficient use of fertilizers.

Successive experiments using fertilizers without supplemental feeds nearly quadrupled pond production over baseline yields, and tripled average production for farm ponds of the region. No data are available on the extent of the technology adoption. The project was forced by political considerations to end before extension activities were implemented.

The CRSP was responsible for building the first water quality laboratory in Indonesia at the research site. Researchers developed a water quality analysis manual which was translated into Bahasa Indonesian. The CRSP also developed a research plan for the Faculty of Fisheries at Institut Pertanian Bogor, which include needs assessments and curricula.

Training results were one Ph.D. and 4 nondegree programs at U.S. institutions. In addition, twelve Indonesians completed B.S. degrees at IPB. Eight journal articles, 19 technical reports and 13 paper presentations were produced by the program.

4. During the period 1982-1987, PD/S CRSP researchers at Auburn University collaborated with Panamanian Direccion Nacional de Aguacultura to develop appropriate aquaculture technologies. Researchers studied the relationship between rate of nitrogen input, primary productivity and production of fish and shrimp. Alternative feeding strategies for shrimp were developed including a) withholding feed to young shrimp until four weeks after hatching, and b) decreasing direct feeding of shrimp by using less-expensive fertilizers such as chicken litter to enrich the pond environment and thereby indirectly feed the shrimp.

No data are available on the extent of technology adoption. The project was forced by political considerations to end before extension activities were implemented.

Training support enabled completion of 13 B.S. and 2 M.S. degree programs in related disciplines. In addition seven received nondegree training. Publications were 4 journal articles 10 technical reports. Seventeen papers were presented in meetings.

Small Ruminant CRSP

In Indonesia, an on-going CRSP project of 12 year duration focuses on breeding more prolific sheep to enable smallholder farmers to increase their herds faster. North Carolina State University (nutrition), University of California, Davis (breeding), University of Missouri (rural sociology) and Winrock International Institute for Agricultural Development (economics) from the United States, in collaboration with the Research Institute for Animal Production in the Central Research Institute for Animal Science, Agency for Agricultural Research and Development of the Ministry of Agriculture in Indonesia participate in the High Prolific Sheep Component of the SR-CRSP.

On-farm testing through the Outreach Pilot Project of management, reproduction, nutrition and marketing techniques, and the analysis of producer responses resulted in a technological package for small producers in a cut and carry system, that has been published in Indonesian, Javanese, Sudanese and English. Production techniques increased yield by fifty percent. An economic surplus model was used to evaluate the OPP and the SR-CRSP in West Java. All costs of the program were considered. These included training of Indonesian and U.S. students, as well as research and travel costs in Indonesia and the U.S. They were discounted against the net benefits of the OPP technological package evaluated for West Java. The results are preliminary and do not include the benefits of the breeding program being developed by the SR-CRSP. Assuming a very conservative adoption rate of 20 percent peak adoption achieved in 12 years for West Java, gave an internal rate of return of 19.2 percent. A faster adoption rate (peak adoption of 20 percent in ten years) resulted in a 22.9 percent internal rate of return. If research spillovers of 19 percent to other provinces are considered, the return is 24.8 percent. The net present value of the later, considering a 10 percent interest rate was more than 5 million dollars. The distribution of the gains from research, given the market conditions, resulted in producers capturing a greater proportion of the surplus generated (77 percent).

The above estimates of returns do not include the benefits of human resource development, an important goal of the program. Indonesian researchers involved with the SR-CRSP received 23 graduate degrees, 12 at the M.S. level and 11 at the Ph.D. level. Of these, 19 were funded by the SR-CRSP. The four U.S. institutions of the High Prolific Sheep Component, funded training and/or graduate research for eleven U.S. doctoral students and fourteen U.S. master students. Research installations constructed with SR-CRSP funding are being used by undergraduate students in the United States. Faculty experienced in research in developing countries prepare U.S. students for the global economy. This evaluation showed that returns to the management nutrition and reproduction package finance the costs of basic research and human capital development, and that this technology will benefit both producers and consumers.
One hundred thirty-three (133) working papers/publications have been produced relating to this activity and the hair sheep activity that is describe below.

2. The same institutions also are collaborating in research to breed and develop hair sheep which are better adapted to the stress of the humid tropics. Sheep are grazed under rubber trees, reducing the need for farmers to procure forage and for rubber tree plantations to use herbicides.

Currently, the Rubber Institute at Sungai Putih in North Sumatra is using hair sheep production systems under rubber trees. Environmental benefits derive from the fact that sheep grazing under rubber trees lessen the need for herbicides--the amount has not yet been quantified. Farmers in North Carolina are benefiting from hair breeds and crosses that are adapted to the climatic conditions of the South East. Seven producers have purchased 250 hair sheep for breeding stock and resistance to internal parasites.

The evaluation approach is to see if the products of short and medium term research, such as management nutrition and reproduction, can finance basic research, genetics and training, which have long development and adoption lags, and therefore impacts in the long run.

Sustainable Agriculture and Natural Resource Management CRSP

A new activity of the SANREM CRSP is programmed for five years in the Philippines with the Department of Agriculture and the Department of Environment and Natural Resources. The activity will focus on sustainable agriculture and natural resource management.

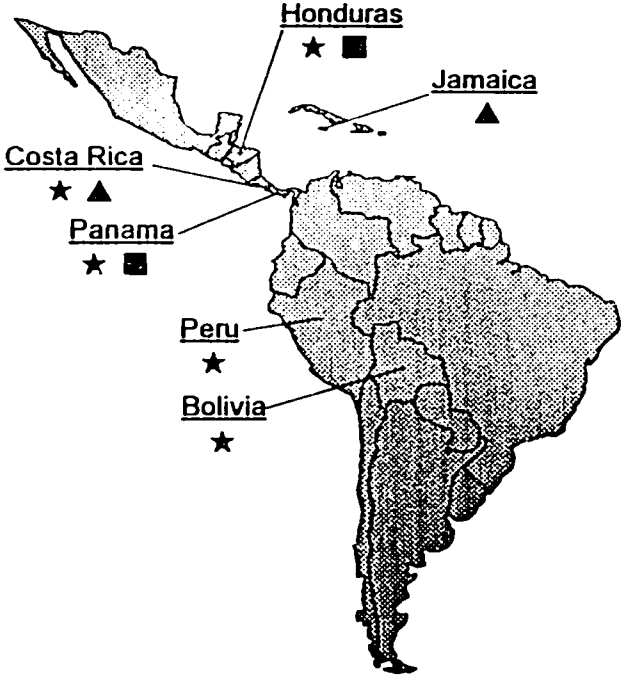
Conclusions

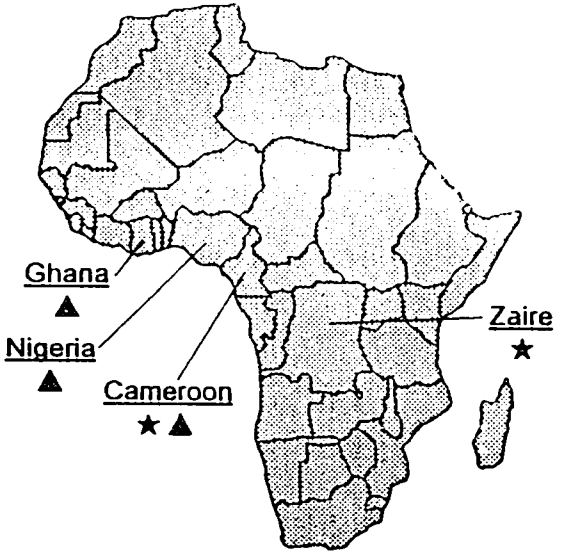
Analysis of the responses reveal possibilities for cross-CRSP collaboration. Cowpea used in low-input systems has both soil management and nutritional benefits. Adoption and impact could be enhanced with greater exchange of CRSP generated knowledge on selection, production and post-harvest use of cowpea. Nutrient management is a common themes in both soil management and pond dynamics. Animal production using improved pasture systems for infertile, acid soils is a natural area for collaboration between the SM-CRSP and the SR-CRSP. Sustainable development is a concept that has universal acceptance among the CRSPs. The new SANREM-CRSP, like the SM-CRSP and Pond dynamics CRSP, is not defined by a commodity but by a regard for resource management. Coordinated management of water and soil research will be foundations of future CRSP activity on sustainable agriculture and resource management.

List of Figures

Figure 1. Global distribution of CRSP activities in the humid tropics.

★ Soil Management
▲ Bean/Cowpea
■ Pond Dynamics
● Small Ruminants
◆ SANREM





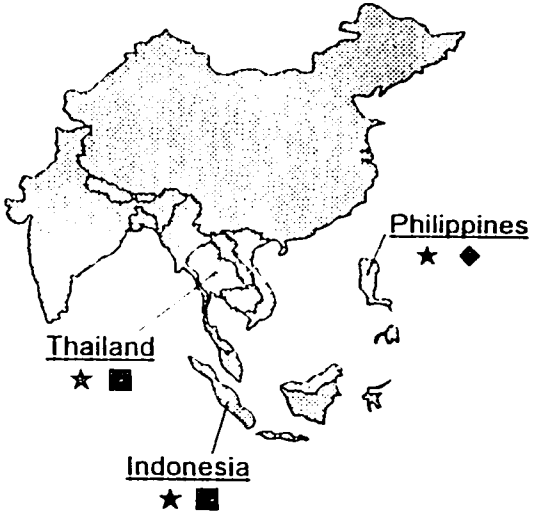


Fig. 1