# Project PE-5 Sustainable Systems for Smallholders:

## Integrating improved germplasm and resource management for enhanced crop and livestock production systems

# ANNUAL REPORT 1999

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# Project PE-5: Sustainable Systems for Smallholders: Integrating Improved Germplasm and Resources Management for Enhanced Crop and Livestock Production Systems

**Objective:** To collaborate with national organizations in developing generic agricultural technologies and information that lead to more productive and sustainable production systems.

**Outputs:** Integrated land use options that contribute to sustaining the natural resource base. Appropriate technologies for farming systems particularly where beans, cassava, livestock and rice are components of the system. Decision support tools and other methods for use by farmers, researchers, planners and policy makers from the local to national levels. Increased capacity of national organizations and farmer groups to conduct demand driven research.

**Gains:** Integration of commodity and natural resource research. New approaches to the development of environmentally sound technologies. Indicators for measuring economic and environmental impact of improved technology at the farm and watershed levels. Methodology to extend results beyond benchmark sites.

**Milestones:**

1998 Workshop to analyze the effectiveness of FPR in the development of new technology options for smallholder systems. Integrated cassava management systems for Asia.

1999 New forage technologies for smallholder systems in Asia and Latin America. Methodology for assessment of socioeconomic and environmental impact at farm level.

2000 Dissemination of new crop and livestock technologies for smallholder systems in Latin America and Southeast Asia commenced. Multi-institutional and participatory models for systems research in place in Latin America and Southeast Asia.

2001 New crop and livestock technologies for smallholder systems in Latin America, Southeast Asia, for example, increased bean production in low P soils; improved fallow systems for the forest margins, with demonstrated impact of the technologies on increased welfare of poor rural families and sustainable land use. An analysis and synthesis of various approaches used for participatory diagnosis of needs and opportunities and in participatory technology development.

**Users:** The research will benefit low-income farmers in Latin America, Asia, and Africa by increasing available food and cash flow to rural households while providing a basis for more sustainable production systems. Adoption of environmentally sound farming practices will benefit society as a whole.

**Collaborators:** ICRAF, ILRI, IRRI; linkages with national R&D organizations and specialized research organizations.

**CGIAR system linkages:** Protecting the Environment (50%); Crop Systems (20%); Livestock Production Systems (15%); Training (10%); Networks (5%).

**CIAT project linkages:** Conservation of genetic resources; germplasm enhancement in beans, cassava, and tropical forages; natural resource management in areas of land use dynamics, soil processes, and watershed management; strengthening NARS through developing partnerships, participatory research, and impact assessment.

# Project Log-frame

**CIAT**
**Area:** Natural Resources
**Project:** PE-5 – Sustainable Systems for Smallholders: Integrating Improved Germplasm and Resource Management for Enhanced Crop and Livestock Production
**Manager:** Peter Kerridge

| Narrative Summary | Measurable Indicators/Milestones | Means of Verification | Assumptions |
|---|---|---|---|
| **Goal**<br>Knowledge, tools, technologies, skills and organizational principles that contribute to the improved management of natural resources are accessible to NARS and beneficiaries | - Use of CIAT NRM research outputs in 3 reference sites in 5 years, related to changes in land management and associated with increases in per capita income and food availability, improved soil-water-nutrient use efficiency, increased biodiversity in production systems, and stakeholders participating in land use planning.<br>- Use of the CIAT NRM research outputs beyond the 3 reference sites in the 3 target agroecosystems (savannas, hillsides, forest margins) by stakeholders in 5 years.<br>- CIAT NRM research outputs applied by at least 3 other institutions outside LAC by the end of the 5th year. | Projects, plans and reports of national sector agencies, donors, NGO's and community-based organization in the 3 reference sites in LAC mandate agroecosystems which refer to use of CIAT's NRM research outputs. | CIAT's partners are willing to use these research outputs to improve NRM. |
| **Purpose**<br>To collaborate with national organizations in developing generic agricultural technologies and information that lead to more productive and sustainable production systems. | - % increase in income of smallholders<br>- no. of new component technologies<br>- % decrease in soil loss, and increase in soil fertility & water retention<br>- changes in functional aspects of biodiversity<br>- decreases in deforestation and burning<br>- widespread adoption of sustainable practices | - impact evaluation studies | - donor and client support for sustainable land use research |

## Outputs

| Narrative summary | Eco. | Personnel | Indicators (Intermediate impact) / Milestones | Means of Verification | Assumptions |
|---|---|---|---|---|---|
| **Outputs 1.**<br>**Alternative land use options for agricultural systems assessed** | | | Analysis of trade-offs and policy options of alternatives for land use and technology development are available for local and national planners | | |
| | FM | DW | 02 Policy options, for use in local and national planning for the forest margins, developed from a synthesis of socio-economic and biophysical effects of alternative land use in the Aguaytia watershed | - Workshop and technical report to Government of Peru | - collaboration and integration of research activities in Pucallpa |
| | Asia | PK,SF | 01 Plan for community involvement in management of resources of watershed site, Vietnam, accepted by government officials | - technical report | - Continued donor support |
| | H, S<br>FM | FH | 00 Options and incentives necessary to develop and utilize feed resources in a sustainable manner in dual-purpose cattle systems in Latin America | - workshop and technical report | - Continued collaboration with NARS partners |
| | Asia | WS | 99 Options for an integrated approach to improving feed resources for livestock in SE Asia | - final report to donor | - Maintenance of close relations with policy makers |
| | Asia | RH | 04 New options adopted for R&D activities in cassava production Thailand, Vietnam and China | - operational plans of government agencies | - IP-3 continues to support R&D in Asia |
| **Activities** (CIAT collaborators) | | | **Milestones** | - Annual report PE-5 | |
| 1.1 Characterize and diagnose problems and opportunities at the system level through community participation (with PE-2, PE-4, SN1, SN3) | FM | SF, DW,PK, DH, GH, RT | 99 Review problems and opportunities in the Aguaytia watershed | | |
| | FM | GH, DW | 99 Analysis of poverty and land use in the Aguaytia watershed | | |
| | S | SF, CEL | 99 Diagnose opportunities in Puerto Lopez area of Llanos | | |
| | Asia | Univ. Hue<br>SF, PK | 99 Catchment site in Hong Ha characterized and problems and opportunities diagnosed for research by Hue team | | |
| 1.2 Assess biological and socio-economic impact of alternative land use options (PE-2, PE-4, BP-1) | FM | DW | 99 Analysis of economic benefits to farmers associated with alternative land use options in Aguaytia using profit-maximization | | |
| | | DW | 00 Riverine flood risk mapped in Aguaytia watershed | | |
| | | DW | 00 Effect of income variation upon farmer-land use decision making in Aguaytia watershed | | |
| | Asia | Univ Hue | 99 Economic analyses of crop alternatives in Hong Ha, Vietnam | | |
| 1.3 Determine indictors of human nutrition in Aguaytia watershed | FM | TM, SF, DW | 99 Describe production and consumption patterns of selected communities<br>00 Assess diet, nutrient intake and physical condition of selected communities | | |
| 1.4 Evaluate social and private trade-off of alternative land use options (BP-1) | FM | DW | 99 Analysis of economic value of fallow periods in Aguaytia watershed | | |
| 1.5 Synthesize results from different outputs and activities (PE-4, BP-1) | FM | DW, SF, FH | 99 Role of intensification in the Forest Margins analyzed | | |
| | Asia | WWS, PH | 99 Range of options for integration of forages into smallholder farming systems in Asia identified | | |

| Narrative summary | Eco. | Personnel | Indicators (Intermediate impact) / Milestones | Means of Verification | Assumptions |
|---|---|---|---|---|---|
| **Output 2.**<br>**Component technologies for sustainable production developed through farmer participatory research** | | | Farmers using new technologies that are more productive and conserve natural resources | | |
| | FM | SF, DH | 02 New technology options developed for Aguaytia watershed | - Annual report | |
| | H | FH, PJA | 00 30% increase in milk production in dry season, CA | - Report Tropileche | |
| | H | MP, PJA | 03 Increased use of forage legumes by small farmers in CA | - Annual report | |
| | S | CEL | 03 New forage options for Llanos | - Annual report | |
| | Asia | WWS | 99 40 farmers at each of 18 sites in SE Asia using improved forages in SE Asia | - Workshop proceedings | |
| | Asia | RH | 04 Increased net benefits to farmers at 12 sites with less erosion in cassava-based systems in Asia | - Impact evaluation | |
| | Africa | CW | 02 Examples of sustainable bean production systems in East Africa | - Technical reports | |
| **Activities** | | | **Milestones** | - Annual report | |
| 2.1 Farmer experimentation to adapt technologies | FM | SF, DH, PK | 02 A wide range of land use options being evaluated by farmers in Aguaytia watershed, Pucallpa | | |
| | | PK, RH | 00 A range of land use options being evaluated by farmers at catchment sites in Vietnam | | |
| | | PK,DH | 99 Multi-institutional FPR team operating in Pucallpa | | |
| | | DW | 99 Application of economic model for DEPAM grants | | |
| 2.2 Improving feed quality and resource management in dual-purpose cattle production systems (IP-5) | H, S | FH,PJA, | 00 30% increase in milk production during the dry season in Costa Rica. | | |
| | FM | CEL | 99 Preliminary results from on-farm sites in CA | | |
| | | PJA | 99 Impact of on-farm research being measured in CA | | |
| | | CEL | 99 On-farm trials established for evaluating new forages, Llanos | | |
| 2.3 Evaluating legumes for feed supply, nutrient cycling and improved fallows (IP-5, PE-2) | H | MP, PJA | 02 Increased use of forages legumes by small farmers in CA. | | |
| | | MP, PJA | 99 Pilot evaluation sites established. | | |
| | Africa | CW | 00 New cover crop legumes identified for soil fertility improvement | | |
| 2.4 Developing integrated forage-based components for upland farming systems (SN-1) | Asia | PK | 00 Plan for extending impact of FSP | | |
| | | WS | 99 An average of 40 farmers at each of 18 sites in SE Asia using improved forages (FSP) | | |
| 2.5 Developing improved soil management practices in cassava-based systems | Asia | SF, WS | 99 Diagnosis of conditions for adoption of forage tree species | | |
| | | RH | 99 Plan for extending impact of phase I on improved resource management in cassava-based systems in Thailand, Vietnam and China | | |
| 2.6 Establish and maintain databases of information and results | FM | GH, DW | 99 Database established in Pucallpa | | |

| Narrative summary | Eco. | Personnel | Indicators (Intermediate impact) / Milestones | Means of Verification | Assumptions |
|---|---|---|---|---|---|
| **Output 3.**<br>**Models/frameworks developed to target research, integrate results, assess impact and extrapolate results** | | | Farmers and technicians using models/approaches that assist decision making at the farm and watershed levels | | |
| | H | AG | 00 Integrated simulation model of germplasm and management options for Central America hillsides | - Working document | - Collaboration with PE-3 and funding available |
| | FM | DW | 99 Economic model available for ex-ante evaluation of research proposals in Pucallpa, Peru | - Working document | - Data available |
| | FM<br>Asia | DW<br>WS,PK | 99 Indicator framework used by all partners in the forest margins, Pucallpa<br>00 Participatory evaluation and monitoring framework to assess FPR technologies in SE Asia | - Working document | - Collaboration with partners |
| | H | MP, LHF | 01 GIS-based DSS of forage adaptation in CA used by extension staff | - Final report | - Need perceived by partners |
| | Asia<br>Africa | RH<br>CW | 00 Decision guides available on soil fertility management for use by extension workers and farmers | - CD Rom<br>- Extension material | - Partners trained |
| **Activities** | | | **Milestones** | - Annual report | |
| 3.1. Adapt and evaluate integrated simulation models for smallholders systems (IP-5, PE-3, PE-4) | H | AG | 00 DSSAT Model adapted and applied to evaluate different land use alternatives in hillsides<br>99 Calibrations of DSSAT model for various crops in smallholder systems in CA<br>99 Data collection for smallholder systems in CA<br>00 Various legume options evaluated for different environmental and management conditions by simulation modeling<br>99 Legume green manure option included in DSSAT | | - |
| 3.2 Develop economic models to assess technology/land use options | <br>FM | FH<br>DW | 99 Proposal developed for calibration of Cornell model<br>99 Economic model for ex-ante evaluation of research interventions in Aguaytia watershed | | |
| | FM | DW | 99 Model to assess potential of riverine areas, Aguaytia watershed | | |
| 3.3 Develop a framework for monitoring and assessing impact of research in the forest margins | FM | DW,SF,GH<br>DH,AI | 99 Impact analysis framework developed for the forest margins | | |
| 3.4 Develop participatory monitoring and evaluation methods for technology development (SN-1, PRGA) | Asia | WS,SF, PK | 00 Participatory evaluation and monitoring framework to assess FPR technologies<br>99 Results of PE&M available for Philippines site | | |
| 3.5 Integrate information on variety adaptation and appropriate technologies with GIS databases to target germplasm use (IP-5, PE-4) | H | MP, LHF | 01 GIS-based DSS for forage adaptation<br>00 Secondary sites established for verification<br>99 Programming completed | | |
| 3.6 Develop decision guides on soil fertility management (PE-2) | Asia<br>Africa | RH<br>CW | 00 Utility of information on soil fertility management packaged for use by extension staff and farmers evaluated | | |

| Narrative summary | Eco. | Personnel | Indicators (Intermediate impact) / Milestones | Means of Verification | Assumptions |
|---|---|---|---|---|---|
| Output 4 . **Increased effectiveness of CIAT and partners to conduct appropriate research for developing productive and sustainable land use practices** | | | Organizations with trained staff using new strategies for R&D | | |
| | All | PK | 99 Coordinated approach to systems oriented research and funding in place | - Annual report, CCER | - Consensus within team |
| | FM | PK, DH, SF | 00 A multi-institutional and participatory approach to R&D accepted by NARS in Pucallpa and operational at Hue, Vietnam | - Site visit | - Approach achieves successes |
| | All | Team | 00 Functional partnerships – Tropileche, DEPAM, SEAFRAD, Cassava R&D network, Univ. Hue | - Annual report | - Need and collaboration |
| | Asia<br>Africa | PK, RH<br>WS, CW | 02 Strategy for scaling up technologies developed using FPR in SE Asia and Africa | - Working document | - New projects funded |
| | | | 99 Manuals on training approaches for applying PR in SE Asia | - Manual available | - Special project funding maintained |
| | All | Team | 00 Technicians at pilot and satellite sites trained in participatory technology development | - Training courses | |
| **Activities** | | | **Milestones** | - Annual report | |
| 4.1 Funding and coordination of PE-5 | All | PK | 99 Funding obtained for on-going and new activities<br>99 Project outputs achieved | | |
| 4.2 Facilitate multi-institutional research at the watershed level for R&D (SN-1, SN-3) | FM<br><br>Asia | DH, SF,PK<br><br>SF, PK | 99 Regular meetings and collaboration within DEPAM team<br>99 Inter Center workshop on research in the FM, Pucallpa<br>99 Workshop on PR and team building in Hue | | |
| 4.3 Facilitate regional partnerships/ networks (IP-3, IP-5) | All | Team<br>WWS<br>FH | 99 Coordinated research plans<br>99 Coordination meetings of FSP<br>99 Coordination meeting of Tropileche | | |
| 4.4 Compare effectiveness of different institutional models for effecting changes in NRM | FM<br><br>Asia<br><br>Africa | DH<br><br>SF<br><br>CW | 00 Review successes and failures of different approaches to institutional change<br>99 Paper comparing participatory and traditional approaches to technology development- FSP workshop | | |
| 4.5 Facilitate a policy enabling environment that ensures adoption of appropriate policies and technologies (PE-3,SN-1, SN-3, BP-1) | FM<br>Asia | SF, DH<br>DH<br><br>DH | 99 Review process of developing a collaborative research approach in Pucallpa<br>01 Review outcomes of enabling policy changes in selected watershed sites<br>02 Review achievements in scaling up technologies developed using FPR | | |
| 4.6 Develop training approaches and materials on targeting, development and diffusion of new technologies and land use systems, and provide training for partners (SN-3) | All | WWS<br>DW<br>FH<br>CW<br>DW, SF,PK | 99 Manuals on FPR approaches<br>99 Training provided on use of economic model in Peru<br>99 Training in use of ex-ante model<br>99 Diffusion of green manure technologies<br>99 Workshop on impact analysis, Pucallpa | | |
| 4.7 Communicate results through networks, workshops and journals | All | Team | 99 Yearly output of papers, newsletters and internet | | |

# Project PE-5. Sustainable systems for smallholders: integrating improved germplasm and resource management for enhanced crop and livestock production

**Purpose**
To collaborate with national organizations in developing generic agricultural technologies and information that lead to more productive and sustainable production systems.

| | Land use options | Component Technologies | Decision support | Capacity building |
|---|---|---|---|---|
| **Outputs** | **Alternative land use systems for agricultural systems assessed** | **Component technologies for sustainable production developed through farmer participatory research** | **Models/frameworks developed to target research, integrate results, assess impact and extrapolate results** | **Increased effectiveness of CIAT and partners to conduct appropriate research for developing productive and sustainable land use practices** |
| **Activities** | 1.1 Characterize and diagnose problems and opportunities at the system level through community participation (with PE-2, PE-4, SN1, SN3)<br>1.2 Assess biological and socio-economic impact of alternative land use options (PE2, PE4, BP-1)<br>1.3 Determine indicators of human nutrition and health in the Aguaytia watershed<br>1.4 Evaluate social and private trade-offs of alternative land use options (BP-1)<br>1.5 Synthesize of results from different outputs and activities (PE-4, BP-1) | 2.1 Farmer experimentation to adapt technologies in Pucallpa, Peru<br>2.2 Improving feed quality and resources management in dual-purpose cattle systems (IP-5)<br>2.3 Evaluating legumes for feed supply, nutrient cycling and improved fallows (IP-5, PE-2)<br>2.4 Developing integrated forage-based components for upland farming systems (SN-1)<br>2.5 Developing improved soil management practices in cassava based systems<br>2.6 Establish and maintain databases of information and results | 3.1 Adapt and evaluate integrated simulation models for smallholder systems (IP-5, PE-3, PE-4)<br>3.2 Develop economic models to assess technology/land use options<br>3.3 Develop a framework for monitoring and assessing impact of research in the forest margins<br>3.4 Develop participatory monitoring and evaluation methods for technology development (SN-1, PRGA)<br>3.5 Integrate information on variety adaptation and appropriate technologies with GIS databases to target germplasm use (IP-5, PE-4)<br>3.6 Develop decision guides on soil fertility management (PE-2) | 4.1 Coordination and funding of PE-5<br>4.2 Facilitate multi-institutional research at the watershed level for R&D (SN-1, SN-3)<br>4.3 Facilitate regional partnerships/networks (IP-3, IP-5)<br>4.4 Compare effectiveness of different institutional models for effecting changes in NRM<br>4.5 Facilitate a policy enabling environment that ensures adoption of appropriate policies and technologies (PE-3, SN-1, SN-3, BP-1)<br>4.6 Develop training approaches and materials on targeting, development and diffusion of new technologies and land use systems, and provide training for partners SN-3)<br>4.7 Communicate results through networks, workshops and journals |

* collaboration with other projects

## Project PE-5 Sustainable systems for smallholders:

## integrating improved germplasm and resource management for enhanced crop and livestock production

### Strategy

CIAT's mission is:

*To contribute to the eradication of hunger and poverty in tropical developing countries by generating technology and information with partners through scientific research and dissemination that leads to lasting increases in agricultural productivity while preserving the natural resource base.*

PE-5's contributes to this mission by collaborating with a range of partners to develop sustainable and productive technologies that integrate improved germplasm with conservative land management practices.

Improved germplasm is taken from **germplasm improvement** projects at CIAT and other sources and incorporated with improved management practices through a farmer participatory research approach to develop relevant **component technologies** at the farm level.

Alternative component technologies from CIAT and other organizations are evaluated at the watershed level for their biological, social and economic effects on productivity and resource management. An analysis of trade-offs between productivity and environmental benefit produces a range of **integrated options** for local and national policy makers.

### Process

Research is conducted in a systems context.

In developing component technologies at the farm/community level, there is diagnosis and evaluation of opportunities for new technologies within the overall farming system, participatory development of the technology with farmers and local partners, monitoring and impact assessment, feedback to applied researchers, and synthesis and dissemination of the results.

Developing a range of integrated options at the watershed level, involves facilitating the formation and operation of multi-disciplinary research teams from organizations working in the area, characterization of the area, diagnosis of problems and opportunities, facilitating adaptive research to work on priority issues, monitoring and impact assessment. Concurrently there is an analysis and synthesis of results for community, researchers and policy makers.

Research focuses on both improving productivity and environmental protection with a balance between intervention and to evaluate and adapt technologies and modeling to target research, integrate results, assess impact and extrapolate results.

We have a team of agronomists, livestock specialist, soil scientist, agricultural anthropologist, resource economist, systems modeler and specialist in participatory research. Individual team members work on developing component technologies and integrated options at the watershed level. The research is dependent on effective partnerships within CIAT and with national and international organizations.

**Strategic outputs**

- Integrated land use options that contribute to sustaining the natural resource base
- Appropriate component technologies, particularly in areas for which CIAT has a mandate
- Decision support tools and other methods for use by farmers, researchers, planners and policy makers from the local level to national levels
- Increased capacity of national institutions to conduct component and systems research using participatory approaches

**Where we work**

We work in upland areas where there is a high incidence of poor rural families, low productivity and problems of resource degradation. At present, PE-5 in involved in the development of component technologies for cassava, forages and rice in the forest margins, hillsides and savannas of Latin America, Asia and Africa and in watershed level research in the forest margins, Pucallpa, Peru and a steep upland watershed in Vietnam.

# Sustainable Systems for Smallholders

# Highlights and Progress towards achieving project objectives

## 1.1 Introduction

The objectives, expected outputs, associated activities, required inputs and the strategy being followed have been summarized in the previous pages. However the environment we work in is dynamic and conditioned to a large extent by opportunities for funding. The major portion of the funding is obtained through Special Projects that have to be designed to meet specific donor as well as stakeholder objectives and are at different stages of implementation. We need to respond to changing stakeholder demands, new technical information and indigenous knowledge of our clients. Nevertheless the logframe with four broad Outputs allow us to maintain our focus on a common set of goals, exchange ideas and outputs, share resources and integrate somewhat diverse activities towards achieving common goals and contributing to the NRM outputs of CIAT.

In this section, we summarize achievements and progress in relation to the subproject areas which, to a large extent, coincide with the Special Projects that fund the activities of PE-5. This presentation provides a more coherent account of the activities needed from different project Outputs to achieve a desired outcome for developing sustainable production at the component or watershed level, e.g. technology inputs, modeling and training. These achievements are cross-referenced to activity reports for the four broad Outputs of PE-5 and demonstrate coherence within project PE-5 as a whole.

Progress towards achieving goals is summarized in relation to (i) development of productive and sustainable component technologies, (ii) improved NRM by communities at the watershed level, (iii) cross project outcomes of research, and (iv) project contributions to CIAT NRM outputs.

## 1.2 Productive and sustainable technologies

### 1.2.1 Forages for tropical dual-purpose systems in LAC (Tropileche project)

*Objective:* To evaluate legume-based feeding systems to improve the efficiency of milk production and improve NRM in smallholder dual-purpose systems in LAC.

*Previous research:*
- Characterized the hillsides and forest margin agro-ecosystems in which the project worked.
- Identified potentially useful legumes, in particular, a new shrub legume, *Cratylia argentea*, adapted to infertile and soils and dry conditions (project IP-5).
- Practical methodologies for assessing affect of feeds on milk production
- Modified a linear programming model for ex-ante evaluation and
- Training for NARS scientists

*Research in 1999* (see Outputs 2.2; 4.3.3; 4.7.3 for full details):
- On-farm research in Costa Rica demonstrated the economic advantage of *C. argentea* to replace purchased supplements when fed fresh or as silage
- Farmers integrated this legume into their production system, improving the management of the *C. argentea*-sugar cane feeding system for the dry season
- Results are being extended to Nicaragua and Honduras in Central America working with project PE-3.
- Website was developed for disseminating information on dual-purpose cattle systems

*Impact:* Tropileche is being accepted as a platform for dissemination of new forage germplasm from project IP-5 and component technologies developed in PE-5, a forum for exchange of ideas, a vehicle for undertaking

FPR research, strengthening the capacity of NARS, providing feedback to CIAT on research priorities, and a mechanism for developing bi-lateral projects with NARS. In the coming year, similar research activities will be continued and extended to other countries with more emphasis on monitoring and impact assessment. Funding will be sought for continuing activities beyond 2000.

### 1.2.2 Forages in upland farming systems in Asia (Forages for Smallholders project)

*Objective:* To integrate forage technology options to improve feed resources and resource management in smallholder farming systems in Southeast Asia, in particular, in Indonesia, Laos, Philippines and Vietnam.

*Previous research:*
- Forage species identified for different environments and farming systems
- Forage technologies being developed with farmers at 18 on-farm sites
- Feedback from on-farm applied research led to strategic research in selection of Brachiaria species for high seed production and Stylosanthes for disease resistance
- FPR teams formed in 4 countries and approach modified for local conditions
- Training provided for >200 researchers and extensionists
- External review noted the FPR approach was the key in bringing forages to farmers

*Research in 1999* (see Outputs 1.2.2; 1.5.2; 2.4.1; 3.4; 4.3.1; 4.6.1; 4.7.1 for full details):
- Synthesis showed 11 forage technology options were identified for 7 smallholder farming systems
- 18 grasses and legumes have been chosen for the region in terms of adaptation to climatic conditions and soils and suitability for various forage technology options
- A framework is being developed for participatory monitoring and evaluation in technology development
- A survey was carried out in 3 countries to identify indigenous criteria for adoption of shrub legumes and reasons for farmer acceptance or rejection of new forage options developed by the FSP
- Rapid impact study is being carried out across 18 sites
- Summarized training approaches for developing new forage technologies in three publications
- Organized international workshop "Working with Farmers".
- Continued to support regional SEAFRAD (Southeast Asia Forage and Feed Resources Network)

*Impact:* This Special Project concludes in December 1999. Most activities for the year have focused on the analysis, summary and synthesis of results obtained during the 5 years of the project. In addition, follow-on projects have been developed to assist and monitor the adaptation and adoption of new forage options and to investigate participatory approaches to scaling up and disseminating the forage technologies.

### 1.2.3 Developing improved soil management practices in cassava-based systems in Asia

*Objective:* To maintain or improve soil productivity and optimize fertilizer use in cassava-based cropping systems

*Previous research:*
- 25 cassava varieties containing genetic material from CIAT have been released in Asia and are estimated to be grown over 600,000 ha.
- This variety improvement was accompanied by the investigation of management practices to reduce soil loss under cassava
- Soil fertility maintenance, inter-cropping and erosion barriers all contributed to reduced erosion.
- Research teams of NARS were set up in China, Indonesia, Thailand and Vietnam and trained to conduct on-farm demonstrations and FPR

- A nucleus group of scientists, extension staff and farmers began to adopt FPR

*Research in 1999* (see Outputs 2.5; 4.3.2; 4.7.2 for full details):

- A second phase of the project was funded by the NIPPON Foundation in 1999 to:
  (i) continue FPR technology development on improved management practices,
  (ii) to scale up and disseminate improved technologies,
  (iii) to undertake research problems that arise from field experience and
  (iv) to train larger numbers of national scientists in FPR
- New sites have been selected and national teams FPR are being established in China (2), Thailand (5) and Vietnam (5).
- Results from 1999 confirm earlier findings:
  - K deficiency can be expected when soil ex. K is <0.15-0.17 me/100g
  - Inter-cropping with cassava gives high economic returns and reduces soil erosion
  - Choice of options for erosion control depends on location, soils and possible end-uses

*Impact:* There is enthusiasm by national partners to continue collaboration in improvement of soil management cassava-based systems. In part, this is seen as a means of ensuring access to advanced cassava lines and other technologies available from CIAT. Most partners are actively supporting the FPR approach by introducing elements to their research and extension services. The challenge to the new project will be to identify participatory approaches for scaling up new technologies.

## 1.3 Natural resource management at the watershed level

### 1.3.1 Systems research in the Forest Margins, Pucallpa, Peru

*Objective:* To contribute to elimination of poverty through development of sustainable production systems that minimize deforestation, loss of biodiversity and gaseous emission to the atmosphere

*Previous research:*

- Area characterized in relation to social groups and land use and the effect of different land use systems on changes in biodiversity
- Commenced facilitation of a multi-institutional and participatory approach to adaptive research
- FPR trials on rice improvement commenced

*Research in 1999* (see Outputs 1.1.1; 1.2.1; 1.4.1; 1.5.1; 2.1.1; 2.1.2; 2.1.3; 3.2.1; 3.3.1; 3.4.1; 4.2.1; 4.2.2; 4.2.3; 4.5.1; 4.6.2 for full details):

- Continued characterization through spatial analysis of poverty in relation to geographical position in the landscape.
- Commenced a study on the causal linkages between human health and resource use
- An analysis of the effect of labor requirement on introduction of new technologies showed that if non-competitive with traditional crops there could be a negative effect on forest cover
- Analysis of studies on intensification of pasture systems suggested that forest scarcity is a prerequisite for intensification of agricultural technology
- The first FPR trials on rice have demonstrated to national scientists that farmers are interested and can contribute to evaluation and adaptation of potentially useful technologies
- A multi-institutional and participatory team (DEPAM) is taking an active role in testing new ways of working across institutions and with farmers
- 11 FPR projects were initiated by DEPAM
- An agro-enterprise unit from SN-1 has been integrated with the activities of DEPAM.
- A farm-level economic model was developed for ex-ante analysis of potential new technologies

- A framework was developed with all partners for monitoring and assessing impact of research
- This was followed up with the formation of inter-disciplinary and multi-institutional working groups to refine impact indicators and collect data for impact assessment
- Separate consultations were held with IARC and national partners to share research agendas and develop programs that were collaborative, complementary and directed to a common set of development objectives
- Close collaboration was maintained with the CGIAR Systemwide Programs, Alternatives to Slash-and-Burn and the Participatory Research and Gender Analysis Programs.

*Impact:* CIAT now has an integrated research agenda in Pucallpa that is complementary to national and international partners. Working relationships have been improved to the extent that joint research proposals are being developed. CIAT's initiative in introducing participatory approaches through a multi-institutional adaptive research team is leading to closer linkages of researchers with farmers in setting and monitoring research. However, this process is in an early stage of development and needs to aim for greater involvement of government planners and policy makers if incentives are to be developed that favor the environmental protection that is a major focus of IARC research in the Forest Margins. We view this as a long-term research initiative of CIAT.

### 1.3.2 Community-based natural resource management, Hong Ha, Vietnam

*Objective:* To improve food security and involve the community in decision making processes that affect maintenance of natural resources.

*Previous research:*
- Identified the watershed of the Hong Ha commune, A'Luoi district, Thua Hue Province, as a study area for community management of natural resources
- Project was developed and funding approved.

*Research in 1999* (see Outputs 1.1.2; 2.1.4; 2.1.5; 4.2.4 for full details)*:*
- The watershed occupied was characterized with respect to physical resources, agriculture, economics, culture and gender issues, and the institutional system
- Farmers have begun evaluating new varieties of rice, cassava, fruit and vegetables, green manure crops and improved small livestock practices
- Rice yields were increased from 50-100% with new varieties
- National partners were provided support in problem diagnosis, defining and prioritizing research opportunities, in PFR, provision of germplasm and technical areas.
- The national team established linkages with district and provincial officers.

*Impact:* The main outcomes to date are a good understanding of the physical and human resources in the watershed, establishment of empathy with the community and linkages with government officials. In addition farmers have already been involved in evaluating solutions to overcoming the acute food shortage and improving living conditions, such as a fresh water supply. As food security is improved more attention can be focused on NRM issues of forest and waste land management. It remains a major challenge to identify acceptable approaches that accept a local community becoming involved in decision making processes that are normally taken at provincial levels.

## 1.4 Cross project outcomes of research

Many outcomes of research in the above areas can be adapted for use across PE-5 as a whole and indeed in other projects in CIAT and by our national and international partners. However, some areas of research are more generic than others and are summarized here.

### 1.4.1 Adaptation and evaluate simulation models for smallholder farming systems

*Objective:* Adapt and evaluate DSSAT for smallholder systems to better understand their strengths and weaknesses and to identify opportunities for their use.

*Previous research:*
- The soil organic matter module in CENTURY was linked to DSSAT.
- A Brachiaria grass module option was developed for DSSAT

*Research in 1999* (see Output 3.1 for full details):
- Validated the CENTURY soil organic module SOM in DSSAT
- Successfully simulated maize production at the Hillsides reference site and identified that moisture was more limiting than N.

*Impact:* Simulation models offer the opportunity to evaluate farm-level management strategies, estimate yields for economic analysis and assess the use of improved germplasm in association with improved NRM. The research conducted here has been directed at supporting the systems research undertaken by project PE-3 in the hillsides of Central America though it has wider application. However, research in PE-5 is likely to be discontinued due to inability to secure Special Project funding.

### 1.4.2 Legumes identified for feed supply, nutrient cycling and improved fallows (with IP-2 and IP-5)

*Objective:* To identify legumes and other plants that can contribute to maintaining soil fertility and a protein source for livestock.

*Previous research:*
There has been a long, though somewhat intermittent study of the effect of legume covers on soil improvement. Research continues because of declining soil fertility and the inability of resource-poor farmers to purchase nutrient inputs.

*Research in 1999* (see Outputs 1.5.3; 2.3.1; 2.3.2; 2.3.4; 2.3.5; 2.4.1; 2.5.1 for full details):
- Legumes being evaluated for multiple uses in Central America and Asia
- Lower nematode populations were maintained with Crotolaria, Lablab and Mucuna than other legumes
- Subsequent crop yields increased by green manure crops in hillsides of LAC and East Africa
- Synthesis of information on legume green manure and cover crops for East Africa

*Impact:* Although various cover crop legumes have been shown to have beneficial effects on subsequent crops, there has not been widespread adoption. Future studies need to focus on the reasons for this and in developing a strategy to encourage more widespread evaluation by farmers. Research could also focus more on developing integrated fertilizer-green manure strategies.

### 1.4.3 Facilitation of policy enabling environments

*Objective:* To develop approaches to enable institutional change that is receptive to improved natural resource management.

*Previous research:*
There has been a strong focus on FPR in PE-5 and CIAT as a whole. However, the concepts of participation at the farm level need to become accepted at higher levels in organizations for research to become more demand driven efficient in use of resources. In particular, this is important for development and implementation of improved NRM practices.

*Research in 1999* (see Outputs 4.2.1; 4.2.2; 4.4.1; 4.5.1; 4.6.1 for full details):
- Review of systems research in CIAT identified a trend for new partnerships and a progression in the development of participatory approaches
- New approaches were developed for targeting and developing new forage and cassava technologies
- Facilitated the formation of integrated multi-institutional teams that use participatory approaches in problem definition and solution.

*Impact:* CIAT is becoming recognized as a leader in enabling institutional changes as evidenced in our systems research in the Forest Margins and Vietnam and in the regional FPR projects developing improved forage and cassava technologies in Asia. More attention needs to be focused on planners and policy makers in addition to community involvement. In addition, social science resources and/or experience need to be increased.

## 1.5 Contributions to the NRM outputs of CIAT

The following are the NRM outputs of CIAT

- Improved Land Use Management
- Decision Support Tools
- Indicators for Sustainability
- NRM Technology components and Information
- Organizational models and participatory methods
- Improved capacity in NARS for NRM

Examples of Project outputs that contribute to these NRM outputs include:

*Improved Land Use Management*

- A range of forage options for farming systems in Southeast Asia (1.5.2)
- Synthesis of information on legume green manure and cover crops in Africa (1.5.3)
- An analysis of intensification and deforestation in the Forest Margins (1.5.1)

*Decision Support Tools*

- Simulation model adapted for smallholder farming systems (3.1.1)
- Ex-ante model for evaluation of research interventions (3.2.1)
- GIS model for targeting of forage germplasm for end users (3.5.2)

*Indicators for Sustainability*

- Framework for monitoring and impact assessment in the Forest Margins (3.3.1)

*NRM Technology components and Information*

- Cratylia argentea-sugar cane supplement for increasing milk production in the dry season (2.2.2)
- Integrated soil management strategy for cassava-based systems in Asia (2.5.1)

*Organizational models and participatory methods*

- Model for multi-institutional and participatory research-DEPAM (2.1.1; 4.2.1; 4.5.1)
- Approaches to targeting and developing technologies (4.6.1)

*Improved capacity in NARS for NRM*

- Research networks (2.4.7)
- Collaborative planning (4.2.2)
- Facilitating multi-disciplinary research (4.2.4)

# Output 1. Alternative land use options for agricultural systems assessed

## *Activity 1.1 Characterize and diagnose problems and opportunities at the system level through community participation*

### 1.1.1 Spatial analysis of socioeconomics, the environment and poverty at Pucallpa, the Forest Margins reference site

**Highlights**

- Linking census data to a GIS database allowed us to demonstrate that differences between some 400 villages could be related to geographical position in the landscape.

**Objective:** To understand how communities in the forest margins function over a broad area and to use this understanding to focus research and development activities.

**Rationale:** The project will help CIAT and its partners target research and development activities to the poorest of the small farmers in the benchmark site. A secondary benefit of the project is to give researchers a tool for research on agricultural systems.

**Methods:** This project focuses on the geographic dimensions of agriculture, environment and population at the village level in the area surrounding Pucallpa, Peru (**Figure 1**).

In 1999 a database was established, training carried out and some preliminary analysis undertaken. Global positioning systems (GPS) receivers were used to locate over 400 villages in the area surrounding Pucallpa. Information from the 1993 Population census and the 1994 agricultural census was then linked to digital maps of the study area. The census data includes information on population dynamics, government services, agricultural systems and poverty.

The training workshop was held Lima for professional staff from the Peruvian Amazon Research Institute (IIAP), the National Statistics and Census Institute (INEI), and Ministries of Agriculture, Education and Health. Workshop participants learned some of the basics of the user-friendly GIS package ArcView in focusing on spatial patterns of poverty and environment.

**Outputs:** Our first results are an analysis of which variables might be useful to understand poverty dynamics in the benchmark site. We calculated basic needs that are unmet (NBI is the Spanish acronym) from the population census. The indicator is made up of 5 socially accepted standards of basic needs. They are school attendance, dependency ratio, house materials, house plumbing and number of persons per room in the house. (**Figure 2**) suggests that the average number of basic needs unmet in each village discriminate differences between villages in the study area. For the 40,369 rural people in the census survey, the average number of NBI is 2. We are using this indicator as a dependent variable in statistical analyses where we are trying to find the factors related to poverty at the village level.

Our next steps will be to make more sophisticated statistical analyses and to interpret the information. This work will be published by INEI as part of their institutional research series.

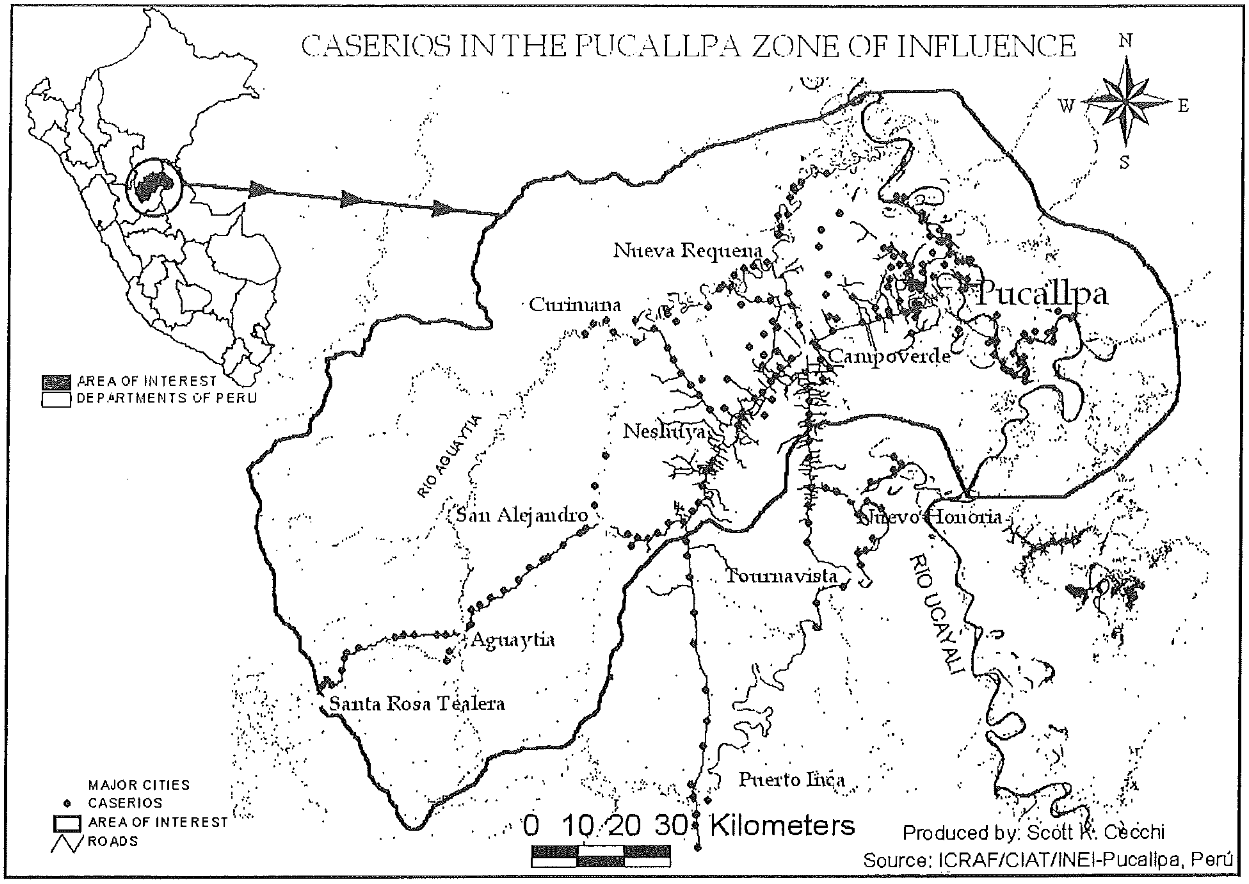



**Figure 1. Linking census data to a GIS database allowed us to demonstrate that differences between some 400 villages could be related to geographical position in the landscape.**

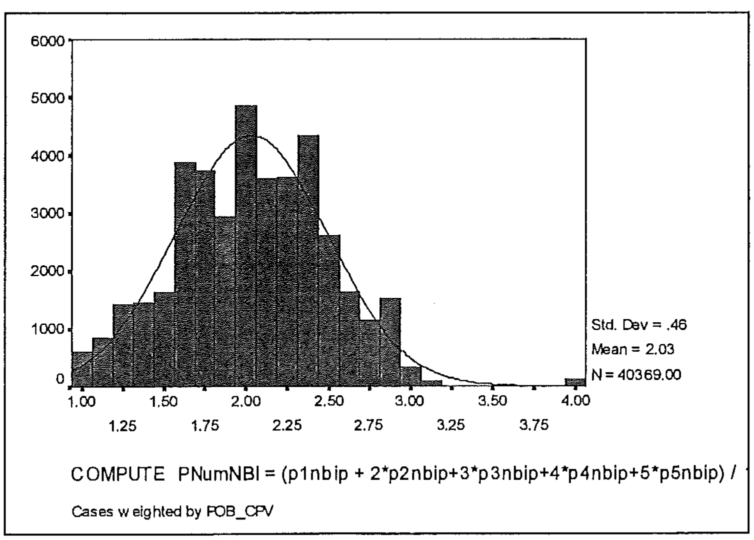



**Figure 2. Frequency distribution of the average number of basic needs unmet (NBI).**
**The x-axis shows average number of NBI per person. The y-axis shows the number of people in each frequency class.**

**Impact:** This study will be used by CIAT and its partners in research and development planning. We will make an analysis of the different kinds of farmers and their problems. We will study the magnitude of these problems and the potential for solutions. The results will be used to match our research and technology strengths to problems of farmers.

**Collaborators:** Glenn Hyman, Doug White and German Lema (CIAT); Clarisa Sanchez, Carlos Santur, Hector Savedre (INEI); Scott Cecchi (Appalachian State University); Carlos Larrea (consultant); Luis Limachi (IIAP); Javier Soto (MAG-DRAU)

## 1.1.2 Community-Based Natural Resource Management: Hong Ha commune, A'Luoi district, Thua Thien Hue Province, Vietnam

### Highlights

- A multi-disciplinary team completed characterization studies and began to develop solutions to food security, income generation and resource use with the community

**Purpose:** To improve family welfare and involve the community in decision making processes in order to develop sustainable and equitable resource use and management options in fragile upland areas in central Vietnam and to build capacity in research and development based on participatory approaches.

The specific objective this year was to characterize the site with emphasis on determining the status of water, soil, agriculture, forestry, livestock and human resources, to understand formal and informal community structures governing the use of natural resources, and determine the key processes and direction of changes.

**Rationale:** Hong Ha is minority community in a devastated upland ecosystem. The community faces a lack of equity in access to resources, food insecurity, and human health problems. A government goal, on the other hand, is to enhance and conserve local forest resources to ensure water supplies for downstream users. While the primary aim is to overcome a critical food shortage and improve family welfare with improved practices that protect the environment, the project also is evaluating an approach of building a team of multi-disciplinary scientists and community officials to diagnose problems and develop solutions with the community. The project will provide a collaborative model for community-based natural resource management. Physical and socio-economic characterization coupled with problem diagnosis and opportunities for problem solution was first undertaken.

**Methods:** Team members have met regularly with community representatives in the village, carried out surveys in their particular disciplinary fields, undertaken group and individual diagnoses, and held joint discussion sessions to analyze the data and met with district and province officials. In parallel with characterization and diagnosis, the team has commenced interventions aimed at overcoming the acute food shortage and severe health problems (reported in Output 2.1.4 and 2.1.5). Diagnosis, monitoring, evaluation and reassessment will be a continuing process involving the community, the team and government officials.

**Outputs:**

*Land use.* The official area of the commune is 28,000 ha. Permanent agriculture presently occupies 120 ha of which 13 ha are irrigated for wetland rice, 10 used for dryland rice and the remainder used for cassava, bananas and home gardens. Land preparation for crop production takes place during February to April. A further 280 ha could be developed for upland agriculture. Livestock numbers, cattle, pigs, goats, chickens and fish, appear to be on the increase. There are 3,000 ha of forest land controlled by the government while the remainder is mountainous and officially not available for commune use. There are large areas of *Imperata* grassland, some of which could be used for agriculture but reforestation is decreasing the amount available. The rainy season extends from April to November and the cold season from December to February.

*Production activities.* Villagers previously practiced slash-and-burn agriculture and extracted forest products. The government has encouraged sedentary agriculture based on a mix of upland crops, paddy rice and livestock. Participatory appraisal indicated the relative importance of different production activities (**Table 1**).

The main production/income sources are cassava, rice, livestock, social income, banana, and non-timber forest products, with home gardens, maize, beans firewood and forestry income also being important for some families. Sale of metal scrap was an important source of income. Presently there are incentives to grow sugar for a mill to be located near Hue. Social income is income from pensions and forestry income is derived from replanting and caring for reforested areas under state or semi-state control. The annual cash income of better-off families is USD25/person while that of the poor families is USD10/person.

**Table 1. Main production activities in Hong Ha commune**

| *Source* | *Score* | *Rank* |
|---|---|---|
| Cassava | 19 | 1 |
| Lowland rice | 15 | 2 |
| "Social Income" | 12 | 3 |
| Bananas | 11 | 3 |
| Non-timber forest products | 9 | 5 |
| Cattle | 7 | 5 |
| Pigs | 7 | 5 |

*Social structure*: There is a population of 1,100 in 180 families from four minority groups (Ka Tu –69%, Pa Coh – 20%, Ta Oi – 7%, Pa Hy – 3%) and a few households of Kinh and Van Kieu –1%. Many households contain 8 to 10 persons. It is estimated that there are only 300 able laborers, 200 being old or incapacitated and the remainder children. The Chairman and Secretary of the People's Committee together with the village heads are responsible for administrative affairs but the traditional 'village older council' still commands much respect. Political organizations such as the Farmers, Women's and Youth associations also play a key role in village life. Men have authority over women.

The community recognizes four wealth levels: better-off, moderate, poor and very poor the moderate and better-off wealth groups have larger farm areas and more livestock/ household than the poor group which in turn has a larger agriculture (including irrigated rice) and home garden area than the very poor. Rice yields are similar between groups.

*Diagnosis of problems*: A participatory diagnosis of the very poor and better-off people from the 5 villages disclosed that their main problems were food security, sickness, low education (illiteracy) and inability to generate cash income.

**Table 2. Main problems faced by the community**

| **Problems** | **Score** | **Rank** |
|---|---|---|
| Lack of capital | 20 | 1 |
| (Human) disease | 18 | 2 |
| Low food production | 17 | 2 |
| Low education | 16 | 2 |
| Lack of labor | 14 | 5 |

Further analysis suggested that the community associated food insecurity with low crop yields due to low soil fertility and incidence of pests and diseases, restricted access to land previously available for shifting agriculture, damage from wild animals, lack of labor and lack of agricultural inputs. The community also indicated that some of their problems were associated with lack of technical knowledge and poor communication. Women highlighted the problems of food insecurity, sickness and poor family planning. There was a consensus that the ability to generate cash income would help to overcome their problems.

Participatory appraisal showed that the farmers faced different combinations of problems over the year. (**Figure 1**). A major challenge is to address the worst combination, that of a coincidence of food scarcity, high labor demand, and high incidence of health problems.

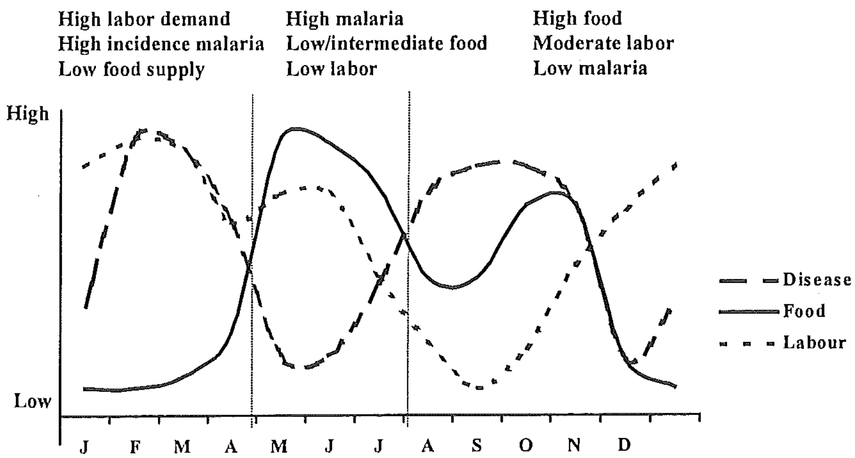



**Figure 1. Seasonal nature of main problems**

*Food security*: The main food sources are rice, cassava and banana. A review of food needs shows that most households do not have adequate food for 4-6 months, others for 7-9 months while a number of better-off families produce sufficient food. The better-off families eat a basic diet of rice with cassava for 6 months and cassava for the other 6 months. The poor families in the commune eat rice and cassava for 2 months and cassava for the other 10 months. The daily meals consist of rice with cassava or cassava only together with salt, chilly and monosodium glutamate and some vegetables collected from the forest.

*Opportunities*: It is understandable that the community did not suggest natural resource management as a major problem (though they were aware of low soil fertility) when they are concerned about producing sufficient food. Thus although the government has initiated reforestation of *Imperata* grasslands to protect the watershed and generate national income, the community looks on this activity as a source of income generation in the short-term rather than a conservation issue.

The most serious problem faced by the community is food insecurity. The project team has decided to give priority to overcoming food security. Farmer participatory research (FPR) has commenced with farmers evaluating:

- Rice varieties for yield and disease resistance
- New cassava varieties and management practices
- Green manure crops to bring *Imperata* grasslands into production
- Fruit and vegetables for home gardens
- Improved pig breeds and management practices
- Improved grasses and legumes for supplementing livestock

University students are located in the villages to gain rural experience and assist the farmers in conducting and evaluating the trials. Training has been provided to sections of the community in livestock production and agronomy.

Secondly, the team is indirectly facilitating a program for overcoming health problems. A clean water supply has been installed in one of the villages.

Thirdly, the team has held meetings with district and province officials to investigate ways in which the community may acquire a long-term interest in the reforested areas. Reforestation has provided needed cash income for labor inputs in the short term. In the long-term it is recognized that some community ownership of forests will provide added protection from fires associated with shifting cultivation.

Fourthly, the team is in constant communication with district officials to involve them in providing services and giving feedback to them on the results obtained.

**Impact:** The upland areas of Vietnam are in a rapid stage of development. A new road is being built through the Hong Ha commune, which will provide rapid access to markets. This will open up opportunity for other cash crops.

The project is seen as providing a model for advanced institutions such as the University of Hue to become involved in community development. Thus the team itself has plans for strengthening its skills in participatory research and teamwork, and designing research around demands and resources of the community.

A major challenge is reduce the large differences in equity within the community. Even community leaders are asking how can the livelihood of the poorest in the community be increased when they currently have few resources allocated to them.

The ultimate challenge is to involve the local community, which is composed of minority groups, in decision-making processes that affect the sustainable use of environment in which they live. Environmental degradation is likely to have more severe effects on downstream communities than on the resident community. Hence society as a whole has an interest in overcoming the present poverty of the local community and ensuring a sustainable land use system is developed. It is not sufficient to pass laws to ban the practice of shifting cultivation or forest extraction. The forestry authority reclaims land for reforestation without consulting the community. Lasting solutions will be achieved only when the local community is involved in decision-making processes. There is a need for a progressive change in the current institutional structures of planning and policy making.

The major outputs are seen as:

- The participatory solution of agricultural and resource management problems at the farm level
- Model for advanced institutions in the development and conduct of participatory research and development
- Pioneering advances in working towards changing policies related to access and control over local resources in ways, which both improve local welfare and protect and maintain environmental services.

**Detailed reports:**

General Characteristics Of Hong Ha Commune, Its Potentials, Problems And Solutions In Community Development - Le Van An

Experiences In Human Ecosystem Management of the Cotu, Ta Oi (Paco, Pahy), Bru-Van-Kieu in Hong Ha Commune, Aluoi District, Thua Thien Hue Province - Nguyen Xuan Hong

Cultural Characteristics of the Cotu, Taoi (Paco, Pahy), Bru-Van Kieu and their Impact to the Development of Economy, Natural Resource and Environment in Hong Ha Commune - Nguyen Xuan Hong

The Roles of Gender in Livelihood Activities and Agricultural Production of Ethnic People in Hong Ha Commune - Vo Thi Minh Phuong

Solutions for Economic Development of Agricultural Householders at Hong Ha Commune, Aluoi District, Thua Thien, Hue Province - Hoang Huu Hoa and Truong Tan Quan

Management of Forest Resources in Hong Ha: Existing Situation, Dynamics and the Path towards Sustainability - Le Quang Bao

The Situation and some Solutions for Improving Food Security in Hong Ha Commune - Nguyen Thi Cach

The Status and Potential for Developing the VAC (V: Home garden; A: Fish pond; C: Livestock) system in Households in Hong Ha Commune - Nguyen Minh Hieu and Nguyen Thi Cach

Animal Husbandry Development based on the Local Feed Supply in Hong Ha Commune: the Situation and Solutions - Le Duc Ngoan, Le Van An, Ngo Huu Toan

The Status and Solutions in Developing Fish Raising in Hong Ha Commune - Nguyen Phi Nam

**Contributors:** Le Van An, project leader, Le Duc Ngoan, animal nutrition, Le Quang Bao, forester, Le Duc Ngoan, animal scientist, Nguyen Thi Cach, agronomist, Nguyen Xuan Hong, sociologist, Nguyen Minh Hieu horticulturist, Hoang Huu Hoa, economist; Nguyen My Van, project secretary; Nguyen Phi Nam, Vo Thi Minh Phuong, Ngo Huu Toan, Truong Tan Quan, support staff (College of Agr.and For.,University of Hue);
Peter Kerridge, systems, Sam Fujisaka, anthropologist, Reinhardt Howeler, cassava agronomist, Peter Horne, forage agronomist, Chris Wheatley, agro-entoprise (CIAT); John Graham (IDRC).

## *Activity 1.2 Assess biological and socio-economic impact of alternative land use options*

### 1.2.1 Analysis of farmer economic benefits and trade-off associated with alternative land use options in the Aguaytia watershed Perú

**Highlights**

- New crops may be either competitive or complementary with respect to the labor demands of traditional farming systems. If labor-competitive, technology adoption may be difficult; whereas if labor-complementary, there is more likelihood of a negative impact upon forest cover.

- The price variability of primary agricultural crops (rice, cassava, plantain, maize) is a direct result of the harvest period. Few farmers can store crops in order to take advantage of better market conditions.

**Purpose :** To investigate the impact of agriculture research and policy options upon smallholder farming systems, as manifested by changing yields and prices.

**Rationale:** Slash-and-burn farming systems within the Aguaytia watershed are diverse. Not only are farms in distinct agro-ecological areas (upland hills, flat-uplands, and riverine), they represent a mixture of subsistence and market-oriented agriculture. Wherever the location, farmers decide how to best invest their labor, land and capital resources to reach the goals of high profit and household food security. However, there often exists a trade-off between these goals. For example, it is common for farmers to plant crops, such as rice, maize and plantains that have low market price, for household use with the surplus for sale. Other crops, such as exotic fruits for export and citrus, are primarily market-oriented and have higher price volatility.

Crop selection depends upon a variety of factors such as the needs and resources of farmers together with agro-ecological factors and market prices. How agricultural research and government policy affect planting decisions, farm profit and food security are best examined with a framework of the entire farming system.

**Outputs:** Seasonal rainfall and river heights affect farm activities (Figures 1-4) throughout the Aguaytia watershed. Preliminary results of an agro-economic model demonstrate marked differences between uplands and riverine agriculture especially in terms of labor use (Figure 1). Allocation of labor is a central component of this research, since along with capital, labor is a scarce resource that restricts agricultural activity in this land-abundant region.

The seasonal nature of labor demands per crop or system requires an examination of how these varying demands are affected by new technological interventions. Promotion of improved varieties and exotic crops by national and international institutions will affect farmer cropping decisions. If a new technology were complementary to the labor demands of traditional farming practices, incomes would likely rise yet be accompanied by a greater impact upon natural resources such as the forest. If new technologies were competitive with respect to labor demands, forest cover may tend to be preserved but family food security may be threatened as traditional subsistence crops could lose prominence. Hence for the Aguaytia region (Figure 1), technologies that require large amounts of labor input in the months of January, February, August or September in the flat-uplands or in May, June or December in the riverine areas could be considered as being competitive to traditional agricultural practices.

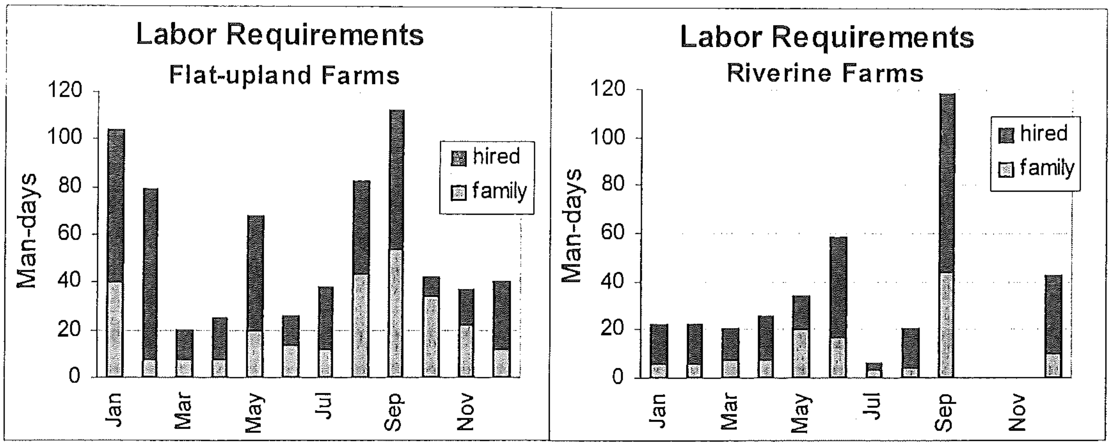
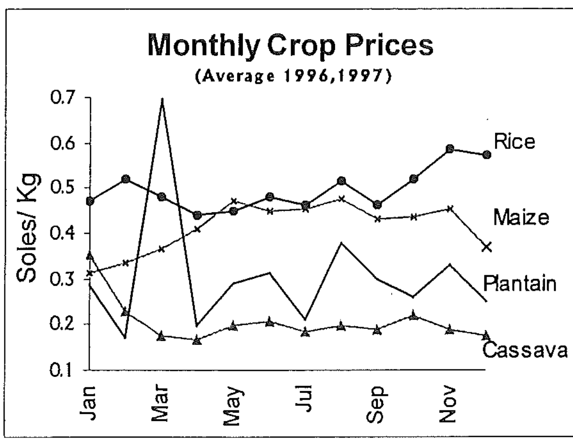
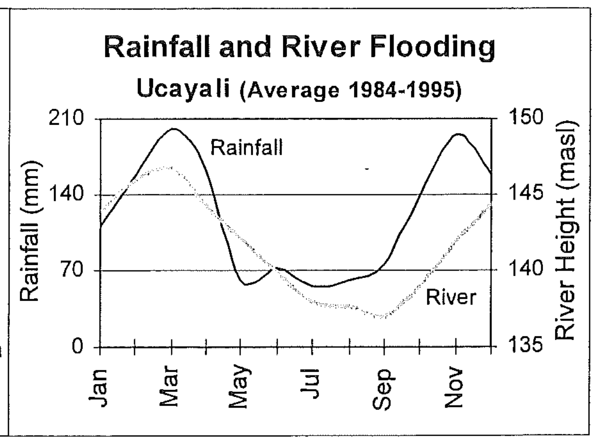



**Figure 1. Labor requirements by month of average flat-upland (20 ha) and riverine (18 ha) farms**

The price variability of primary agricultural crops (rice, cassava, plantain, maize) is related to the time of harvest. Since few farmers have crop storage capability and a strong desire to quickly sell their harvest prices decline markedly at harvest time. For rice, the harvests are in January (uplands) and September (riverine).




Data: Ministry of Agriculture-Ucayali, Universidad Nacional del Ucayali

**Figure 2. Monthly crop prices for rice, maize, plantain and cassava**

**Figure 3. Rainfall and river flooding in Ucayali**

**Impact:** The trade-off between economic and environmental goals are best examined by starting analysis at the farming system level. Both agricultural research and government policy initiative can be modeled in an *ex-ante* manner to foresee likely implications upon farmer income, household food security and forest cover.

Price variability of primary agricultural crops can be an advantage if crop storage were an alternative for farmers. Future research should examine farmers interest in storage and the benefits versus the costs (potential pest damage, capital investment required). These benefits and costs should also be compared against improving yields of traditional agronomic crops.

**Contributors:** Douglas White, Ricardo Labarta, SN-1 (CIAT), INIA, MinAg-Ucayali, DEPAM, ICRAF

### 1.2.2 Forage tree adoption and use in Asia

**Highlights**

- In traditional systems in Bali, farmers grew trees for fodder if:
  - agriculture was intensive;
  - cattle were penned and fed by cut-and-carry;
  - agroforestry was a part of traditional systems;
  - the system did not depend on shade-intolerant annual crops;
  - trees were superior in providing dry season fodder.
- Farmers testing legume fodder in projects were positive in terms of animal health and weight gain.

**Purpose:** Examine farmers' traditional and project-introduced adoption and management of forages, especially legume shrubs and trees.

**Rationale:** Slow adoption of legume shrubs by farmers at sites of the Forages for Smallholders (FSP) project indicated a need to understand traditional systems in which such forages were already employed; and to understand farmers adoption and non-adoption where the project was facilitating farmer testing and adaptation to local systems.

**Methods:** Ethnographic and participatory evaluation procedures were used to understand mixed agricultural systems, farmers' animal feeding systems and their perceptions regarding the forages utilized.

A small team of researchers from the Faculty of Animal Husbandry at Udanaya University (Denpasar, Bali, Indonesia), the Environmental Bamboo Foundation, and CIAT visited Besakih and Petang in the uplands north of Denpasar and sites on Nusa Penida an island south of Bali. These sites featured traditional mixed agroforestry and livestock systems ranging in intensity from fully penned animals in Besakih to cut-and-carry combined with tethering in Peteng and Nusah Penida. Farmers were asked about their wet and dry season fodder use and to evaluate the forages used according to their own criteria. Eighteen to twenty-five farmers were individually interviewed at each site. Field observations were recorded.

FSP sites were visited in central Vietnam (Xuan Loc near Hue), northern Sumatra (Marenu), and northern Mindanao (Malitbog). At each site, a small group of researchers collaborating with the FSP project visited both forage adoptors and non-adoptors to discuss forage use and evaluations.

The proportion of fodders used by each group interviewed were aggregated for the individual forage uses across the sample. Most farmers had similar numbers of livestock at each site. Where a few informants had larger herds, care was taken to determine if their forage use proportions were similar to those of their neighbors and to correct the aggregate use as necessary.

In terms of participatory forage evaluations, farmers evaluated forages using matrices showing each respondent's species x each respondent's evaluation criteria with the farmers assigning relative values using beans or maize as counters. Individuals differed in terms of both forages used and evaluation criteria. Data was aggregated in two ways: (i) by presenting relative values for those planting a particular forage and employing a given evaluation criteria; and (ii) by presenting the percentage of total "votes" received by a given species x evaluation criteria combination. The first method over-valued the less frequently encountered species x criteria combinations, i.e. it ignored the negative "votes" of informants not using a particular forage and evaluation criteria combination. The second method undervalued the species x evaluation combinations held by the minority. Data aggregated from farmers' individual evaluations were, thus, presented to show both sets of values.

The matrix method also suffered in that values assigned to a cell could not be less than zero, eliminating relative degrees of negative evaluations. Farmers were then simply asked to name both positive or "good" and negative or "bad" characteristics associated with each forage source.

**Outputs:**

***Traditional intensive crop/livestock/agroforestry in Bali.*** Nineteen farmers were interviewed in Besakih. The volcanic slopes used by the Besakih farmers extend from some 1000 to 1500 meters above sea level, providing a cool climate and relatively rich soils suited to agroforestry and root crops. Farm size was a mean 0.95 ha, skewed by three extended families. Mean farm size was 0.6 ha for the 16 families (range 0.2-1.0 ha); while the remaining three families had 2.0-4.0 ha. Coffee and sweet potato were the most important crops followed by cassava, citrus, banana, cloves, coconut, and some maize. *Albizia* sp was grown for timber for the local wood carving industry.

Modal number of cattle was two (range 2-6 for the 16 families, 7-20 for the three extended families). Cattle were penned and not grazed or tethered. All feed was provided by cut-and-carry. Farmers relied upon on-farm feed resources ranging from natural grasses or weeds to planted grasses (*Pennisetum purpureum*), trees (*Calliandra calothyrsus, Gliricidia sepium, Albizia saman,* and jackfriut), and crop residues (sweet potato vines, leaves, and tubers) (**Table 1**).

**Table 1. Farmers' fodder sources (%), wet and dry seasons, Bali**

| | Besakih | | | Peteng | | | Nusa Penida | | |
|---|---|---|---|---|---|---|---|---|---|
| | % farmers | Wet Season | Dry Season | % farmers | Wet Season | Dry Season | % farmers | Wet Season | Dry Season |
| **Tree fodder** | | 37[2] | 43 | | 25 | 37 | | 41 | 53 |
| *G. sepium* | 78[1] | 11 | 10 | 100 | 12 | 14 | 100 | 32 | 28 |
| *C. calothyrsus* | 100 | 20 | 19 | 28 | 2 | 3 | | - | - |
| *A. saman* | 33 | 2 | 7 | 22 | 1 | 1 | | - | - |
| *E. orientalis* | | - | - | 50 | 4 | 6 | | - | - |
| *Ficus* sp | | - | - | | - | - | 89 | 5 | 23 |
| *Sesbania* sp | | - | - | | - | - | 28 | 4 | 2 |
| Jackfruit | 61 | 4 | 7 | 83 | 6 | 13 | | - | - |
| **Planted grasses** | | | | | | | | | |
| *P purpureum* | 94 | 19 | 15 | 100 | 21 | 13 | | - | - |
| **Local grasses** | 89 | 11 | 8 | 94 | 24 | 11 | 94 | 25 | 8 |
| **Crop residues** | | 13 | 13 | | 24 | 30 | | 28 | 33 |
| Sweet potato (tuber, leaf) | 89 | 13 | 13 | | - | - | | - | - |
| Cassava | | - | - | 61 | 6 | 8 | 63 | 6 | 6 |
| Banana stalk | | - | - | 100 | 14 | 15 | 83 | 12 | 16 |
| Coconut fronds | | - | - | 56 | 4 | 7 | 56 | 1 | 10 |
| Bean leaf | | - | - | | - | - | 50 | 9 | 1 |
| **TOTAL** | | 80 | 79 | | 94 | 91 | | 94 | 94 |

[1] % of farmers using a particular forage; [2] % of fodder coming from a forage type or species

Farms were intensively cultivated, with small parcels separated by "live fences" comprised of a wide mix of trees and a few grasses. Fence row species included the trees *G. sepium, C. calothyrsus, A. saman, Erythrina orientalis*, jackfruit, avocado, *salak* (a local fruit), and grasses *P. purpureum* and King grass (a *P. purpureum* x P. typhoides hybrid). Farmers admitted that with all animals penned, the apparent live "fences" were not established as fences per se. More likely is that these were "linear fields" established for fodder (and some fruit and timber) and having the advantages of ease of harvest and, more importantly, the deflection of much of the above- and below-ground competition of the trees into adjacent pathways, roadsides, and terrace walls.

Individual farmers in Besakih evaluated the forages they each used, using criteria each saw as important. When data is aggregated to show entries reflecting the mean score for farmers planting a particular forage and using a given criteria (**Table 2**), *C. calythyrsus, G. sepium, P. purpureum*, and sweet potato were judged as somewhat equal and superior to *A saman*, jackfruit, and local grasses. The most important criteria were yield, palatability, and weight gain. Calliandra scored high in terms of weight gain, yield, animal health, and fast growth. Although scoring high across most criteria, Gliricidia was especially valued for yield. *P purpureum* was valued for its high yield; and sweet potato (leaves and tubers) especially high for palatability, weight gain, and fast growth.

**Table 2. Species evaluation*, Besakih, Bali**

| | | Evaluation Criteria | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Planting | Yield | Palatability | Weight Gain | Animal Health | Dry Season | Establishment | Fast Growing | Planting Material | Total | Rank |
| **Use criteria (%)** | | 78 | 78 | 72 | 50 | 22 | 22 | 17 | 5 | | |
| *C. calothyrsus* | 100 | 5 | 4 | 6 | 5 | 3 | 3 | 5 | 2 | 33 | 1 |
| *G. sepium* | 78 | 5 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 32 | 1 |
| *A. saman* | 33 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 21 | 5 |
| *Jackfruit* | 61 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 20 | 5 |
| *P. purpureum* | 94 | 6 | 5 | 5 | 2 | 3 | 3 | 4 | 2 | 30 | 1 |
| Local grasses | 89 | 4 | 3 | 4 | 2 | 1 | 3 | 1 | 1 | 19 | 5 |
| Sweet potato | 89 | 4 | 7 | 7 | 4 | 2 | 1 | 6 | 2 | 33 | 1 |
| **TOTAL** | | 30 | 29 | 31 | 21 | 16 | 19 | 25 | 17 | | |
| Relative Importance | | 1 | 1 | 1 | 5 | 7 | 5 | 4 | 7 | | |

* Eighteen farmers each planted different species and used different evaluation criteria. Entries are mean scores for those planting a given species and using a given criteria. Relative scores for species are percent planting x total. Relative importance of criteria are percentages using criteria x total.

Only slightly different results emerged when the percentage of "votes" gained by each species x evaluation criteria was considered (**Table 3**). The criteria of yield, palatability, and weight gain remained the most important; and the forages Calliandra, Pennisetum, and sweet potato were still the highest rated.

*Table 3. Species evaluation*, Besakih, Bali*

| | % Planted | Yield | Palatability | Weight Gain | Animal Health | Dry Season | Establishment | Fast Growing | Planting Material | Total | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Evaluation Criteria | | | | | | | | | |
| **Use criteria (%)** | | 78 | 78 | 72 | 50 | 22 | 22 | 17 | 5 | | |
| *C. calothyrsus* | 100 | 5 | 5 | 5 | 3 | 1 | 1 | 1 | <1 | 21 | 1 |
| *G. sepium* | 78 | 4 | 3 | 3 | 2 | <1 | 1 | 1 | <1 | 15 | 4 |
| *A. saman* | 33 | 1 | 1 | <1 | <1 | <1 | <1 | <1 | <1 | 3 | 7 |
| Jackfruit | 61 | 2 | 2 | 2 | <1 | <1 | <1 | <1 | <1 | 7 | 6 |
| *P purpureum* | 94 | 6 | 5 | 5 | 1 | 1 | 1 | 1 | <1 | 20 | 1 |
| Local grasses | 89 | 4 | 3 | 3 | 2 | <1 | 1 | <1 | <1 | 14 | 4 |
| Sweet potato | 89 | 4 | 6 | 6 | 3 | <1 | <1 | 1 | <1 | 21 | 1 |
| **TOTAL** | | 26 | 25 | 24 | 11 | 3 | 5 | 5 | 2 | 100 | |
| Relative Importance | | 1 | 1 | 1 | 4 | 7 | 5 | 5 | 8 | | |

* Entries are percentage of all "votes" for each species x evaluation combination. Species rank and relative importance of criteria reflect respective sums of rows or columns.

Gliricidia and local grasses followed in popularity. The "less important" evaluation criteria for Besakih farmers were animal health, ease of establishment, fast growth, dry season productivity, and availability of planting material.

Moving downslope, 18 farmers were interviewed in Petang. Farm size was a mean 0.6 ha. Cassava was the most important crop, followed by citrus, coffee, banana, cacao, cloves, peanut, coconut, ginger, papaya, and maize. As in Besakih, farmers in Peteng relied on their linear fields for tree fodders (*G. sepium* throughout the year and *E. orientalis* and jackfriut in the dry season) and *P. purpureum,* as well as local grasses and crop residues--banana stalk, cassava leaf, and coconut fronds (Table 1).

Eighteen farmers were interviewed in Sakti on the small island of Nusa Penida off the southern coast of Bali. Mean farm size was 2.0 ha (range 0.3-7.0 ha, mode 1.5 ha). The island receives less rainfall, has a drier dry season, and has poorer (limestone) soils than the Balinese uplands. Main crops were cassava, maize, coconut, banana, and beans.

Mean number of cattle was three head per family (range 1-5, mode, 2 head). Cattle were fed by tethering (largely on each farmers' own lands, often under coconut) and by cut-and-carry. Farmers relied on tree fodders, including *G. sepium* throughout the year and *Ficus* sp in the dry season. Local grasses were abundant in the wet season (accounting for 25% of cut-and-carry fodder); less so in the dry season. Banana stalk was an important feed source throughout the year (Table 1).

Although farmers in Sakti agreed that *Sesbania* sp was superior to all other forages in terms of weight gain, palatability, and animal health, only one fourth of the farmers maintained the tree, which accounted for only 4% of feed in the wet season and 2% in the dry. Sesbania was not more widely adopted because of its short life span. On the other hand, although *Ficus* sp was viewed as providing poor quality fodder, it served as an "insurance" feed source in the dry season adopted by 50% of the farmers and providing 23% of dry season fodder.

***Forage project cooperators, non-cooperators, adopters, and non-adopters in Sumatra, Vietnam, and northern Mindanao.*** The FSP site in Marenu, Sumatra, is a recently settled transmigration site. Farmers, both FSP project cooperators (n = 10) and non-cooperators (n = 8) reported having a mean of one ha; although some may have had more land and reported the "official" land holding for settlers. Cooperators had a mean 34 head of sheep; while non-cooperators had 19. Main income sources for cooperators were sheep, upland crops, and off-farm labor. Cooperators additionally claimed lowland rice and oil palm as main income sources. Cooperators complained of wild pigs, drought/lack of water, lack of capital, lack of job opportunities, and sheep theft as problems. Non-cooperators saw pigs, lack of capital, and drought/lack of water as problems. It appeared that non-cooperators had fewer sheep than cooperators, but were more successful in terms of off-farm employment and in the establishment of lowland rice paddies and oil palm plantations.

Sheep were fed by combined grazing on commons and cut-and-carry for mornings and evenings when animals were penned. Both cooperators and non-cooperators planted grasses and trees. Rates of adoption for several grasses were higher for cooperators, with non-cooperators relying more on King grass than cooperators. Half of the cooperators compared to none of the non-cooperators had sown *Stylosanthes guianensis*; and more cooperators had adopted and were using *G. sepium* and *L. leucocephala* compared to non-cooperators. Non-cooperators relied more upon local grasses than cooperators in the dry season (**Table 4**). Farmers' evaluations of fodder species were also recorded in terms of positive and negative qualities of each (see Table 7).

**Table 4. Forage use, FSP cooperators & non-cooperators, wet and dry seasons, Marenu, Sumatra**

| | Cooperators | | | Non-cooperators | | |
|---|---|---|---|---|---|---|
| | % farmers | WS | DS | % farmers | WS | DS |
| **Trees** | | 25[2] | 19 | | 13 | 12 |
| *G. sepium* | 90[1] | 10 | 7 | 38 | 4 | 3 |
| *A. saman* | 50 | 6 | 5 | 50 | 4 | 4 |
| *L. leucocephala* | 90 | 9 | 7 | 50 | 5 | 5 |
| **Legumes** | | | | | | |
| *S. guianensis* | 50 | 8 | 4 | 0 | 0 | 0 |
| **Local grasses** | 80 | 12 | 17 | 63 | 19 | 32 |
| **Planted grasses** | | 45+ | 50 | | 61 | 45 |
| *P. atratum* | 90 | 15 | 15 | 100 | 20 | 15 |
| *P. guenoarum* | 100 | 16 | 12 | 75 | 11 | 8 |
| *B. humidicola* | 60 | 4 | 12 | 25 | 7 | 6 |
| *B. decumbens* | 60 | 7 | 6 | 50 | 9 | 6 |
| *S. sphacelata* | 20 | 3 | 3 | 13 | 1 | 1 |
| King grass | 10 | <1 | 2 | 63 | 13 | 9 |
| **Total** | | 91 | 90 | | 93 | 80 |

[1] % of farmers using a particular forage; [2] % of fodder coming from a forage type or species

Ten FSP cooperators and 8 non-cooperators were interviewed in Xuan Loc near Hue in central Vietnam. Besides producing lowland rice and sugar cane, almost all farmers were tree planters. Most had fairly large numbers of fruit trees; a large proportion managed reforestation areas under government contract; and a high proportion had family land similarly sown to plantation forests.

Comparing cooperators and non-cooperators, cooperators had more land (mean 2.4 ha vs 1.6 ha), but--for families having each enterprise--similar areas of lowland rice (0.2 ha), sugar cane (0.2 ha), areas under family forestry (1.3-1.4 ha) and numbers of cattle (4.0-4.4). Greater proportions of cooperators, however, had sugar cane, family forestry, and cattle (67% vs 50%). Although fewer non-cooperators had water buffalo, those having such animals had a higher number per family. More non-cooperators cared for government forest plots, but had smaller areas (7.5 ha) compared to those cooperators (9.7 ha) having such contracts (**Table 5**).

**Table 5. Production assets, Xuan Loc, Vietnam**

| | Participants (n=10) | | | Non-participants (n=8) | | |
|---|---|---|---|---|---|---|
| | % sample | Mean | Range | % Sample | Mean | Range |
| Farm size (ha) | 100 | 2.4 | 0.3 - 8.0 | 100 | 1.6 | 0.3 - 3.4 |
| Paddy area (ha) | 83 | 0.2 | 0.1 - 0.3 | 88 | 0.2 | 0.1 - 0.2 |
| Sugar cane (ha) | 89 | 0.2 | 0.1 - 0.3 | 57 | 0.2 | 0.1 - 1.0 |
| Family forestry (ha) | 83 | 1.4 | 0.1 - 5.0 | 29 | 1.3 | 0.5 - 2.0 |
| Contract forestry (ha) | 27 | 9.7 | 6.0-20.0 | 50 | 7.5 | 6.0-10.0 |
| Fruit trees (units) | 100 | 104 | 23-290 | 86 | 140 | 29-280 |
| Cattle (animals) | 67 | 4.4 | 1-10 | 50 | 4.0 | 1-10 |
| Buffalo (animals) | 44 | 1.7 | 1-3 | 25 | 4.0 | 3-4 |

Farmers identified problems as lack of water for crops, lack of capital, low soil fertility, and lack of transport--followed by a lack of labor for grazing livestock and a lack of grazing land.

Cooperators were just becoming familiar with some of the grasses and fewer of the trees through testing (on small plots) as a part of FSP activities. The main evaluation criteria used by farmers were palatability, "quality", yield, weight gain, and animal health. If the evaluations of farmers using particular species and evaluation criteria are compared (without reference to the actual proportions of farmers actually using a given forage and/or evaluation criteria), native grasses were given highest marks due to high scores in terms of quality, palatability, and yield. *P maximum* was also rated highly across criteria, and especially in terms of palatability. The trees *G. sepium* and *L. leucocephala*, although planted by 77% of the informants, scored low across criteria. Factoring in proportions of farmers planting a given forage and using particular evaluation criteria, native grasses, *P. maximum*, and *S. guianensis* (which all were testing or using) were given the highest ratings (**Table 6**).

Ironically, farmers' tree planting practices appeared to work against the adoption of fodder trees. Most farmers planted a wide range of fruit trees in their home gardens and cared for forest plantations on both their own and on government lands. Introduced fodder trees had to compete with fruit trees in the home gardens and with commercial timber elsewhere. Because farmers perceived the potential for receiving high (and apparently low-risk) returns to forestry, the enterprise competed with livestock husbandry.

**Table 6. Fodder assessment (n=13), Xuan Loc**

| | % farmers | Criteria: Palatability | Quality | Yield | Weight Gain | Animal Health | Total | Rank | Corrected Total | Corrected Rank |
|---|---|---|---|---|---|---|---|---|---|---|
| **% used criteria** | - | 100 | 85 | 77 | 70 | 38 | | | | |
| *S guianensis* | 100 | 2 | 3 | 3 | 3 | 3 | 14 | 4 | 14 | 1 |
| *P maximum* | 70 | 6 | 4 | 4 | 4 | 2 | 20 | 2 | 14 | 1 |
| *B ruziziensis* | 31 | 3 | 7 | 3 | 2 | 2 | 17 | 3 | 5 | 6 |
| Native grasses | 46 | 7 | 8 | 7 | 4 | 3 | 29 | 1 | 13 | 1 |
| *G sepium* | 77 | 2 | 2 | 2 | 2 | 1 | 9 | 5 | 7 | 5 |
| *L leucocephala* | 77 | 2 | 2 | 2 | 1 | 3 | 10 | 5 | 8 | 4 |
| **TOTAL** | | 22 | 26 | 21 | 16 | 14 | | | | |
| Relative importance | | 2 | 1 | 2 | 4 | 4 | | | | |
| Corrected total | | 22 | 22 | 16 | 11 | 5 | | | | |
| Relative importance | | 1 | 1 | 3 | 4 | 5 | | | | |

* Entries are relative mean scores for those planting a given species and using a given criteria. Ranking of species and relative importance of criteria were calculated from sums of rows and columns, respectively. Corrected totals and ranking reflect proportion of those using the species and criteria.

Maturing forest plantations also resulted in less available natural fodder for either grazing or cut-and-carry. Some farmers had reduced their animal numbers; and the community as a whole may reduce cattle and buffalo numbers further to the point where draft needs are met.

Future forage adoption will depend on the relative economic importance of lowland rice, sugar cane, forestry, and livestock. The importance of livestock will depend on needs for draft, the importance of farmyard manure, and the long-term investment advantages of cattle compared to forestry. A guess would be that cattle numbers would either stay the same or decrease. Livestock enterprises may, however, intensify in response to demand from Hue for higher quality feed produced on small on-farm areas.

A short period was spent in Maltibog in northern Mindanao in the Philippines. Small farmers have one or two head of cattle fed by tethering and cut-and-carry. Main crops are bananas, maize, and coconut. Although FSP cooperators were testing a range of new forages, many appeared to be interested in the possibility of receiving cattle via government dispersal programs (which traditionally required adoption of new forages as a pre-requisite). The high availability of banana stalk and open grazing lands meant that fodder resources were available, a factor working against new forage adoption. One community had a large area of mature *L. leucocephala* trees, which was not being used as a major fodder source. On the other hand, dry-season fodder shortages and increasing demand for meat in the city of Cagayan de Oro may eventually lead to an increase in the genuine adoption of new forages for cattle-fattening enterprises.

***An evaluation of forage species across sites.*** Farmers across sites were asked to name positive and negative characteristics associated with their different forage options (**Table 7**). The results were

**Table 7. Farmers' evaluations of fodder species**

| Species | | Evaluations |
|---|---|---|
| *Calliandra* spp | Good: | Weight gain, yield, palatable, animal health |
| | Bad: | Root competition, must mix w/other fodders, reduces animal fertility |
| *G. sepium* | Good: | High yield, weight gain, animal health, milk production, palatable, prevents diarrhea, easy to grow, easy to harvest, cutting tolerant, long life |
| | Bad: | Not palatable if fed to much, must mix, lowers cattle fertility, leaf fall in DS, pests, slow regrowth, pests |
| *Albizia* sp | Good: | Commercial wood, weight gain, palatable, fast growing , drought tolerant |
| | Bad: | Difficult to harvest, diarrhea, not palatable, slow regrowth, excess leads to hair loss |
| *L. leucocephala* | Good: | Palatable, high milk production, easy to harvest, drought tolerant, cutting tolerant, quick regrowth |
| | Bad: | Pests, must mix, excess causes ewes to bleed |
| *Sesbania* sp | Good: | Animal health, weight gain |
| | Bad: | Short life |
| *Ficus* sp | Good: | Produces in DS, long life |
| | Bad: | Low nutritive value, low yield, one harvest per year, not for animal health, shade competition |
| Jackfruit | Good: | Available in dry season/drought resistant, timber, prevent diarrhea |
| | Bad: | Low nutrient value, constipation |
| *Erythrina* sp | Good: | Weight gain, palatable, animal health |
| | Bad: | Low yield, diarrhea |
| *Stylosanthes* sp | Good: | Nutrition, animal health, good for weanlings, palatable, drought tolerant |
| | Bad: | Old growth not palatable (OGNP), itchy, not drought tolerant, slow regrowth, not palatable |
| *P. purpureum* | Good: | Weight gain, fast growing, perennial, yield, palatable, easy to harvest, available |
| | Bad: | OGNP, must mix, no contribution to animal health, needs fertilizer |
| *P. atratum* | Good: | Quick regrowth, cutting tolerant, drought tolerant, high leaf yield, easy to harvest, palatable, all parts consumed |
| | Bad: | Sharp edged, OGNP |
| *P. guenoarum* | Good: | Fast regrowth, cutting tolerant, yield, easy to harvest, palatable, weight gain, produces in DS |
| | Bad: | Not drought tolerant, OGNP, rots if cut too low |
| *P. humidicola* | Good: | Drought tolerant, quick regrowth, cutting tolerant, palatable, easy to maintain |
| | Bad: | Less leaf production, OGNP, crop competition, cannot plant other crops on same land after |

Table 7 Farmers' evaluations of fodder species (continued)

| Species | | Evaluations |
|---|---|---|
| King grass | Good: | Easy to establish, quick regrowth, palatable, easy to harvest, yield |
| | Bad: | OGNP, crop competition, not drought tolerant, difficult to maintain, itchy |
| *Setaria* sp | Good: | Quick regrowth, palatable, drought tolerant |
| | Bad: | Short life |
| Local grasses | Good: | Natural mixtures for animal health, fast growing, weight gain, palatable, available |
| | Bad: | Low productivity in dry season |
| Sweet potato | Good: | Fattening & animal "finishing" |
| | Bad: | Diarrhea |
| Cassava leaf | Good: | Palatable, weight gain |
| | Bad: | Not palatable 3 days after harvest, bloat |
| Banana stalk | Good: | Animal health, provides water in DS, palatable, easy to harvest, increases milk production in DS |
| | Bad: | Diarrhea if fed in excess |

aggregated because of the substantial consensus across sites in the three countries (albeit, farmers at each site had a different suite of forages and, therefore did not evaluate all species).

The legume trees, *Calliandra* sp, *G. sepium*, and *L. leucocephala* were viewed positively in terms of yield, palatability, animal weight gain, and animal health. Negative characteristics included the need to mix leguminous tree fodder with other fodders, pests, and leaf fall in the dry season (*G. sepium*). *Sesbania* sp fodder was considered of especially high value in Nusa Penida, but was not more widely planted because of its short life span. Although viewed as producing fodder of low nutrient value, *Ficus* sp and jackfruit were valued for their needed dry season productivity. Vietnamese farmers appeared to prefer to plant fruit rather than fodder trees in their home gardens. *Albizia* sp and jackfruit were valued for their timber as well as fodder.

Although farmers agreed that *Stylosanthes* spp was good in terms of animal health, nutrition, and weanlings, slow re-growth and itchiness (for farmers harvesting the fodder) were described as problems. Informants disagreed as to the palatability and drought tolerance of Stylosanthes.

Most of the planted grasses were found to be desirable in terms of fast growth, high yield, palatability, weight gain, and ease of harvest. Common complaints about the grasses included that old growth was not palatable and competed with crops. Farmers sought grasses, which were cutting tolerant, drought tolerant, adapted to low soil fertility, and were fast to re-grow.

Farmers across sites generally favored natural grass mixtures as being fast growing, good for animal health and weight gain, palatable, and, of course, available. In some areas, lowered production in the dry season was mentioned as a problem.

Sweet potato tubers and leaves were used for cattle fattening and "finishing" in some of the upland areas of Bali. Cassava leaf was commonly used as fodder in many areas, and was also viewed positively in terms of animal weight gain. Banana stalk was a significant fodder source at several of the sites. Among several positive characteristics was that it also provided water in the dry season.

**Impact:** Recent studies range from pessimistic to hesitantly optimistic concerning the adoption of trees on farm, especially for fodder. Case studies in Nepal and India have shown that, in spite of increased tree planting for fuelwood and shifts from open grazing to stall feeding, farmers have relied heavily on crop residues and forage grasses to meet animal feed needs. Researchers concluded for these cases "In contrast to the previous analysis of fuel, trees on farm do not appear to be a viable strategy for livestock feed (Warner *et al* 1999). Another review of forage husbandry in the tropics concluded that, "A wide and diverse range of trees and shrubs are used as fodder, but few are planted. When they are planted, it is seldom primarily to provide forage. Rather, forage is a by-product of fruit trees, live fences, and erosion-control strips, and makes the planting of these trees more attractive to farmers" (Bayer and Waters-Bayer 1998:139).

Farmers in the highlands of Nicaragua (in an area somewhat similar to the sites visited in Java), on the other hand, used *Lacuna* spp and *G. sepium* as fodder sources, and maintained naturally occurring *Guazuma ulmifolia* and *Acacia pennatula* trees because of their dry-season forage productivity (Nicola Maria Keilbach, personal communication, cited in Bayer and Waters-Bayer 1998). A collection of studies from South Asia and Eastern Africa indicated, in general, that the (albeit few) observed shifts to more intensive on-farm tree planting was occurring in regions undergoing agricultural intensification, and that this intensification has taken place in the more arable and productive areas with relatively higher rainfall (Arnold and Dewees, 1997).

For the areas visited in this study, several factors would appear to affect decisions regarding forage and tree forage adoption by smallholder farmers with mixed crop and livestock systems. Tree adoption was encountered where a combination of relatively high populations over a fixed land area had led to agricultural intensification. In Bali, such intensification featured high to exclusive reliance upon cut-and-carry feeding for penned animals; and a high reliance upon on-farm planted forages. In these cases, off-farm commons or open access areas supplying grazing land or fodder for cut-and-carry were not available. Indeed, in Besakih every plant--trees, crops, weeds--was privately owned. Fodder tree adoption also appeared more likely where farmers were already agroforesters growing a range of trees for a variety of purposes. Agroforestry itself also appeared more likely where systems were not largely reliant upon shade intolerant annual crops such as upland rice or maize. Finally, fodder trees were likely to be adopted where a marked dry season significantly decreased the relative availability of fodder from non-tree compared to tree sources.

The presence of adequate fodder sources in the form of open grasslands, grasslands under coconut, crop residues (e.g., banana stalk in Indonesia and the Philippines), and the growing of field crops for animal feed (some of the sweet potato in Besakih) would tend to decrease adoption of fodder trees. Livestock serve as a "bank account" for many small farm systems. Family forestry (in Vietnam) served the same purpose and was viewed as a better long-term investment, thus "competing" with livestock as an enterprise.

Farmers in project areas may also genuinely adopt new forages as they shift from herding and grazing to increased stall feeding (e.g., goats in Marenu) or spuriously in the hope of receiving animals through cattle distribution programs (e.g., Malitbog). These factors are synthesized in farmers' decision tree (**Figure 1**).

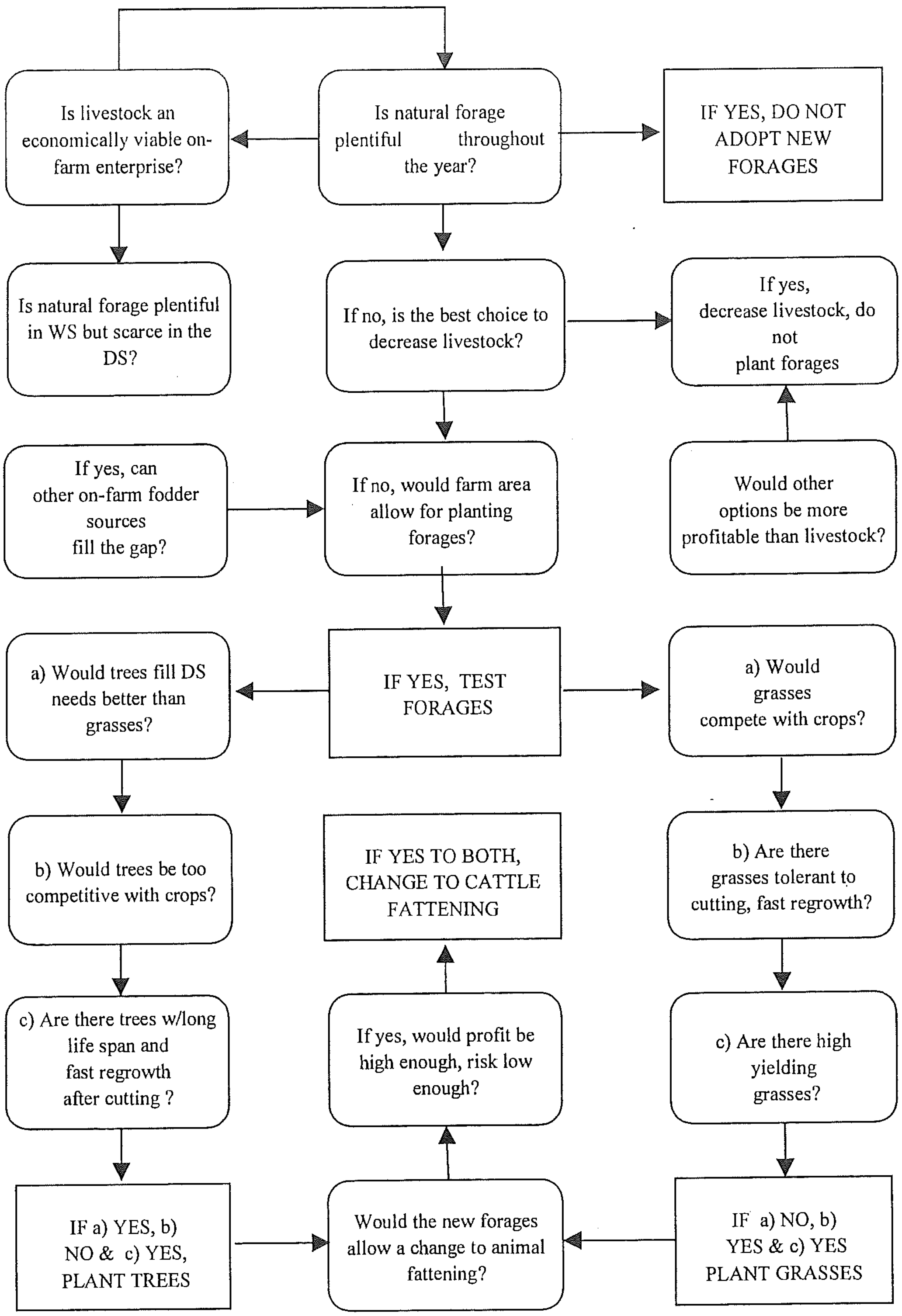



**Figure 1. Farmer forage & tree adoption decision model**

*Implications for the forages for smallholders project.* The FSP is correct in offering farmers at selected sites menus of forage grasses, legumes, and trees; and in facilitating farmer-participatory research in the testing of the introduced materials. The fieldwork reported on here provides several other suggestions:

1. There needs to be continuing emphasis on demand for introduced forages in relation to existing forage resources and the changing relative profitability of livestock over other on- or off-farm enterprises. There may be little opportunity for intensification where livestock simply take advantage of available native forages or where other enterprises such as forestry would "compete" with livestock. Though it is acknowledged that in many cases the FSP has found that farmers like to have small areas of improved forages to use at those times when labor is limiting for collection of existing forages or for herding livestock, even though other fodder sources may be available.

2. Areas undergoing intensification--e.g. where land is becoming less available and penned animals are replacing grazing--would be likely for the adoption of new forages. "Linear fields" such as those encountered in Bali may be appropriate for mixes of trees and grasses where open fields are not available.

3. Farmers in areas with more available land and natural forage resources may still be interested in new grasses and possibly trees if there are clear advantages in terms of dry season productivity. Farmers were willing to plant or use fodder trees producing inferior feed as long as dry season production was assured when needed. The *El Nino* related drought appears to have generated interest in Kalimantan when the new forage species provided the only green to be seen (Werner Stur, personal communication).

4. Farmers expressed a range of perceptions regarding the suitability of legume forages. In general, although good for weight gain and animal health, farmers also thought that legumes needed to be mixed with other foods, that animals refused to eat more than small amounts, and that fertility-related problems could arise. If not already doing so, the project may need to work with farmers willing to experiment with feeding regimes to determine the soundness of such perceptions. Farmers at one FSP site are apparently now more interested in *G. sepium* after recently finding that their goats would, contrary to previous belief, consume loppings from the tree (Werner Stur, personal communication).

5. Further research is needed on the gender and age distribution of labor for cut-and-carry systems. Although male informants generally claimed to contribute equal shares of labor as women, observations give the impression that women contribute more for cut-and-carry and that children provide more for grazing and tethering. Women may have less involvement in fodder or tree planting decisions; and the opportunity costs of children's labor may be low. Both factors could reduce new forage adoption.

6. Crop residues were a major animal feed source in the areas visited. The FSP may want to integrate crop residues within any on-farm research.

7. Where natural forages are plentiful, the FSP may want to work with farmers to address the resource use/access issues associated with such forages in order for farmers to beneficially improve management of the resource. Communities may be able to work together on enriched natural pastures, for example.

8. Finally, and to repeat several points above, farmers did not appear to be worried about the establishment costs in terms of time to productivity and care of seedlings associated with trees.

Competition with crops, longevity, recuperation and regrowth after lopping, tree pests, and fodder suitability were the main concerns.

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## *Activity 1.3 Determine the indicators of human nutrition and health in the Aguaytía watershed*

### 1.3.1. Health, Biodiversity and Natural Resource Use on the Amazon Frontier: An Ecosystem Approach

**Purpose:** To developing and test a participatory ecosystem approach to human health assessment that provides insight into the causal linkages between natural resource use, biodiversity, health and nutrition.

The following hypotheses are being evaluated:

- A more productive ecosystem results in higher nutritional status
- Greater biodiversity on and surrounding the farm results in higher nutritional status
- Nutritional status will vary between native and colonist communities due to differences in culture and local knowledge of biodiversity and ecological resources
- The shift from more subsistence-oriented to commercial production systems does not necessarily result in an increase in nutritional status
- The shift to commercial production affects the role of women in the household, their time allocation and involvement in health and nutrition decisions
- Nutritional status will vary by age and sex within the household
- Nutritional status will vary throughout the year due to seasonal differences in nutrient intake

**Rationale:** Ucayali and the surrounding upper rainforests are of great biological significance, containing 23% and 44% of known tropical plant and bird diversity in the Neotropics (IUCN 1996). Despite the natural diversity and fecundity of the setting, rural communities face a range of nutritional and health problems. Chronic malnutrition affects 47% of rural children below age five (INEI 1997), anemia and vitamin A deficiencies are widespread and incidence of malaria, dengue fever and persistent diarrhea continues to rise (Direccion Regional de Salud 1997). Health research has demonstrated the importance of nutrition to child development and human health (Pelletier et al. 1993; Bailey et al. 1998). In the study area, agricultural production, fishing and wild food extraction, provide the main sources of food consumed. Nutritional status and human health is therefore dependent on the family's ability to ensure sufficient nutrient intake through a diversity of production activities. Exploitation of resources in the surrounding ecosystems result in diverse seasonal combinations of farming, fishing, logging, and hunting and gathering activities. Within such populations, the relationship between household production, income level and nutrition is complex and poorly understood (Leonard et al. 1993). More specifically, the nutritional status of Amazonian populations in Peru has largely been ignored, and the impact on nutrition, and particularly gender relations, of recent shifts to commercial production, has yet to be explored

**Methods:**
***Current research activities*** include:

- Characterization and assessment of the livelihood systems of riverine and upland communities with respect to:
  - i) diversity of food and income sources;
  - ii) agricultural diversity and biodiversity of wild foods gathered from surrounding forests;
  - iii) contribution of different land uses (fishing, farming, hunting and gathering, logging) to dietary quality and food security.

- Assessment of household food security and nutritional status of individual men, women and children, with emphasis on seasonal changes in nutrient intake and deficiencies of micronutrients (iron, zinc, vitamin A, B and C)
- Characterization of child morbidity patterns and disease periodicity
- An ethnographic study of local beliefs, knowledge and decision-making processes that affect the selection of foods and the treatment of illness.

Once the above field activities are complete, the project will:

- determine the significant correlates of nutritional status and identify the causal linkages between natural resource use, health and nutrition through bivariate and multivariate analyses,
- develop with each community their own definitions and indicators of individual and community health using participatory methods,
- develop and implement Community Action Plans (CAPs), drawing on the problems and opportunities identified through the research and the community's own definitions of health.

***Building institutional collaboration.*** From the outset of the project, local representatives of government and non-governmental organizations have been involved in refining the research objectives, designing the specific methodology and carrying out the research. Initially, focus groups and key informant interviews were held with all relevant organizations to confirm the key health issues in the region and provide a richer description of the institutional setting and current efforts in the health arena. These meetings included; the Ministries of Health, Fisheries, and Agriculture, AMUCAU (Asociación de Mujeres Campesinas de Ucayali), AIDESEP and FECONU (Federación de Comunidades Nativas de Ucayali), OMIAP (Organización de Mujeres Indigenas de la Amazonía Peruana) and IIAP. At this time inter-institutional agreements with CIAT were formalized.

***The research team.*** In addition to the core research team of six full-time staff, a larger team of local representatives was established. This group meets regularly, providing feedback on research activities and advice on future work. More importantly, the direct involvement of these representatives in the actual implementation of the research (household surveys) has contributed greatly to the exchange of information, training of local researchers, complementarity of research efforts and a greater interest and sense of local ownership over the research and its findings. Through the formal agreement with the Ministry of Health, they have provided an environmental health expert for testing the quality of water sources and taking stool samples for parasitic infections. In addition, a recent graduate from the nursing program is conducting her one-year rural residency with the project. The Director of FECONU is leading the study on the role of the fisheries in nutrition and facilitating community participation in the native sites. And lastly, two health promoters from the government nutrition program (Kusiykulu) and AMUCAU are conducting the anthropometric assessments at all sites.

***Site selection*** was a critical step in the research. Specific criteria were identified in order to capture the heterogeneity of the region and all local partners were involved in the process. Eight sites were selected based on differences in;

- ecosystem type (riverine versus upland forests)
- ethnicity (native versus colonist)
- access to markets and involvement in market economy
- time of settlement (early versus old frontier)
- dominant land use strategy (slash and burn agriculture, fishing, cattle ranching and oil palm plantations).

The research sites include:

Riverine communities:

| | |
|---|---|
| Upper Ucayali River | Cunchuri (mestizo) |
| | Puerto Belén (native) |
| | Caco Macaya* (native) |
| Aguaytía River | Santa Rosa (native) |
| | Naranjal* (mestizo) |

Upland communities:

| | |
|---|---|
| Palmeros*(Neshuya-Curimaná) | Oil palm growers (mestizo) |
| Ganaderos (CampoVerde-Km 80) | Cattle ranchers (mestizo) |
| Hierbas Buenas (Km 38) | Slash-and-burn agriculture (mestizo) |

Cao Macaya, Naranjal and Neshuya-Curimaná are sites for the ethnographic study.

Two research methods are being used:

i) household and community surveys of all eight sites (3-4 days at each site), and
ii) ethnographic study of three sites (10-12 days at each site).

Research visits for the surveys are being carried out for:

i) household and community surveys in June-July 1999 (dry season), October-November 1999 (start of the rainy season), February-March 2000 (height of wet season).

This captures the seasonal changes that result from the 10m rise in river levels in the rainy season. The affect of the hydrological cycle on food availability, water quality and disease incidence is critical to understanding the health and ecological dynamics of the rainforest and its inhabitants.

ii) ethnographic study, research visits are in; August-September 1999 (dry season), Jan-February 2000 (wet season).

Tables 1 and 2 indicate the frequency of collection and period of recall of each variable measured.

Within the household, the primary female and male caregivers are the main informants. Children are divided into four categories (0-23 months, 2-5 years, 6-10 years, 11-18 years) and one child is selected randomly from each category. Within each research site, between 32 and 50 families are interviewed, depending on the size of the community. In the ethnographic study, participatory research methods are used, with specific emphasis on gender dynamics, intra-household food allocation, local beliefs and knowledge of health and nutrition, ethnographic food classification and decision-making processes regarding the diagnosis and treatment of childhood illness. All community members are participants in the ethnographic study.

***The Ecosystem Approach.*** The goal of the Ecosystem Approaches to Human Health Program Initiative at IDRC is to improve human health by supporting trans-disciplinary research on the structure and function of stressed ecosystems on which people depend for their livelihoods and by applying this knowledge to the development of appropriate and effective interventions and policies.

In contrast to the more traditional medical model of health, the ecosystem approach focuses on the relationship between health and ecology. This shift in focus to the surrounding ecosystem and its impact on health, forces us to consider for example, how floods and poor water quality affect parasitic infections and incidence of diarrhea, how biodiversity increases dietary quality and reduces susceptibility to micronutrient malnutrition, how soil infertility and land degradation reduce household food security and how the lack of hygiene and sanitation practices facilitates the spread of infectious disease.

The ecosystem approach is guided by three principles; it is hierarchical, participatory and adaptive. Ecosystems exist in nested hierarchies; each comprised of smaller systems while at the same time being part of a larger whole. The different layers (individual, household, community, region) evolve within a variety of ecological and socio-economic contexts and constraints constraints (Allen et al. 1982; 1993; Conway 1987). Research and intervention must therefore target all levels, recognizing that the decision-making constraints imposed by governance structures at the regional and national level impact on the array of options available at the household level. An ecosystem approach is inherently participatory. Its ultimate goal is to create a locally-driven sustainable process to assess, analyze and alleviate malnutrition. It aims to enhance local capacity to cope with key problems affecting human health, increase self-reliance and reduce the need for external funds and expertise. A participatory approach allows local stakeholders to define their own goals and develop a sense of ownership over the research findings and desired interventions. Lastly, an ecosystem approach is adaptive, recognizing that socio-ecological systems are dynamic and often unpredictable. Interventions emphasize the development of social and human capital, with the understanding that the capacity of people and institutions to adapt to sudden and unexpected stresses, is what ultimately leads to a more sustainable and resilient system.

**Projected Outputs:**

(i) Report of nutritional and health status of men, women and children in selected communities and the significant determinants of nutritional status

(ii) Analysis of the impact of seasonality on resource use activities, food availability, income levels and disease periodicity, and identification of critical periods when cycles of disease and food insecurity most severely threaten the health of women and children

(iii) Community Action Plan (CAPs) for each site, addressing key health and nutrition problems and incorporating local definitions and indicators of human health

(iv) Dietary guidelines for each community, based on the availability of local sources of nutrient-rich foods

(v) Educational programs and improved nutrition programs targeting high-risk groups and critical periods when the cycles of nutrient intake and disease most adversely affect health.

(vi) Small-scale food production projects in each community, aimed at increasing the diversity of foods consumed, eg. family gardens, small animals, fruit orchards and fish ponds.

(vii) Short course developed for local university students in agronomy and health addressing the issues of malnutrition and health in Ucayali, based on the insights gained at the eight research sites.

**Projected Impacts:**

This project has two key potential impacts. First, the resulting analyses of nutritional status will allow more targeted and effective nutrition rehabilitation and health programs at the regional level. At the site level, community action plans, dietary guidelines and small-scale food production projects will increase dietary quality and diversity and reduce nutrient deficiencies.

Second, the project may play an important role in the assessment of alternative land use options for the Pucallpa benchmark site. Despite a myriad of international studies, the link between agricultural development and health and nutritional status is not yet clear (von Braun et al. 1994). Increases in production and income that result from improved technologies and agricultural intensification may, but do not necessarily, lead to changes in health and nutritional status. As one of the main goals of PE5 is to evaluate the biological and socio-economic impact of different land use options, this project provides the methods and data to broaden this evaluation and include the consequences for human health and nutrition.

**Contributors:**

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*Collaborators:* The official collaborating organizations are CIAT; Ministry of Health, Ucayali; Ministry of Fisheries, Ucayali; Instituto de Investigacion de la Amazonia Peruana; University of Guelph; and the University of Waterloo.
Individuals involved are: Tamsyn Murray (CIAT Pucallpa/Univ. of Western Sydney Hawkesbury); David Waltner-Toews (Univ. of Guelph); James Kay (Univ. of Waterloo); Douglas White, José Sanchez Choy, Carolina Rengifo, Yolanda Malqui, Francisco Econaise, Maria Elena De Aguila (CIAT, Pucallpa); Tania Tuesta, Victor Gonzales (Ministry of Health, Ucayali); Juan Carlos Saavedra (Ministry of Fisheries, Ucayali); Rafael Uriqui, Adolfo Pino (FECONU); Sam Fujisaka (CIAT, Palmira), Peter Berti (PATH Canada).

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**Table 1. Data Collection for Surveys**

| Level | Indicators | Variables | Survey 1 Ju-Ju 99 | Survey 2 Oc-No99 | Survey 3 MaAp00 | Methods | Freq.of collection/ Period of recall |
|---|---|---|---|---|---|---|---|
| Landscape | Ecosystem productivity | Soil fertility | | X | | Soil tests | Once at each site |
| Community | Access to food | Food prices | X | X | X | Observe | 3X |
| | | Food availability | X | X | X | Observe | 3X |
| | Access to health services | Health services available | X | X | X | Interview with health worker | Once on initial visit/ Include changes during study |
| Household | Socio-economic status | Wealth index | | X | | Recall | Once |
| | | Non-food expenditures | | X | | Recall | Once. Recall period varies with item |
| | Nutritional status Food Security | Energy and nutrient intake | X | X | X | 24 hour recall | 3X for prior 24 hours |
| | Dietary Quality | Nutrient intake | X | X | X | Food frequency recall | 3X for prior 7 days |
| | Dietary diversity | Food sources | X | X | X | Recall | 3X for prior 24 hours |
| | Income level; diversity | Income by source | X | X | X | Recall | 3X, round 1 for prior growing season, round 2 and 3 for period b/w visits. |
| | Production levels; diversity | Production and extraction outputs | X | X | X | Recall | Same as above |
| | Food security | Crop storage | | X | X | Recall | 2X, report what is in storage at time of visit |
| | Water access; contamination | Water Quality | X | X | X | Water samples | Three times |
| | Environmental health | Hygiene Practices | | X | | Recall | Once |
| Child | Growth and development | Anthropometric measurements | X | X | X | Actual measurement | Three times |
| | Nutritional status | Energy and nutrient intake | X | X | X | Recall | 3X for prior 24 hours |
| | Health status | Breastfeeding history | X | | | Recall by mother | Once on initial visit |
| | | Diarrhea incidence & patterns | X | X | X | Recall by mother | 3X, round 1 for prior 6 months, round 2 and 3 for period between visits |
| | | Incidence and patterns of respiratory infections | X | X | X | Recall by mother | Same as above |
| | | Morbidity patterns | | X | | Recall by mother | Once for prior six months and whole life |
| | | Mortality | | X | | Recall by mother | Once, deaths during survey period are recorded |
| | | Iron Status | | X | X | Measurement of haemoglobin | Twice (PATH anemia strip) |
| | | Parasitic infection | | X | X | Stool samples | Twice |

| Level | Indicators | Variables | Survey 1 Ju-Ju 99 | Survey 2 Oc-No99 | Survey 3 MaAp00 | Methods | Freq.of collection/ Period of recall |
|---|---|---|---|---|---|---|---|
| Women | Nutritional status | Energy and nutrient intake | X | X | X | Recall | 3X for prior 24 hours |
| | Female fertility | Reproductive history | X | | | Recall | Once on initial visit |
| | Health status | Morbidity patterns | | X | | Recall | Once, deaths during survey period are recorded |
| | Labour demand | Time allocation | X | X | X | Recall | 3X for prior 24 hours |
| Men | Nutritional status | Energy and nutrient intake | X | X | X | Recall | Same as above |
| | Labor demand | Time allocation | X | X | X | Recall | Same as above |

**Table 2: Data Collection for Ethnographic Study**

| Level | Variables | Summer AuSe99 | Winter JaFe00 | Methods | Participants<br>* *number in brackets indicates the # of groups* | Freq. of collection/ period of recall |
|---|---|---|---|---|---|---|
| Landscape | Spatial mapping of ecological diversity; lakes, swamps, forests, rivers, palm forests etc. | X | X | GPS/GIS | Farmers/fishermen/ hunters and gatherers | Twice |
| | Spatial mapping of resource use activities; farming, fishing, hunting, gathering and logging | X | X | GPS/GIS | Farmers/fishermen/ hunters and gatherers | Twice |
| Community | Sources of information | X | | Observe/key informant interviews | Community leaders, teachers, students | Once |
| | Community organization | X | | Observe/key informant interviews | Community leaders, teachers | Once |
| | Community facilities and resources | X | X | Community mapping | 2 groups of male comm. members approx. 20 people | Twice |
| | Hygiene and sanitation | X | X | Observation, Community mapping & Health walk | 2 groups of female comm. members approx. 20 people | Twice |
| | Disease periodicity | X | X | Seasonal calendar (focus group) | 2 groups of female comm. members approx. 20 people | Twice, summer and winter recall periods |
| | Historical information | X | | Timeline (focus groups) | Groups of 6-9 people<br>• Elderly (1*)<br>• Fishermen (2)<br>• Hunters (2)<br>• Farmers (2)<br>• Women (3) | Once, for entire history of community |

| Level | Variables | Summer AuSe99 | Winter JaFe00 | Methods | Participants<br>** number in brackets indicates the # of groups* | Freq. of collection/ period of recall |
|---|---|---|---|---|---|---|
| Individual | Diarrhea management | X | X | Key informant interv./ case histories and decision models | Interviews with:<br>• 8-10 people knowledgeable of health issues<br>• 10 women with children with a recent diarrhea episode | Twice in dry and wet seasons |
| | Nutritional ethnography (local classification) | X | | Pile sort/food attributes/attribute rating | Small groups of 2-3 people include:<br>• women with children < 5 yrs. (5)<br>• women > 45 yrs (5)<br>• men (2)<br>• adolescents (2)<br>• teachers (2) | Once |
| | Health ethnography | X | | Focus groups | Focus groups include:<br>• women with children < 5 yrs (2)<br>• women > 45 yrs (2)<br>• men (1)<br>• adolescents (1) | Once |
| | Fertility (pregnancy, prenatal care, birth, diet, contraception etc.) | X | | Interviews | Interviews with 10 women of different ages | Once |
| | Risk Management (identification of risks, frequency, predictability and coping strategies) | X | X | Focus groups | Groups of 6-9 people<br>• Elderly (1)<br>• Fishermen (2)<br>• Hunters (2)<br>• Farmers (2)<br>• Women (3) | Twice (recall is to the extent to which they can remember) |

# *Activity 1.4 Evaluate social and private trade-offs of alternative land use options*

## 1.4.1 Fallow management strategies and trade-off analysis of the economic value of fallow periods in the Aguaytia watershed

**Purpose:** To analyze the economic value and trade-off of fallow management strategies.

**Rationale:** In slash-and-burn agricultural systems, lands are fallowed to rejuvenate soil fertility and to reduce weed proliferation. Yet as land becomes scarce, farmers often shorten fallow periods (Thiele, 1993). However, shortened fallow typically come at a double cost, namely, lower crop yields and higher labor requirements for weeding. Alternatives to the traditional fallow-cropping cycles of slash-and-burn agriculture systems include improved fallow and secondary forest management. Whereas improved fallow research attempt to make the rotation period shorter with the introduction of trees and leguminous cover crops, secondary forest management concentrates upon the non-agricultural products provided by the maturing fallow. Both national and international research institutions commonly have initiatives to intensify the use of agricultural and secondary forest land. It is seen as a way to increase farm earnings and reduce pressure upon the forest resources, intensification is seen to be a win-win situation.

Yet the economic benefits and costs of the improved fallow and secondary forest management options are not well known. For example, an experiment by (Montagnini and Mendelsohn, 1997) conducted on an agricultural research station touted the potential benefits of improved fallows. An assumed real interest rate of 5% makes the results seem unreal as smallholder farmers typically face high interest rates in order to borrow capital funds. Again the whole issue of farmer adoption of the improved fallow technology option was overlooked.

**Outputs:** The research will focus upon the following:

- the effect of fallow periods and other significant determinants upon agricultural yields
- an economic value of resting the land i.e. the latent (non-use) value of the secondary forest.
- the sensitivity of agriculture-secondary forest tradeoffs to changes in interest rates and prices of agricultural and forest products.

**Impact :** The three IARC's, ICRAF, CIFOR and CIAT, working in the Ecoregional Center in Pucallpa, have identified fallow as an integral component of their research agenda. A joint study has been planned between the three centers. As a result, planning and implementation has taken longer than expected but with an anticipated outcome of a more widely accepted output. Theoretical and empirical analyses have commenced and will be completed in 2000.

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## *Activity 1.5 Synthesize of results from different outputs and activities*

### 1.5.1 Effect of pasture intensification in the forest margins, Peru, Latin America

**Highlights:**

- Empirical evidence supports the hypothesis that forest scarcity is a prerequisite for intensification of agricultural technology.

**Purpose:** To examine the ability of intensive pasture technology to positively or negatively affect deforestation rate and to identify conditions that lead to more adoption.

**Rationale:** As part of a CIFOR conference entitled *Agricultural Technology Intensification and Deforestation*, CIAT presented results of its research experience with improved pastures. Two opposing schools of thought regarding the effect of improved pasture technologies are found in the literature: either they increase deforestation, or decrease deforestation. Little empirical evidence is used to support either argument. In this paper, in addition to providing empirical results, we add a third perspective: pasture technologies can also have no effect upon forest cover.

**Methods:** The paper employed empirical data from the research and extension consortium *Tropileche*. Since longitudinal data linking pasture and forest cover are scarce, a synthesis approach was used linking empirical results from three research sites (Costa Rica, Perú and Colombia). These sites provide a stage on which to compare the introduction and effects of an intensive technology option, improved feeding systems for small-scale farmer milk and beef production, upon the forest.

**Outputs:** Given that the value of forested land in tropical Latin America (and elsewhere) is low, continued deforestation and extensive cattle production appear to be rational private choices. The forest margin regions of the Amazon provide an example of such land use. In the case of older forest margins, which are more developed regions such as in Central America and increasingly in South America, farmers intensify production in order to prevent degradation of pastures and avoid the higher cost option of expanding onto neighboring lands. Hence, the initial question posed by the conference, whether intensification causes increased or decreased deforestation has resulted in an unfortunate alternative hypothesis: *forest scarcity is a pre-requisite for technology intensification.*

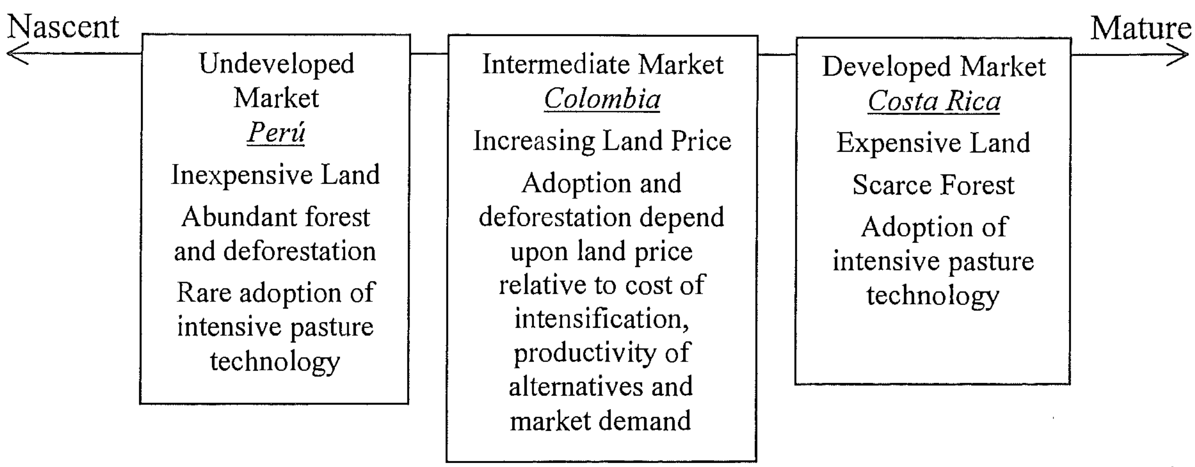
Causal links between the intensification of pasture technology and deforestation are difficult to determine. The relationship contains the combined issues of land degradation, technology feasibility, adoption, and farmer incentives to preserve forests. Out of a set of bio-physical and socio-economic factors presented for each of the study sites, we distinguish one measure, land price, which captures the effect of two opposing forces: the level of development (i.e. market access) and the amount of forest cover. In areas where land prices are low, markets are immature and forest is relatively abundant. Whereas where land prices are high, markets are more developed and forest cover is scarce. Land price also serves as an *ex-ante* indicator for the feasibility of pasture technology adoption.

A land use history framework permits a linking of empirical evidence from the case study sites to test the hypothesis (**Figure 1**). On one side of the continuum lie nascent regions with low land values where intensive pasture technologies are not adopted. In these areas, both continued deforestation and extensive cattle production appear to be rational private choices. Hence technology adoption, the first step required to affecting forest cover, is not an attractive option. The Peruvian Amazon is an example of such land use.

On the other side of the continuum, lie regions where improved pasture technologies are an attractive option and appear to be adopted yet the effect on forest cover is small since little forest remains.

Nevertheless, there may be opportunity for reforesting land areas. An intermediate position along the continuum is where adoption is feasible and may reduce pressure on forest cover. As land use becomes more mature, with less forest and better developed markets, land prices rise. In Colombia and to a greater extent in Costa Rica, farmers intensify production in order to avoid degradation of pastures and the higher cost option of expanding onto neighboring lands.

**Figure 1. A Land Use Continuum with respect to Markets, Land Prices, Forest Cover and Technology Adoption**




Policy interventions will be needed in order to achieve long-term success in controlling deforestation. In tropical Latin America where land degradation can spur further deforestation, technological advances that make land productive again are a critical component of a policy response. Yet minimizing deforestation and land degradation are but two environmental objectives. A concurrent issue is the human welfare of those living at the forest margin. Technical advances such as improved pastures will achieve these multi-faceted objectives of human welfare and environmental quality as long as they are properly targeted and coupled with policies that will restrict deforestation or make it an unattractive financial alternative.

**Impact**: While perhaps unpleasing to some, the future of forest margin regions will continue to have cattle because of producer and consumer demands. In many frontier regions, farmers search for profitable land use alternatives. Examples of desperation are the Pucallpa farmers who establish pastures without having cattle. The mere hope of having cattle is enough to compel the land use decision. Moreover, consumer demand increases for animal products are expected to be especially large. For developing countries, future expansion of the livestock industry is predicted to be so great that an IFPRI/FAO/ILRI, (1998) study calls it 'The Next Food Revolution.'

Whether the necessary increases in agricultural and animal production will be extensive or more intensive/commercial remains open to debate (May and Segura Bonilla, 1997). The implications of failing to implicate a relation between deforestation and intensification necessitates a shift from examining the positive or negative impacts of intensification on deforestation to one of how to guide research efforts so that deforestation and extensive land use become a less attractive option for farmers. Together, both technical research to increase land use productivity, and policy research to test ways to increase incentives for forest preservation, become a pressing global need.

**Contributors***:* D. White, F.Holmann, S.Fujisaka, and C.Lascano (CIAT); K.Reategui (DEPAM)

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### 1.5.2 A range of forage options for different farming systems in Southeast Asia

**Highlights**

- A broad range of forage technology options identified for smallholder farms in Southeast Asia

**Purpose:** To integrate forage technology options to improve feed resources and resource management in smallholder farming systems in Southeast Asia, in particular, in Indonesia, Laos, Philippines and Vietnam.

**Rationale:** Livestock provide much needed stability in fragile upland agricultural systems in Asia. They provide an opportunity to accumulate capital (which can be readily converted into cash in times of need), food, draught power and they contribute substantially to nutrient cycling through manure. Ruminants utilize freely-available local feed resources, such as residues from crop fields and communal grasslands, forests and roadsides. These feed resources are 'free' to the farmer as they cannot be utilized in other ways. With intensification of agricultural lands, the communal feed resources are becoming scarcer, and, degraded by over-use. The options are to reduce the number of animals or intensify forage production. Once farmers perceive a need for planting forages, these can be grown in ways which not only provide feed but also enhance natural resource management through suppression of weeds, improvement of soil fertility and control of erosion.

**Methods:** During the last five years the Forages for Smallholder Project (FSP), funded by AusAID, has been using farmer participatory approaches (see Outputs 2.4 and 4.6) and conventional 'forage evaluation' techniques (Output 2.4) to develop sustainable forage technology options for resource-poor upland farms in Southeast Asia. The project has been working at 18 sites in Southeast Asia (**Figure 1**), which cover the main range of environments and upland farming systems of the region.

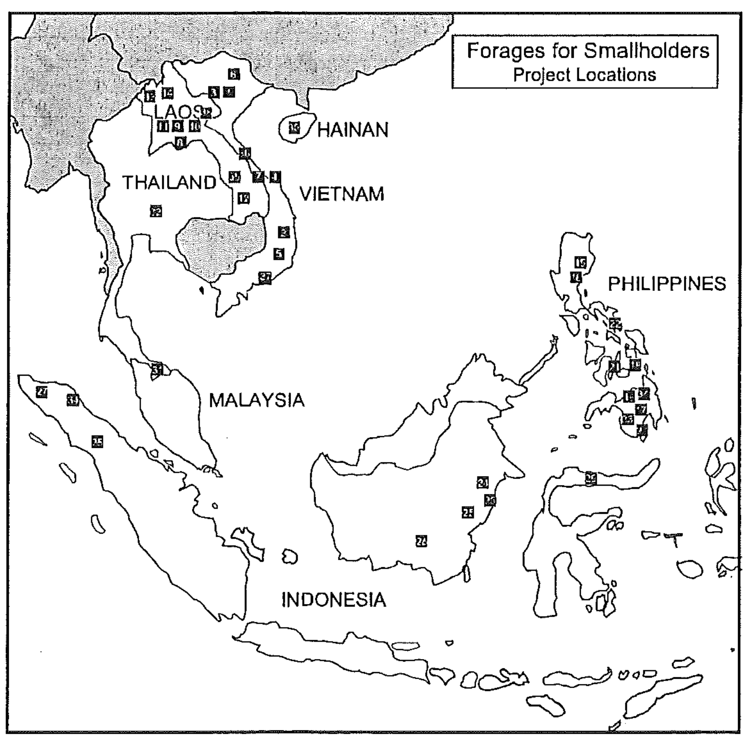


**Figure 1. Project locations of the Forages for Smallholders Project (includes on-farm, regional and nursery evaluation sites)**

**Outputs:** A summary of the forage technology options that are being evaluated and adopted by farmers in different agricultural systems is shown in **Table 1**. Intensively managed 'cut & carry' grass plots near houses or animal sheds are being evaluated and adopted in almost all areas regardless of the type of agricultural system. Often farmers identified a lack of labor as a limitation and they see intensively managed plots as an attractive way of reducing the demand on labor of keeping livestock. In many cases farmers intend to use these intensively managed plots only at specific times. Examples are days when they have to go to the market, some family members are sick, or during periods of peak labor demand by other agricultural activities. In other cases stalling animals facilitates manure collection for use on high return agricultural crops such as coffee.

**Table 1. Forage technology options for upland farms in Southeast Asia**

| Farming systems | Forage technology options | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut & carry plots | Grazed plots | Living fences | Hedgerows | Improved fallow | Cover crops in annual crops | Cover crops under trees | Ground covers for erosion control | Legume supplementation for the dry season | Legume leaf meal | Grass & legume for fish |
| Short-duration slash & burn | ✓ | | ❍ | | ❍ | | | | | | |
| Grassland | ✓ | ❍ | ✓ | | | | | | | | |
| Plantation | ✓ | | | | | | ✓ | | | | |
| Extensive upland | ✓ | | | | ❍ | ❍ | | | | | |
| Moderately intensive upland | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ❍ | | |
| Intensive upland | ✓ | | ❍ | ✓ | | | ✓ | ✓ | ❍ | | ✓ |
| Rain-fed lowland | ✓ | | ❍ | | | | | | ✓ | ❍ | |

✓ = forage technology adoption occurring
❍ = emerging or potential forage technologies

The range of technologies tested by farmers increases as they become familiar with forages and they see more opportunities on their farms. Some technologies aimed at better resource management are emerging in the more intensive systems. These include grasses grown in contour hedgerows or for stabilizing gully erosion, legumes as ground covers and grasses and legumes for feeding fish.

**Impact:** More than 1000 farmers are already growing improved forage technologies at FSP sites which is above the target of 720 set by the year 2000. The impact of the introduction of new forage species and forage technologies is currently being assessed and will be available by November 1999. The study of impact includes a rapid survey at several sites (see Output 1.2.2), more formal study at two sites (see Output 3.4) and a monitoring and evaluation system (Forage Adoption Tree) at all sites (see Output 3.4). At several sites considerable spontaneous adoption has been observed (Staples and Roder 1998). There has been a formal request by Laos and Vietnam for bi-lateral country projects to extend the introduction of forages to larger numbers of farmers.

Nevertheless the challenge ahead is to consolidate the gains made by continuing to work with farmers to assist them with further developing their feeding systems. Participatory technology development with farmers is an on going process not a one-off injection of species into farming systems. New farmers tend to grow forages in cut & carry plots; only those with two of three years of experience have expanded and are growing forages in other ways such as contour hedgerows or ground covers for erosion control. Some have realized the potential of these new technologies and started to fatten animals for sale.

The use of forages is spreading to areas near the project sites and this process should also be supported and monitored. The FSP has shown that participatory research is an effective approach to technology development. The next challenge is to develop participatory approaches for use in extension of technologies and agricultural information. Support for continuing this process of technology development and disseminating the technologies has been assured by the Asian Development Bank.

**Table 1. Forage technology options for upland farms in Southeast Asia**

| Farming systems | Forage technology options | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cut & carry plots | Grazed plots | Living fences | Hedgerows | Improved fallow | Cover crops in annual crops | Cover crops under trees | Ground covers for erosion control | Legume supplementation for the dry season | Legume leaf meal | Grass & legume for fish |
| Short-duration slash & burn | ✓ | | O | | O | | | | | | |
| Grassland | ✓ | O | ✓ | | | | | | | | |
| Plantation | ✓ | | | | | | ✓ | | | | |
| Extensive upland | ✓ | | | | O | O | | | | | |
| Moderately intensive upland | ✓ | | | ✓ | ✓ | ✓ | | ✓ | O | | |
| Intensive upland | ✓ | | O | ✓ | | | ✓ | ✓ | O | | ✓ |
| Rain-fed lowland | ✓ | | O | | | | | | ✓ | O | |

✓ = forage technology adoption occurring
O = emerging or potential forage technologies

**Contributors:** Werner Stür, Francisco Gabunada and Louie Orencia (CIAT, FSP Philippines); Peter Horne and Phonepaseuth Phengsavanh (CSIRO, FSP Laos); Viengsavanh Phimphachanhvongsod (NAFRI, Laos); Maimunah Tuhulele (DGLS, Indonesia); Ibrahim (Livestock Service, East Kalimantan, Indonesia); Tatang Ibrahim (BPTP, North Sumatra, Indonesia); Ed Magboo (PCARRD, Philippines); Willie Nacalaban (LGU, Malitbog, Philippines); Perla Asis, LGU, Cagayan de Oro, Philippines); Le Hoa Binh (NIAH, Vietnam), Le Van An (UAF, Hue, Vietnam), Bui Xuan An (UAF, Ho Chi Minh City, Vietnam), Bryan Hacker (CSIRO Tropical Agriculture, Brisbane, Australia), Peter Kerridge (CIAT, Cali, Colombia).

### 1.5.3 Synthesis of information on legume green manure/cover crops in Eastern Africa

**Highlights**

- Information was compiled and interpreted for the best-bet green manure and cover crop (GMCC) options, their niches were identified, and recommendations were formulated for dissemination.

**Purpose:** To make information from research and experiences more easily available to researchers, development workers and farmer on the use of GMCC options

**Rationale:** There is a long history of research and development efforts on the use of GMCC legumes. The information is not sufficiently available to many workers for it to be well used. Needless false starts and duplication of efforts occur because of inadequate consideration of the work of others. A synthesis and interpretation of available information is expected to enable those working with GMCC legumes to achieve greater success.

**Methods:**
Dr. C. Gachene did an initial synthesis and interpretation of available information. A working group meeting followed to add to the synthesis and interpretation, to identify 'best bet options' and their niches, and recommend future activities.

**Outcome:** The 'best bet options' included *Mucuna pruriens* (Velvetbean), *Canavalia ensiformis* (Jackbean), *Crotalaria (ochroleuca and juncea)*, *Lablab purpureus*, *Desmodium* (*intortum* and *uncinatum*), *Vicia (dasycarpa,* and *benghalensis)*, and *Tephrosia vogelii.*

This synthesis is being documented by the African Highlands Initiative.

**Collaborators:** C. Gachene (U. of Nairobi), C. Palm (TSBF), J. Mureithi (Rockefeller Foundation), C. Wortmann (CIAT).

# Output 2. Component technologies for sustainable production developed through farmer participatory research

## *Activity 2.1 Farmer experimentation to adapt technologies*

### 2.1.1 Multi-Institutional and Participatory Research in Pucallpa (DEPAM)
(see also Ouputs 4.2.1 and 4.5.1)

**Highlights**

- 47 Researchers from 13 institutions are collaborating in 11 interdisciplinary and participatory research projects in Pucallpa, testing innovative technology options jointly with farmers.

**Purpose:** To create a collaborative team of researchers from national and international institutions in Pucallpa who jointly plan and carry out participatory agricultural research projects that are demand driven.

DEPAM (Desarrollo Particpativo Amazonico) is the entry point in a long-term strategy to facilitate the institutionalization of collaborative and participatory research approaches among national and international centers in Pucallpa and which will be led by national researchers.

**Rationale:** A need was seen to link strategic and applied research being conducted by the international Centers more closely to issues identified by local stakeholders, which include both the farmers and local R&D organizations and to introduce a more participatory approach to solution of problems. There was also an opportunity to facilitate closer collaboration between all organizations working in Pucallpa, which is needed to ensure efficient use of scarce resources.

**Process:** Priorities areas for research and a workplan were developed by the stakeholders during a three-day workshop in February 1998. A Stakeholder Committee of farmers and farmer organization representatives has been formed to continue the process of priority setting, to monitor research and adoption of the outputs. An Advisory Committee, comprised of representatives of organizations that participate in the Participatory Research Team (DEPAM), provides technical advise and also monitors the research. CODESU provides administrative support and CIAT technical support in the areas of agronomy and participatory research and in training. Small research grants are being used as an incentive for institutions to work together in a farmer participatory approach. (**Figure 1**).

**Outputs:** Considerable progress has been made in establishing the Participatory Research Team. The Stakeholder and Advisory Committees have been meeting regularly, on some occasions jointly. The project coordinator was appointed in May 1998 and agroindustry specialist in October 1998. Institutions have given their support to developing joint projects and active research is underway through the small grant scheme. The Participatory Research Team (DEPAM) meets regularly. CIAT has appointed a scientist with experience in participatory research and institutional relationships to facilitate the process. An initial course in farmer participatory research will be held in October 1998 and a new series of courses is in progress,

To date, one of the DEPAM projects (Survey of Fish Culture) has been completed, and one (the CIAT-led project testing new varieties of rice and banana) has completed two production cycles. The following is a summary of the projects that have been established.

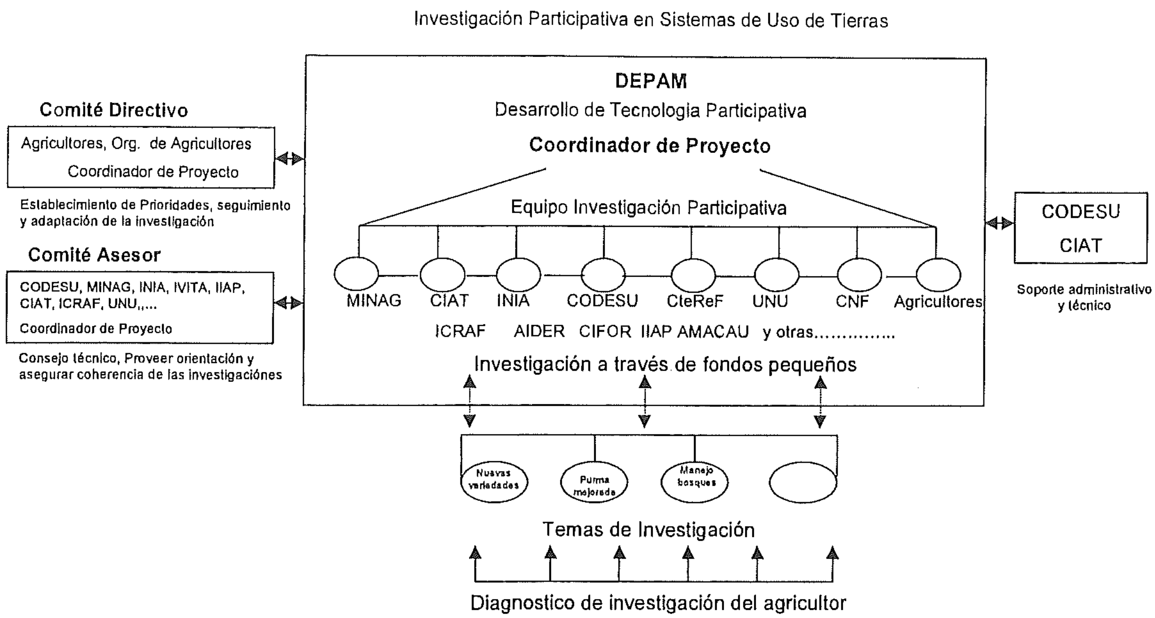


**Figure 1. Structural representation of operation of DEPAM**

## (i) Botanical Origins of Honey from Secondary Forests in Pucallpa

This project works with 57 apiculturalists, the majority new to honey production. The project has given training and support to these farmers, and has a core group of some 6 farmers who regularly record details on foraging behavior of honeybees, and the plant species they visit. These species are being identified, and the information prepared to share back with all participating farmers.

This aspect of the project was overtaken by problems of a long winter with a consequent loss of queens from the colonies of inexperienced apiculturalists, but the project responded by sharing information among farmers regarding capture and maintenance of queens.

The first harvest of honey from the project hives is being collected at the time of writing.

## (ii) Fish Culture integrated with Agricultural Development

This diagnostic project, now completed, identified a declining use of existing fish tanks with corresponding deterioration of infrastructure with only 53% of existing fish tanks are in use. The 97 farmers involved in the study claimed that the principal reasons for this are a lack of capital, a lack of technical information, robberies, and competing sources of fish. A participatory planning process with farmers has led to the development of a subsequent proposal.

### (iii) Production Systems involving Management of Secondary Forest Species

This project creates an audit with farming families of the actual and potential economic value of species found in their secondary forests, with help from local expert farmers. On the basis of this information, the following project was designed.

### (iv) Secondary Forest as a Component of the Economy of small- and medium-sized Farms

A diagnosis and planning meeting with 60 farmers led to the development of strategies for management of secondary forests to realize more of their potential value. Individual action plans are currently being developed from these with individual farmers, separately with men and women, and involving different mixes of institutional resources depending on the needs of each farmer.

### (v) Participatory Evaluation of varieties of rice and banana on smallholder farms

(See Output 2.1.2 for full details.)

40 farmers have tested five new rice varieties. Yields of the new varieties were not higher than traditional varieties, yet farmers report that 3 of the varieties will be widely adopted in the following season due to superior characteristics such as early maturing, resistance to pests, and cooking qualities. In addition, the trials have integrated with and amplified farmers' existing informal research, with 36% of the farmers reporting that they will continue deliberate testing of the varieties in the following season.

Separately, 9 villages have installed trials of new varieties of potentially Sigatoka-resistant banana following their own methods of evaluation, in September 1999. One village preferred a single, large, communally-managed trial, while the remainder chose to spread their resources across many farms, as a response to diversity in conditions and a lack of trust in communal activities. Within all villages, there is enthusiasm to share and compare results. An additional goal is that joint decisions making in each of these systems will increase the ability of the groups involved to coordinate future research and development activities together.

### (vi) Participatory Research in management of maize variety Marginal-28

This project tests intensification of maize production in the relatively fertile, yet transient soils of the floodable margin of the Ucayali river. Two trials have been installed with the cooperation of farmers' groups, testing variety, fertilization rates, and plant spacing. Farmer participation at this stage in the project is limited to providing land for the trials.

### (vii) Participatory research in the agricultural system of Ucayali: a farm-level economic evaluation of traditional crops.

(See Output 2.1.3 for full details)

A first-draft, linear programming economic model has been produced that analyses inputs and outputs on a monthly basis for all of the major crop production systems (and mixtures) found in Pucallpa. Data came from interviews with 42 farmers in the region. The model is being refined and applied with participation from research and extension organizations in Pucallpa for a number of uses, such as checking the viability of proposed new crops or interventions.

### (viii) Participatory Evaluation of Soil Management in smallholder farms in Ucayali

This project identified farmers' interest in soil issues through a survey, and works with 60 farmers who share an expressed concern for the maintenance of soil fertility. Farmers have chosen technologies to test from the following options: fertilizer management for annual and for perennial crops, improved fallow, multi-strata systems, and contour hedging.

The results from the first season are being evaluated.

### (ix) Soil Conservation with Agroforestry Systems in the Alexander Von Humboldt zone

This project involves 14 farmers in the design and testing of agrosilvopastoral systems, and multi-strata systems to conserve soil. The farmers have participated in identifying needs, and in designing and implementing the experiments, and will meet to discuss results.

### (x) Biocidal Plants in Ucayali Region

Management of pests and diseases in annual crops was ranked as the first priority of the DEPAM farmer committee. This project aims to create an inventory of plants with biocidal properties to look for innovative solutions, using local knowledge of the properties of plants. The project will start in September 1999.

### (xi) Participatory Evaluation of Market Options for Amazonian Products

This project aims to understand farmers' decisions in selecting crops and markets, design a portfolio of products with market potential which are liked by farmers, and create links between smallholder farmers and markets to establish and strengthen rural agroenterprises. This project is linked with ongoing activities of the DEPAM Agroenterprise Development Unit.

Surveys and group meetings with 168 farmers in 60 communities have identified diverse priorities for farmers throughout the region. Roadside farmers want to try growing *cocona* because of its rapid production; riverine farmers would prefer *camu-camu* due largely to its secure market and profitability. The project is continuing with a study of the effectiveness of local businesses.

**Impact:** Apart from the CIAT-led project testing rice and banana varieties (Section 2.1.2), none of the projects has completed a cropping cycle, so it is not yet possible to evaluate the impact of the technologies that are being produced. However, the *processes* of participating with both farmers and with partner institutions have brought about changes in the ways that research is carried out in the projects. The participatory research team reported the following benefits from working in a participatory fashion in the projects:

- There is a better interaction between the researcher and the farmer
- Adoption of results of research are immediate, unlike in traditional research
- It takes advantage of the knowledge of the farmer about their own conditions, environment, and production technologies
- The farmers identify their problems and intervene with their own solutions
- Institutional strengths are better used
- There is full participation of the farmer and their family

The projects are also having impacts within institutions, creating a new forum for joint implementation and collaboration in field activities.

**Contributors:**

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## 2.1.2 Farmer rice and banana trials in the Aguaytia watershed, Pucallpa

**Highlights:**

- More farmers are testing and adopting new rice varieties;
- Nine farmer communities have commenced evaluation of potentially Sigatoka-resistant banana varieties
- National researchers are developing skills and experience in participatory research approaches.

**Purpose:** Farmers wanted to solve problems associated with their upland rice and with Sigatoka in bananas. Research goals in the forest margins include solving problems not only related to shorter-term private needs (e.g., crop production) but also to longer-term system sustainability and wider social goals (e.g., biodiversity maintenance and reduction of GHG emissions). Research seeks to increase farmer participation and to gradually and in step-wise fashion widen the scope of such participation.

**Rationale:** Previous projects have been unsuccessful in working with farmers on improved fallow, the incorporation of legumes in systems, secondary forest management, biodiversity conservation, and other more "knowledge-intensive" technologies leading to improved systems sustainability. We hypothesized that success in more simple participatory problem solving would facilitate farmer (and NARS enthusiasm).

**Methods:** We first worked with farmers interested in testing new rice varieties. Seed was provided for small plot trials. Researchers helped farmers in the use of replications and controls, sampling, moisture correction, and yield calculations. Farmers selected varieties and trial layouts, and conducted all trial operations. Continual feedback among farmers and researchers was accomplished by field visits and field days throughout the two years and five plantings. Trials and farmer adoption of the new materials has been monitored. The research is "owned" by farmers.

A different process has been followed with testing bananas in order to deepen the communal ownership of the trials. We identified 9 communities where a majority of farmers identified sigatoka in bananas as their principal production problem. We brought to these communities limited numbers of suckers of potentially sikatoga-resistant banana varieties. There were not enough suckers for all interested farmers to try all the varieties that they wanted to. Hence decisions had to be made as a group regarding how the material would be tested.

As the trials with bananas were only commenced recently, this report only presents the results of the rice trials.

**Outputs:** Farmers planted rice trials within five different sets of dates. Farmers tested the introduced varieties CT-11253-6-1-M-M, Porvenir 95, INIA 14, Ucayali 91, Capirona, and Uquihua; and their varieties, Carolino, Chancabanco, and Aguja Blanca in the first three (5-15 Nov 1997, 30 Nov 1997-6 Jan 1998, and 12 Jan-6 Feb 1998) sowings. Yields of the introduced varieties were not superior to yields of farmers' varieties. The second planting period suffered heavily from *El Niño* related drought. Some farmers adopted trial varieties on their own fields after the trials. Yields of the new varieties on farmers' "commercial" fields were satisfactory (mean 1.7 t/ha for rice planted in periods 3 and 4)); but again not superior to farmers' own varieties on their commercial fields (1.7 t/ha in period 3 and 2.3 t/ha in period 4, **Table 1**).

Initially tested materials were lowland varieties introduced to farmers as such. An initial goal was to start the participatory testing, albeit with an understanding by farmers that we were then in the process of multiplying more appropriate upland rices. Farmers suffering from the effects of drought in the second planting period said that they were not discouraged as a result. Enthusiasm by other farmers increased once trials got underway.

**Table 1. Farmers' rice yields, seasons 1-3, Pucallpa, Peru**

| | Farmers' experiments | | | Own fields | |
|---|---|---|---|---|---|
| Season | 1 | 2 | 3 | 3 | 4 |
| **Variety** | (n=5 | 10 | 4) | | |
| *Introduced* | | | | | |
| CT-11253 | - | 0.8 | 1.5 | 2.1 | 1.8 |
| Porvenir | 1.4 | 0.8 | 1.4 | 1.7 | 1.6 |
| INIA 14 | 1.2 | 0.7 | 1.1 | - | 1.7 |
| Ucayali 91 | - | 0.7 | 0.8 | 1.4 | - |
| Capirona | 1.1 | 0.5 | 0.7 | - | - |
| Uquihua | 0.7 | 0.5 | 0.5 | 1.7 | - |
| **Mean** | **1.1** | **0.6** | **1.0** | **1.7** | **1.7** |
| *Local* | | | | | |
| Carolino | 1.3 | 0.9 | 1.0 | 1.7 | 1.8 |
| Chancabanco | - | 0.5 | 1.8 | 1.9 | 2.5 |
| Aguja Blanca | 0.9 | 0.8 | - | 1.5 | - |
| **Mean** | **1.1** | **0.7** | **1.4** | **1.7** | **2.3** |

For the fourth and fifth planting periods (10 Oct-25 Nov 1998 and 14 Sep-5 Oct 1998), farmers tested the introduced varieties CIRAD, IRAT 146, Sabana 10, Sabana 6, and Progresso. Mean yields (2.2 t/ha in period 4 and 1.9 t/h in period 5), were slightly but not significantly higher than those obtained from farmers' varieties (**Table 2**). Farmers continued to adopt selected introduced varieties on their own fields,

**Table 2. Farmers' rice yields (t/ha), seasons 4, 5, Pucallpa, Peru**

| | Season | | Adoption after experiment | | | |
|---|---|---|---|---|---|---|
| | 4 | 5 | | | | |
| **Variety** | (n=19 | 24) | Number adopters | Area (ha) | Number adopters | Area (ha) |
| *Introduced* | | | | | | |
| CIRAD | 2.4 | 1.9 | 9 | 0.9 | 13 | 1.0 |
| IRAT 146 | 2.3 | 2.0 | 6 | 0.9 | 10 | 0.5 |
| Sabana 10 | 2.3 | 2.1 | 8 | 0.9 | 12 | 0.7 |
| Sabana 6 | 2.1 | 1.7 | 5 | 0.4 | 5 | 0.5 |
| Progresso | 2.0 | 1.9 | 7 | 1.0 | 10 | 0.8 |
| **Mean** | **2.2** | **1.9** | | **0.9** | | **0.7** |
| *Local* | | | | | | |
| Chancabanco | 2.5 | 2.3 | | | | |
| Aguja Blanca | 1.7 | 1.4 | | | | |
| Carolino | 2.9 | 2.5 | | | | |
| Cambio 90 | 1.5 | - | | | | |
| Cica 8 | - | 2.2 | | | | |
| **Mean** | **2.0** | **1.8** | | | | |

using seed multiplied from their previous trials. The number of participating farmers increased to 19 in the fourth and 24 in the fifth planting periods.

Farmers evaluated the tested varieties. In general and in response to questions, most desirable was first yield, second panicle size, followed equally by a number of characteristics (**Table 3**). Farmers also evaluated each of the introduced and local varieties against such characteristics (**Table 4**). Using interviews and a participatory matrix, farmers have so far identified the introduced CIRAD 409 and their local Chancabanco and Aguja as superior (**Table 5**). CIRAD 409 and Chancabanco were selected on the basis of slightly shorter duration (95 days) and high yield (2.4 t/ha). Varieties such as Aguja are preferred for cooking/consumption quality in addition to having reasonable yields.

**Table 4. Varietal evaluation (n=52)**

| Variety | Evaluation |
|---|---|
| *Introduced* | |
| *CIRAD 409* | Yield, panicle size, duration, resistance to pests and diseases, small grain, cooking quality, grain breakage, lodging resistance |
| IRAT 146 | Duration, easy to thresh |
| O. Sabana 10 | Yield, panicle size, resistance to pests and diseases, tillering, grain breakage |
| O. Sabana 6 | Panicle size, easy to thresh, cooking quality, lodging resistance |
| Progresso | Yield, tillering, small grain, cooking quality, lodging resistance |
| *Local* | |
| Chancabanco | Yield, duration, not itchy |
| Aguja | Easy to thresh, small grain, cooking quality, grain breakage |
| Carolino | Easy to thresh, grain breakage, not itchy |

**Table 5. Farmer varietal evaluation**

| Variety | Interviews (n=27) | Matrix (n=27) |
|---|---|---|
| *Introduced* | | |
| CIRAD 409 | 15 | I |
| IRAT 146 | 12 | II |
| O. Sabana 10 | 10 | II |
| Progreso | 6 | - |
| O. Sabana 6 | 3 | III |
| Local | | |
| Chancabanco | - | I |
| Aguja | 1 | I |
| CICA 8 | 1 | IV |

The trials have integrated with and amplified farmers' existing informal research, with 36% of the farmers reporting that they will continue deliberate testing of the varieties in the following season. Based in their participation in the rice trials, farmers were enthusiastic about further testing of other crops, especially sikatoka resistant banana and maize (**Table 6**).

**Table 6. Farmer preferences for further testing (n=27)**

| Testing | Frequency |
|---|---|
| Banana | 12 |
| Maize | 9 |
| Peanut | 5 |
| Soya | 5 |
| Bean | 3 |
| Citrus | 3 |
| Yuca | 2 |
| Chiclayo | 2 |
| Cacao | 2 |
| Coffe | 1 |
| Guaraná | 1 |

This wide variety in the desires of farmers for future activities provides an opportunity to increase the ownership by national institutions of the processes of participatory research by responding to the new expressed needs. National counterparts are currently discussing innovative ways to more flexibly manage the project funding to bring about such a change.

**Banana Trials**

Of the 9 communities, one designed a single communal trial of the banana varieties, while the others chose to distribute the materials among all interested farmers in response to a stated diversity in conditions, and a stated lack of trust among community members to engage in communal work. Within the communities , farmers will compare data on yield and sigatoka incidence.

**Impact:** Activities in Pucallpa seek to facilitate participatory and collaborative research as a means to solving a range of problems. Numbers of participating farmers have initially decreased and then increased over the period of rice testing. Farmers and researchers from different participating NARS expressed positive views about the participatory research (**Table** 7). Farmers working with researchers on rice are now interested in testing other crops (and are starting to test bananas). We continue to work towards farmer and institutional interest in more knowledge-intensive technologies oriented towards maintaining sustainability and meeting social goals.

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**Table 7. Statements by technicians and farmers**

| Person | Statement |
|---|---|
| Technicians from | |
| *DRAU* | "Me comprometo a incluir otros agricultores, que no han participado en el ensayo, para la próxima campaña" |
| INIA | "Para solucionar los problemas del agricultor se necesita realizar ensayos manejados por ellos mismos para facilitar su adopción" |
| UNU | "Para generar tecnologías viables se necesita incluir al agricultor en el proceso de investigación" |
| INIA | "El agricultor debe estar en todo proceso de la investigación porque es un eterno investigador" |
| **Farmer** | |
| 1 | "Me gusta esta forma de probar y encontrar diferencias entre las variedades del ensayo" |
| 2 | "Es importante las visitas continuas de los técnicos al ensayo para observar juntos con nosotros los agricultores las diferencias entre variedades y seleccionar las mejores" |
| 3 | "Cuando una semilla es desconocida es mejor probar un poco en parcelas pequeñas, para evitar riesgos" |
| 4 | "Nos gusta que los técnicos no impongan una nueva tecnología que funciona en un solo lugar, se necesita saber cómo se comporta en nuestras parcelas, para quedarnos con la que es más adecuada" |

### 2.1.3 Application of a farm-level economic model for ex-ante analysis of potential new technologies

**Highlights**

- While rice has been identified as a high priority crop by farmers, the improved varieties are likely to reduce farm income while increasing household food security.

**Purpose:** To examine the potential impact of proposed technologies upon complex slash-and-burn farming systems.

**Rationale:** New crops and varieties can alter the distribution of land, labor and capital resources of farmers. In cases where the new allocation of these scarce resources is not feasible, adoption of the new technology will be difficult without added incentives, such as subsidized credit or subsidies. Within a farming system there are trade-offs between agronomic options. Subsistence crops, while often less profitable, have more stable prices and assure household food security. On the other hand, exotic crops may have the potential for export and higher earnings, but unknown or fluctuating prices make them a potentially risky option.

**Outputs:** *Ex-ante* agro-economic farming system analysis demonstrates a trade-off with the adoption of improved varieties. For example, yields were improved by 15% with new varieties in on-farm rice trials. The farming system model reveals that associated rice crop profits change from an increase of 76% in newly cultivated areas converted from forest, to a 180 % increase in fallowed areas. Yet overall farm profits are slightly negative and essentially zero.

**Table 1. Impact of improved rice varieties on an average flat-upland farm** (S/ =Peruvian Soles)

| | After primary forest | | | After fallow | | |
|---|---|---|---|---|---|---|
| | *Traditional* | *Improved* | *% Change* | *Traditional* | *Improved* | *% Change* |
| Yield (Kg) | 2200 | 2530 | 15 | 2000 | 2300 | 15 |
| Profit from rice (S/) | 170 | 299 | 76 | 67 | 187 | 180 |
| Overall farm profit (S/) | 8570 | 8516 | -0.06 | 8588 | 8479 | -0.1 |

Causing the trade-off is the condition of scarce labor resources during the harvest in January. Through the model, this month has been identified as having an extremely high opportunity cost of labor (S/56 per day) as compared to the normal wage of S/10 per day. Hired labor, while used, is often insufficient or difficult to find. Therefore the increased rice production, which requires added labor inputs for harvest, decreases available labor for other slighly more profitable farm activities such as citrus and plantain production.

**Impact:** Rice is an important subsistence crop for farm families. Higher production will lead to greater food security. In addition, the rice profit results tend to be low since Perú is currently experiencing overproduction of the crop. National campaigns to promote its planting in the coastal regions have been very effective in boosting production, as a result prices are experiencing severe declines. With changing government agricultural policies, these profit results of farms in the Ucayali could dramatically change in the future.

Farming system *ex-ante* and *ex-post* research is currently underway for a variety of traditional and exotic crops. This modeling tool will permits both economists and agronomists to evaluate the impact of technological options upon farm profits and food security.

**Contributors:** Douglas White, Ricardo Labarta, SN-1 (CIAT) INIA, MinAg-Ucayali, DEPAM, ICRAF

## 2.1.4 Increasing food security in Hong Ha, Vietnam with the participation of farmers

**Highlights**

- New rice varieties increase yields by 60% and are being adopted by households

**Purpose:** To increase yields of wetland rice and other crops

**Methods:** Farmers opinions were sought on crop improvement. They expressed most interest in improvement of wetland rice. The project is also interested in introducing more beans and vegetables to improve the diet and as crops that can be sold. Trials were planted with farmers and both researchers and farmers participated in management of the crop. Training was given on crop protection and management of wetland rice. A field day was held with farmers to discuss and appraise results.

*Variety trial wetland rice:* Most of the Hong Ha people have not had access to new varieties as have the lowlanders and have used the variety IR38 for over 10 years. Five households participated in evaluating 4 new rice varieties in comparison with a local variety known as IR38, with and without an application of fertilizer. Fertilizer application was (per $500^2$m): - 200 kg animal manure, 10 kg urea, 20 kg P compound, 6 kg Mg compound, 20 kg lime. Area of each plot was $15^2$m and there were 3 replications.

*Rice evaluation by households.* 100 households were given seed of TH30 for evaluation, five of them comparing it with and without fertilizer application.

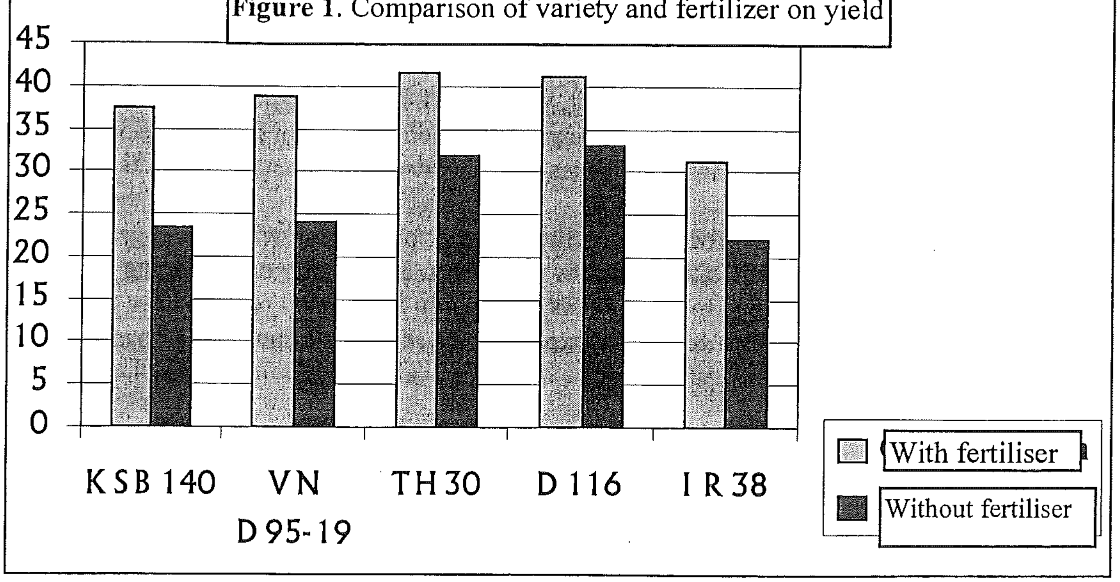
*Evaluation of maize VN10, vegetables and beans:* Seed of improved varieties of maize, several types of beans and vegetables were given to farmers for evaluation.

*Cassava trials:* Six cassava varieties were planted either in monoculture or intercropped with peanut to study their yield potential and acceptance by consumers, as well as to increment planting material for future, more intensive, testing.

*Green manures:* A collection of ten green manure species, mainly *Mucuna* sp., was planted to observe their adaptation and productivity. Commercially available *Mucuna* was also planted by farmers in old crop land and Imperata fallow to observe performance.

**Ouptuts:** *Variety trial wetland rice:* The new varieties TH30 and D116 gave higher yields (to 4.1 t/ha) than the control variety, IR38, even in the absence of fertilizer (**Figure 1**). They are suitable for low fertility soils but also respond stongly to fertilizer application, more so than KSB140 and VN_D95-19.

**Figure 1**. Comparison of variety and fertilizer on yield



*Rice evaluation by households.* The rice variety TH30 produced higher yields than the local variety, IR38, in all villages (**Table 1**) though production was highest in Kon som and Kon sam villages. It was more resistant to pests and disease than local varieties. Ninety-five pecent of households who evaluated the new variety like it and plan to use it in the future.

**Table 1 : Result of providing new variety in Hong Ha**

| Villages | Yield of TH30 (t/ha) | Yield of IR38 (t/ha) | Farmers' comments |
|---|---|---|---|
| Kon tom | 4.15 | 2.25 | Less pest and disease |
| Pahy | 3.78 | 2.03 | Less pest and disease |
| Kon sam | 4.24 | 2.75 | Less pest and disease |
| Parinh | 3.81 | 2.51 | Less pest and disease |
| Arom | 3.72 | 2.60 | Less leaf roll pest |

Five households evaluated the use of fertilizer with the new variety, TH30. They each had a control plot of $500^2$m without fertilizer. The fertilizer application was (per $500^2$m): 200 kg livestock manure, 8 kg urea (in two applications).

The results are shown in **Table 2**. Fertilizer increased rice yield from an average of 3.17 to 4.21 t/ha, an increase of 1.04 t/ha.

**Table 2. The rice yield (t/ha) with and without fertilizer application**

| Name of household | With fertilizer (tons/ha) | Without fertilizer (tons/ha) |
|---|---|---|
| Kon Xuong | 4.50 | 3.10 |
| Kon Luu | 4.80 | 3.30 |
| Kon Thoi | 4.25 | 3.96 |
| Kon Vua | 3.50 | 2.50 |
| Kon Cuong | 4.00 | 2.98 |

*Technical training and field days:* Two training sesssions were conducted, one on techniques for TH30 rice variety production, and the other on disease and pest management of Spring-Winter wetland rice, including the recognition of common pests and treatment.

*Evaluation of maize VN10, vegetables and beans:*

*Maize:* Maize VN10 proved to be suitable for Hong Ha conditions. Most of participating households liked the variety. It is now being distributed to many other households by Mr Xuong and Mr. Vuong.

*Groundnut:* Yields in Hong Ha are low. It is liked by local people and they are asking for advice on how to increase yields. It is planned to evaluate if there is a need for extra calcium for seed set.

*Green bean:* Most households who evaluated the green bean did not harvest because of damage by leaf roller insects. One farmer, harvested some seed.

*Black bean:* On the contrary this grew well and gave high yields. One farmer, Mr Dien, harvested 105lon/ 500 sm (about 25kg). (He said that he had borrowed 500.000 VND from the project for pig raising, the pig died, so he invested this money to growing black bean. He obtained 300.000VND from the sale of the black beans). All participating households said that black bean was suitable for Hong Ha conditions and plan to develop the cultivation of this bean in the future.

Vegetables evaluated were cabbage, bindweed and string bean:

*Cabbage*: This developed very well

*String bean*: There were no beans produced, in part, due to insect attack. String bean needs high investment and carefull attention. The local people are accustomed to planting and harvesting their crops without much investment in management or inputs.

*Bind weed:* Villagers like this plant as it can be used for animal feed as well as human food, and moreover it is easy to grow.

*Cassava and green manure evaluations:* Results not yet available.

**Impact:** From the above results we can see that:

- Rice. Villages are very interested in improving their rice yields as it is a high quality subsistence crop for them. It remains to be seen if they will be prepared to or have the resources to invest in fertilizer.
- Maize production could be increased and would help to improve food security. Technical training will be needed.
- Groundnut. There is a need to investigate the reasons for poor productivity, such as nutrient deficiency, before engaging in evaluation with a large number of farmers.
- Black bean is popular and intercropping with cassava and other crops should be investigated.
- Vegetables: It is better to study the use of local vegetables such as water cress with the aim of improving the daily diet. Other vegetables could be evaluated, in particular, with a view for sale.

**Contributors:** Nguyen Thi Cach (University of Hue), R. Howeler, P. Kerridge (CIAT).

### 2.1.5 Other interventions – Hong Ha commune, Vietnam

**Purpose:** To work with farmers to increase productivity of livestock, fish, home garden and natural resources through interventions of new and improved genetic materials and training

**Rationale:** The community development project aims to respond to all promising opportunities to develop more productive and sustainable agricultural systems that are appropriate to the community and the ecosystem.

**Opportunities:** From previous experience and following discussions with community leaders, the project has initiated activities in the following areas:

i) Improvement of home gardens based on models that exist in the commune
ii) Introduction of improved genetic stock of pigs complemented by training and development of local feeding systems
iii) Introduction of improved forages that might allow cattle to be stalled and manure collected
iv) An analysis if the VAC (Livestock-Fish-Home garden) system to see where it may be modified for Hong Ha conditions
v) Diagnosis of the possibilities for increasing fish culture
vi) Investigation of allocation of areas of 'production' forest to the community

**Impact:** The characterization studies (Output 1.1.2) provided a good understanding of the dynamics of land use change in Hong Ha and where interventions might be made. Initial experience in implementing some of these has provided experience in working with the community. The project is still in an early stage of implementation. While some objectives might be accomplished in the initial 3-year term of the project, it is suggested that there needs to be a 10-year projection for major impact.

**Contributors:** Le Van An, project leader, Le Duc Ngoan, animal nutrition, Le Quang Bao, forester, Le Duc Ngoan, animal scientist, Nguyen Thi Cach, agronomist, Nguyen Xuan Hong, sociologist, Nguyen Minh Hieu horticulturalist, Hoang Huu Hoa, economist; Nguyen My Van, project secretary; Nguyen Phi Nam, Vo Thi Minh Phuong, Ngo Huu Toan, Truong Tan Quan, support staff (Univ. of Hue). Peter Horne, Reinhardt Howeler, Peter Kerridge (CIAT).

## *Activity 2.2 Improving feed quality and resource management in dual-purpose cattle production systems.*

This activity is carried out through the project "Improved Legume-based Feeding Systems for Smallholder Dual-Purpose Cattle Production in Tropical Latin America" which is a CIAT-led consortium that operates under the Systemwide Livestock Program (SLP) convened by ILRI. The consortium consists of scientists from CIAT, ILRI and national agricultural research organizations in Peru (IVITA, CODESU, INIA, FUNDAAM), Costa Rica (MAG, ECAG, CATIE, UCR), Nicaragua (IDR), and Honduras (DICTA). The strategy to improve feeding systems is through three components:

*Optimization of forage utilization*

- an evaluation of new feed resources to match nutritional requirements of animals led by scientists

*Development of new feeding systems for dual-purpose cattle*

- on-farm evaluation of new legume-based forage components, and

*Utility of the new forage systems*

- economic analysis, and acceptability/adoption studies and dissemination.

### 2.2.1 Optimization of forage utilization

#### 2.2.1.1 Feeding and grazing trials to determine relations between milk production and forage resources.

**Highlight**

- Response in milk yield during the dry season to legume supplementation, either fresh or as silage, of sugarcane, is similar to yields obtained using commercial concentrates

**(i) Effect on milk yield and its components from feeding *Cratylia argentea* either fresh or as silage during the dry season**

**Rationale.** In agroecosystems with prolonged droughts, supplementation to dairy cows with legumes such as *Cratylia argentea* cut fresh during the dry season has been successfully used to replace concentrates and maintain milk production. However, the use of this legume during the rainy season did not seem justified to farmers because of the abundant biomass available for grazing. Some of them began conserving *C. argentea* as silage. The next step was to evaluate the use of *Cratylia argentea* cut fresh or conserved as silage to replace protein concentrates during the dry season.

**Methods.** This study was carried out from 25 February to 20 April, 1999 in the Escuela Centroamericana de Ganaderia (ECAG) Atenas, Costa Rica. Atenas is at an altitude of 460 m.a.s.l. with an annual mean temperature of 28°C.

Treatments were:
T1=Sugarcane (1% BW) + rice polishing (0.5% BW) + concentrate (1.48% BW) + urea (0,02% BW);
T2= sugarcane (1.3% BW) + concentrate (0.5% BW) + freshly cut *Cratylia argentea* (1.2% BW); and
T3= sugarcane (0.1% BW) + concentrate (0.5% BW) + silage of *Cratylia argentea* (2.4% BW).

Six mature Jersey cows within 50 days of postpartum were randomly assigned to the three treatments in a cross-over Latin square design in which each pair of cows were fed the three treatments simultaneously and then rotated through the other treatments.

The *Cratylia* silage was made from 6-month old regrowth of a protein bank cut at 30 cm. The chemical composition of the silage was 16.4% crude protein (CP) and 1.9 Mcal of metabolizable energy (ME). The fresh *Cratylia argentea* was from 3-month old regrowth cut daily at a height of 30 cm. The chemical composition was 20% CP and 1.8 Mcal ME. Both sources of *Cratylia* were mixed with the sugarcane.

The nutritional content of the sugarcane was 2% CP and 3.0 Mcal ME. The commercial concentrate was mixed at ECAG and made primarily from corn and soybeans with a composition of 14% CP and 2.3 Mcal ME. The rice polishing had a composition of 12% CP and 3 Mcal ME.

Each treatment period comprised twelve days, seven for adaptation and five for sampling for total milk production, and during days 1, 3 and 5, for the following variables:

(i) Milk quality: Samples were taken from both milkings (100 ml/cow/milking), and analyzed for fat, protein, lactose, total solids and non-fat solids.
(ii) Dry matter intake and quality (IVDMD) of offered and rejected material;

**Results.** There was no significant differences among the three rations offered with regards to dry matter intake between *C. argentea* fed fresh (10.7 kg/cow/day) or as silage (10.4 kg/cow/day; **Table 1**). Also there was no difference with respect to milk yield and its components except for the milk protein ($P < 0.01$), which was greater in the treatment where concentrate was utilized and a trend ($P < 0.06$) for higher fat concentration where *C. argentea* was fed as silage.

Most importantly, the level of milk production achieved with rations of *C. argentea* fed fresh or as silage (10.9 and 10.7 kg/ cow/ day, respectively) were similar to those obtained with a typical concentrate for dairy cows where the protein source comes from corn and soybeans (11.1 kg/cow/day).

There were large differences ($P < 0.0001$) in the production costs for the different treatments, that with freshly cut *C. argentea* being the lowest and *C. argentea* fed as silage the highest. The cost of C. argentea silage was very high due to the amount of labor required to separate the edible leaf and fine stem from the six-month old regrowth.

**Table 1. Feeding cost, dry matter intake, and milk production and its components by treatments.**

| **Treatment** | **FeedCost** | **DM Intake** | **Milk Yield** | **Fat** | **Protein** | **Lactose** | **TS** | **NFS** |
|---|---|---|---|---|---|---|---|---|
| | ($/kg milk) | kg/cow | kg/cow | | | (%) | | |
| Concentrate | 0.20 | 10.8 | 11.1 | 3.53 | 3.36 | 4.80 | 12.39 | 8.86 |
| Fresh *Cratylia* | 0.16 | 10.7 | 10.9 | 3.69 | 3.24 | 4.84 | 12.47 | 8.78 |
| *Cratylia* silage | 0.43 | 10.4 | 10.7 | 3.81 | 3.22 | 4.76 | 12.49 | 8.68 |
| Significance level | | P<0.59 | P<0.27 | P< 0.06 | P< 0.01 | P< 0.35 | P< 0.74 | P< 0.09 |

**Impact.** The results from this experiment demonstrate that complementing a high energy feed, such as sugarcane, with *Cratylia argentea* during the dry season maintains milk yield at a similar level, as do protein sources from a commercial concentrate. Using fresh-cut *Cratylia* was cheaper than feeding it as silage. It will be useful to investigate if silage made from 3-4 month old regrowth reduces labor requirement and hence cost of the silage. It is important that an economic use be found using *Cratylia* leaf produced during the rainy season. Possible alternative uses to making silage are feeding as a fresh supplement during the rainy season or as a green manure to improve soil fertility for high value crops.

**Contributors:** F. Romero and J. Gonzalez, ECAG, Costa Rica.

### (ii) Effect on milk yield due to the inclusion of forage legumes in the diet of dual-purpose cows in Pucallpa, Peru.

**Rationale.** Despite the existence of forage legumes adapted to tropical conditions, the response in milk yield to legume supplementation has generally been modest or inconsistent in the Peruvian Amazon region of Pucallpa. Therefore, it was considered useful to evaluate legume supplementation under controlled conditions with the objective of estimating the effect on milk yield.

**Methods.** The experiment was carried out in the Experimental Station of IVITA in Pucallpa which is situated 270 m.a.s.l. and with annual mean precipitation of 2000 mm and mean temperature of 26°C.

Treatments were:
T1=Legumes - *Pueraria phaseoloides*, *Stylosanthes guianensis*, and *Centrosema macrocarpum*
T2=Proportion of legume in the diet - 0, 15, 30, and 45% with king grass (*P. purpureum* x *P. typhoides*)

Crossbred Zebu x Holstein milking cows from 20 to 90 days into the lactation were used as test animals. Feeding was arranged in a Latin square design with 2 cows per treatment at each cycle of the cross-over design.

The different diets were offered at 3% DM/100 kg liveweight and fed twice a day to confine cows over four consecutive feeding periods. Each period lasted 14 days, the first 7 days for adjustment and the remaining 7 days for data collection. Individual milk yields were recorded every milking during days 1, 2, and 5 of the data collection period. Samples were taken from both forage offered and refused for chemical analysis. Milk samples were analyzed for urea, fat, and non-fat solid contents.

**Results.** The trials using *P. phaseoloides* and *S. guianensis* have been concluded. **Table 2** summarizes the results for milk yield, contents for milk urea nitrogen, fat, and non-fat solids, and liveweight gain.

**Table 2. Values of different variables by proportion of legume in the diet of milking cows**

| Legume | Milk Yield (kg/cow/d) | Urea content in milk (%) | Fat content in milk (%) | Non-fat solid content in milk (%) | Liveweight gain (g/cow/d) |
|---|---|---|---|---|---|
| | | | | | |
| ***Pueraria phaseoloides* (% of diet)** | | | | | |
| 0 | 5.7 | 8.6 | 2.8 | | 606 |
| 15 | 6.2 | 13.7 | 3.1 | | 500 |
| 30 | 5.8 | 18.0 | 3.1 | | 125 |
| 45 | 6.0 | 23.8 | 3.1 | | 340 |
| Significance level | >0.05 | <0.05 | >0.05 | | <0.05 |
| | | | | | |
| ***Stylosanthes guianensis* (% of diet)** | | | | | |
| 0 | 5.1 | 10.6 | 3.0 | 8.8 | 482 |
| 15 | 5.5 | 12.5 | 3.2 | 8.9 | 196 |
| 30 | 5.1 | 15.5 | 3.1 | 8.8 | 321 |
| 45 | 5.1 | 16.4 | 3.1 | 8.9 | 517 |
| Significance level | >0.05 | <0.05 | >0.05 | >0.05 | <0.05 |

These results show that the only variables that were affected by increasing legume content in the diet were urea in the milk and liveweight gain. The increase of urea in milk had a linear and consistent pattern for both legumes. The higher rate of increase with *P. phaseoloides* than *S. guianensis* reflects the higher N concentration in the former. The response in liveweight gain was erratic with both legumes. Chemical analysis of the refused forage indicated that there was a slight reduction in total dry matter intake as the legume content of the diet was increased.

The reason why an increase in the protein content of the diet, which is reflected in the increasing urea in the milk, did not increase milk production is not clear. Crossbred animals were used and should have been able to respond to increased protein in the diet. Data from the chemical analysis of forage consumed may assist in the interpretation of the results.

**Impact.** Under the conditions of energy/protein balance of the animals in this trial, legume intake increased the level of milk urea nitrogen but not milk yield. Thus, urea level in milk has potential as a metabolic indicator to protein intake and where the only variable source is legume, then the amount of legume in the diet. Research has not demonstrated the value of grass-legume pastures for diary cattle in Pucallpa

**Contributors:** M. Ara, M. de la Torre and C. Reyes (IVITA), and I. Unchupaico (Universidad Nacional del Centro), Peru.

### 2.2.1.2 Feeding, and cutting trials to refine methods of supplementation during the dry season using different forage resources.

## Highlights

- Nitrogen intake was higher with more frequent feeding at high levels of legume supplementation
- Frequent cutting of *Cratlyia* is more important than cutting height for producing a high quality feed supplement

### (i) In vivo studies on the complementarity between forage basal diet and legume supplement

**Rationale:** Previous results from confined feeding trials suggested that in supplementing available forage sources to overcome nutrient deficiencies in ruminants, it is important to synchronize feeding of the higher quality forage supplement with the basal forage so that energy and protein are available concurrently. On the other hand, synergism among forages may vary not only with the types of forages fed but also with how they are fed (level and frequency).

**Methods:** Eight African type weathers (24 kg LW) fed a low quality grass basal diet were randomly allocated to 4 treatments of supplementation with sugar cane (60%) mixed with *Cratylia argentea* (40%). Treatments arranged in 4x4 Latin Square design were:

T1- Low level of supplementation (0.5% of BW) fed once a day (AM),
T2- High level of supplementation (1.0%% of BW) fed once a day (AM),
T3- Low level of supplementation (0.5% of BW) fed twice a day (AM+PM) and
T4- High level of supplementation (1% of BW) fed twice a day (AM+PM).

Measurements included quality of the basal diet and supplements offered intake, digestibility and N balance.

**Results:** The low quality grass basal diet was low in CP (4.8%) and high in cell wall content (NDF 79% and ADF 44%). On the other hand, chopped sugar cane fed as an energy supplement was low in CP (3.1%) but had low cell wall content (39% NDF and 24%ADF). The legume (leaves of *Cratylia*) fed had high CP (21%) and high levels of cell wall (67%NDF and 37% ADF). Thus the supplement fed was high in energy and medium in protein (10% of DM). Intake of the basal diet did not differ among treatments, but there were differences in supplement intake due to treatments. As expected, intake of sugar cane and *Cratylia* tended to be higher when fed at the highest level. However, it is interesting to note that when supplements were offered at the high level, intake of sugar cane and *Cratylia* increased with twice-a-day feeding relative to once-a-day feeding (**Table 3**).

These differences in intake of supplements were not reflected in significant changes in DM or cell wall digestibility. Nevertheless, there was a tendency for higher digestibility with a twice a day feeding at both levels of supplementation.

As expected, N intake was highest with increased level of supplementation (**Table 4**); however at the high level of supplementation N intake was higher with twice a day feeding. Since fecal and urinary N did not change with treatment, N retention was greater when sheep were given the forage-based supplements at the high level and twice a day (Table 5).

**Impact:** With the forage-based supplement fed it was evident that level and frequency of feeding had an effect on nitrogen utilization by growing sheep. However, the results indicate that feeding twice a day would only be justified when high levels of forage-based supplements are offered. When the high level

(1% of BW) of sugarcane/*Cratylia* was fed twice a day there was a 33% increase in N retention relative to feeding the same amount of supplement once a day. This was not the case when the low level (0.5% of BW) was offered.

**Table 3. Effect of level and frequency of forage-based supplementation on intake and digestion by sheep fed a low quality grass.**

| Item | Frequency and level of supplementation* | | | | |
|---|---|---|---|---|---|
| | AM** 0.5% BW | AM 1% BW | AM + PM*** 0.5% BW | AM + PM 1% BW | SE |
| Intake (gDM/kgBW/d) | | | | | |
| Basal diet | 25.7 | 25.2 | 25.2 | 25.7 | 0.8 |
| Sugar cane | 2.5 b | 3.3 b | 2.8 b | 4.0 a | 0.4 |
| Cratylia | 2.0 c | 3.1 b | 2.0 c | 3.6 a | 0.1 |
| Digestibility (%) | | | | | |
| DM | 53.0 | 53.0 | 55.4 | 56.6 | 1.7 |
| NDF | 54.1 | 54.3 | 57.7 | 57.1 | 1.8 |
| ADF | 51.6 | 50.7 | 54.3 | 53.1 | 1.9 |

*60% sugar cane + 40% *Cratylia argentea* (leaves)
**Supplement fed once a day at 0.5 or 1% of BW
***Supplement fed twice a day at 0.5 or 1% of BW
a,b,c Means different ($P<0.05$)

**Table 4. Effect of frequency and level of forage-based supplementation on nitrogen utilization by ships fed a low quality grass.**

| Item | Frequency and level of supplementation* | | | | |
|---|---|---|---|---|---|
| | AM** 0.5% BW | AM 1% BW | AM + PM*** 0.5% BW | AM + PM 1% BW | SE |
| N Intake (g/d) | 5.6 a | 6.2 b | 5.6 a | 6.7 c | 0.01 |
| Fecal N (g/d) | 3.5 | 3.5 | 3.3 | 3.5 | 0.1 |
| Fecal N, % N intake | 62.5 a | 57.1 b | 59.9 a | 52.0 c | 2.0 |
| Urine N (g/d) | 1.4 | 1.5 | 1.5 | 1.6 | 0.2 |
| Urine N, % N intake | 25.4 | 25.8 | 28.6 | 24.7 | 3.7 |
| Retained N (g/d) | 0.8 e | 1.2 d | 0.8 e | 1.6 a | 0.2 |

*60% sugar cane + 40% *Cratylia argentea* (leaves)
**Supplement fed once a day at 0.5 or 1% of BW
***Supplement fed twice a day at 0.5 or 1% of BW
a,b,c,d,e Means different ($P<0.05$)

**Contributors:** W. Quiñonez, P. Avila, and C. Lascano, CIAT, Colombia.

## (ii) Productivity of *Cratylia argentea* cut at different frequency and height in the Central Pacific region of Costa Rica.

**Rationale.** The legume *Cratylia argentea* has proven to be an alternative to farmers because it provides forage biomass with a high protein content during the dry season. It is necessary to have more details of a management strategy to maximize the quality and quantity of biomass of *Cratylia* that guarantees the sustainability of the bank in the long-term. Earlier cutting studies had shown that yield increased with high density of planting (10,000 to 20,000 plants/ha) and that it could be cut as early as 4 months after planting without a long term effect on yield. In feeding trials, it has been observed the crude protein concentration of leaves is higher at a cutting frequency of 90 days (20%) cf.180 days (16%). As the reason for supplementing with *Cratylia* is to provide a high protein feed, it was thought useful to investigate the effect of cutting more frequently and also learn if cutting height affected productivity in the longer term. We present the first years results of a cutting trial investigating these factors. The experiment was conducted on-farm under researcher control.

**Methods.** 210 plants from a protein bank of *Cratylia argentea* established in 1996 were divided into 3 groups of 70 plants each managed at three height levels: 30, 60, and 90 cm. Each group was then divided into two sub-groups of 35 plants each for two harvesting frequencies to give re-growth of 60 and 90 days. Plant spacing was 0.5 m between plants and 1 m between rows (20,000 plants/ha). Chemical analysis for crude protein, non-detergent fiber, acid detergent fiber, and lignin was performed on the edible portions (leaves and thin stems of approximately less than 6 mm thick).

**Results.** Results indicate that there was no significant difference in forage quality between cutting heights (30, 60 and 90 cm above ground level) for plants cut at either 60 or 90 days though the nutritional quality (higher CP and lower NDF) for material from plants cut at 60 than 90 days. Yield increased with a higher cutting height and at the lower cutting frequency (**Table 5**).

**Table 5. Evaluation of *Cratylia argentea* at two ages of re-growth and three cutting heights**

| Re-growth | Cutting height | Height of re-growth | Re-growth Shoots | DM | CP | NDF % | ADF % | Lignin % |
|---|---|---|---|---|---|---|---|---|
| (days) | (cm) | (cm) | (#) | % | % | | | |
| | | | | | | | | |
| | 30 | 0.61 | 8.58 | 28.8 | 18.7 | 52.7 | 44.9 | 14.6 |
| 60 | 60 | 0.51 | 9.64 | 24.5 | 18.0 | 55.4 | 43.9 | 15.4 |
| | 90 | 0.70 | 13.44 | 22.5 | 19.1 | 57.9 | 43.9 | 15.3 |
| | **Mean *** | **0.60** | **10.55** | **25.3** | **18.6** | **55.3** | **44.1** | **15.1** |
| | | | | | | | | |
| | 30 | 1.10 | 9.88 | 32.3 | 16.2 | 57.0 | 44.1 | 15.8 |
| 90 | 60 | 1.15 | 12.69 | 34.4 | 15.2 | 59.5 | 46.1 | 16.5 |
| | 90 | 1.24 | 14.53 | 33.9 | 15.9 | 61.8 | 44.2 | 16.0 |
| | **Mean **** | **1.16** | **12.37** | **35.5** | **15.8** | **59.4** | **44.8** | **16.1** |

* Average of 5 cuts; ** Average of 3 cuts

**Impact.** The slight reduction in biomass (8%) at the shorter cutting interval of 60 than 90 days is well compensated by a higher nutritive value (19% Vs 16% CP). These results need to be made known to farmers growing *Cratylia* as a protein bank. It is planned to continue this trial over 2-3 years to determine if more frequent cutting is sustainable in the long term.

**Contributors:** M. Lobo and V. Acuña, MAG, Costa Rica

## 2.2.2 Development of new feeding systems through on-farm research

### 2.2.2.1 Evaluation of different forage systems for dual-purpose cattle

**Highlights**

- Forage feeding systems for strategic supplementation during the dry season reduce the need for purchasing animal feed concentrates and increases income in dual-purpose farms
- The use of legumes with an energy source during the dry season maintains milk production

#### (i) Milk production with dual-purpose cows grazing *Brachiaria brizantha* associated with *Arachis pintoi* and *Centrosema brasilianum* during the rainy season in the Central Pacific region of Costa Rica.

**Rationale:** The overall constraint limiting animal productivity in the Central Pacific region of Costa Rica is the low quality of naturalized grasses. There is a need to develop new feeding alternatives to overcome this limitation. In our on-farm work, some farmers have chosen to develop fodder banks (e.g., of sugarcane and shrub legumes). For others this did not seem feasible because of high labor demand. Another alternative is to develop more productive grass-legume pastures to improve forage quality. This reports on-farm research with a farmer who did not wish to plant fodder banks and had relatively level land on which to establish improved pastures associated with legumes. Previously this farmer had had experience only with pure grass pastures.

**Methods:** Areas were selected for pure grass pasture and grass-legume associations. At the beginning of the 1996 rainy season, pure grass pastures and associations of 4 ha of *B. brizantha* with *A. pintoi* and *C. brasilianum* were established. There were two paddocks per treatment. The *B. brizantha* and *C. brasilianum* were established by seed at a rate of 4 kg/ha for each species and the *A. pintoi* with vegetative material at a rate of 1 t/ha. Both legumes were planted in furrows set at a distance 70 cm apart after the grass was established. Pastures were grazed for 5 days grazing by the dairy herd every month. Measurements were made only during the rainy seasons over the two years, 1997 and 1998 when milk yield was measured on days 1, 3, and 5.

**Results: Tables 6 and 7** show forage biomass availability, botanical composition, and milk yield of cows grazing pure grass and the grass-legume associations. Biomass production was higher during both years in the pasture containing the greatest proportion of legume, which suggests that nitrogen fixation promoted greater grass growth. Likewise, milk yield was 8% higher than pure grass where there was 30% legume and only 3 to 5% higher where there was 20% legume.

**Table 6. Forage availability and botanical composition of *B. brizantha* associated with different proportions of legumes during the 1997 and 1998 rainy seasons.**

| | Pasture with 20% legumes | | Pasture with 30% legumes | |
|---|---|---|---|---|
| | 1997 | 1998 | 1997 | 1998 |
| | | | | |
| Biomass (kg DM/ha) | 4110 | 4480 | 5110 | 5410 |
| Grass (%) | 62 | 67 | 57 | 58 |
| Legumes (%) * | 22 | 18 | 31 | 27 |
| Weeds (%) ** | 16 | 15 | 12 | 14 |

**Calopogonium muconoides*, *Zornia* spp *Aeschinomene* spp, *C. brasilianum and Arachis pintoi.*

** *Mimosa modest*, *Amaranthus* spp, *Borreria* spp and others.

**Table 7. Average milk yield (kg/cow/day) of dual-purpose cows grazing pastures with different proportions of legumes during the rainy season in 1997 and 1998.**

| Type of pasture | Milk production (kg/cow/d) | | Increase (%) | |
|---|---|---|---|---|
| | 1997 | 1998 | 1997 | 1998 |
| | | | | |
| Only grass | 8.6 | 7.6 | | |
| Grass with 20% legumes | 9.0 | 7.8 | 4.7 | 2.6 |
| Grass with 30% legumes | 9.3 | 8.2 | 8.1 | 7.9 |

**Impact.** The increase in milk production on the grass-legume associations occurred despite the fact that cows were receiving a daily supplementation of 5 kg of chicken manure and 1.5 kg of soybean hulls. Thus, the use of legumes in association with grasses increase milk yields, especially when the proportion is around 30% of total edible biomass. This could be due to a combination of higher biomass availability during the rainy season and higher N content in the diet.

**Contributors:** M. Lobo and V. Acuña, MAG, Costa Rica

## (ii) Milk production of dual-purpose cows supplemented with *Cratylia argentea*, chicken manure, and sugarcane during the dry season in the sub-humid tropics.

**Rationale:** In ecosystems with prolonged droughts such as the Central Pacific region of Costa Rica, the production and quality of forage biomass from grasses is reduced drastically. Producers solve this limitation by supplementing with agricultural by-products such as chicken manure. This by-product was inexpensive several years ago. However, its demand has been growing and therefore, its price in real terms has increased. As a result, producers are interested in the evaluation of alternatives to replace the use of chicken manure. We report three on-farm trials, two evaluating the replacement of chicken manure with *Cratylia argentea* and the other trial evaluating *Cratylia* fed fresh or as silage.

**Methods:**
Experiment 1. This trial was conducted during the dry season (April 1999) in a farm of a small producer located in Miramar in the Central Pacific region of Costa Rica. Miramar is at an altitude of 250 m.a.s.l. with an annual mean temperature of 28°C and mean precipitation of 2400 mm. Treatments evaluated were:

T1= Control group, grazing only (naturalized and jaragua grasses),
T2= Sugarcane + *C. argentea* + rice polishing + grazing,
T3= Sugarcane + chicken manure + rice polishing + grazing.

Nutritional characteristics of feeds were:

Sugar cane: 2% CP, 3.0 Mcal ME.
Chicken manure: 19.5% CP, 1.8 Mcal ME
Rice polishings: 12% CP, 3.0 Mcal ME
Fresh Cratlyia: 20% CP, 1.8 Mcal ME (from 90 day regrowth cut at 30 cm)
Cratylia silage: 16.4%CP, 1.9 Mcal ME (from 180 day regrowth cut at 30 cm)

A latin square design was used with the three treatments with two cows in each of them and with selected cows in the second month of lactation. Animals in treatment 2 received 12 kg of sugarcane, 8 kg of *C. argentea*, 0.6 kg of semolina, and 0.5 kg of molasses per cow in addition to grazing, while animals in treatment 3 received 3 kg of chicken manure instead of *C. argentea*. The experiment lasted for 30 days, animals were rotated through each treatment for 10 days (7 days of adjustment and 3 for data collection).

Experiment 2: This trial was conducted in a small farm located in Barranca in the Central Pacific region of Costa Rica. Barranca is at an altitude of 280 m.a.s.l. with an annual mean temperature of 28°C and mean precipitation of 2500 mm. Treatments evaluated were:

T1= Sugarcane + silage of *C. argentea* + rice polishing
T2= Sugarcane + fresh *C. argentea* + rice polishing; and
T3= Sugarcane + chicken manure + rice polishing.

A latin square design was used with three treatments with two cows in each one as in the above experiment. Animals were handled in individual groups and received for treatment 1 an averaged of 12 kg of sugarcane, 6 kg of Cratylia silage and 0.6 kg of rice polishing as fed; treatment 2 received 12 kg of sugarcane, 6 kg of *C. argentea*, and 0.6 kg of rice polishing; and cows in Treatment 3 received 12 kg of sugarcane, 3 kg of chicken manure and 0.6 kg of rice polishing. The experiment lasted for 30 days, animals rotated on each treatment for 10 days each (7 days for adjustment and 3 days of data collection).

Experiment 3: This experiment was conducted on-farm as part of student thesis program. This trial was conducted in the middle of the dry season (February to May, 1998) in a small farm located in Barranca in the Central Pacific region of Costa Rica. Barranca is at an altitude of 280 m.a.s.l. with an annual mean temperature of 28°C and mean precipitation of 2500 mm. Treatments evaluated were:

T1= Chicken litter and molasses,
T2= Chicken litter, sugarcane, molasses and wheat bran,
T3= Chicken litter, molasses, *C. argentea*, and wheat bran

Details of the diet are presented in Table 10. The diets were balanced to be isonitrogenous and isocalorific with different quantities of supplements used. In $D_3$, *C. argentea* contributed more than 75% of the CP requirements of animals but a small amount of chicken litter was included in the diet since observed intake of *C. argentea* was not sufficient to balance N requirements. Animals had access to *H. rufa* pastures. The crude protein (CP) content and in vitro dry matter digestibility (IVDMD) for Cratylia was 19.2% and 58.4%, respectively, and for H. rufa was 3.9% and 33.9%, respectively.

A 3x3 Latin square change over design with three replications was used with a total of 9 crossbred cows between 60 to 80 days into the lactation. Each of the three experimental periods consisted of 10 days of adaptation to treatments and 5 days experimental data collection.

**Results:**
Experiment 1: **Table 8** shows milk yield and composition, feeding costs, income from milk, and the benefit: cost ratio for the different treatments evaluated. As can be observed, milk yields between treatments 2 and 3 were not significantly different (p=0,076), which suggests that C. *argentea* can be used to substitute for chicken manure without a decrease in milk production. In addition, these results indicate that when milk is produced with *Cratylia argentea*, the feeding costs are lower and the benefit: cost ratio greater, thus making this alternative more attractive economically to producers.

**Table 8. Average milk production and composition, supplement feeding cost, milk income, and benefit: cost ratio of diets supplemented cows with *Cratylia argentea* and chicken manure.**

| Treatments | Milk yield kg/cow/d | Total solids (%) | Fat (%) | Supplement Feeding Cost ($/kg milk) | Income ($/kg milk) | B:C Ratio |
|---|---|---|---|---|---|---|
| | | | | | | |
| Grazing only | 5.45 b | 11.2 | 3.1 | - | 0.24 | |
| Grazing + Cratylia | 5.85 a b | 11.5 | 3.2 | 0.11 | 0.25 | 2.22 |
| Grazing + Chicken manure | 6.29 a | 11.2 | 2.9 | 0.22 | 0.24 | 1.08 |

Experiment 2: **Table 9** show that the feeding alternatives based on *Cratylia argentea*, both as silage and as fresh leaf, were more economical than the alternative to supplement with chicken manure. In addition to *Cratylia* rations being more economical, the milk yields of cows consuming *Cratylia* either as fresh or as silage were similar to those with chicken manure. However, milk yields from cows consuming *Cratylia* silage were lower than those from cows consuming fresh *Cratylia.* Nevertheless, *Cratylia* silage might be used as a substitute for chicken manure because of lower feed costs.

**Table 9. Average milk yield of dual-purpose cows supplemented with *Cratylia argentea* either fresh or as silage and with chicken manure.**

| Treatments | Milk yield (kg/cow/d) | Total solids (%) | Fat (%) | Supplement Feeding cost ($/kg) | Milk Income ($/kg) | B:C Ratio |
|---|---|---|---|---|---|---|
| | | | | | | |
| Cratylia as silage | 5,09 b | 12,33 | 3,65 | 0.17 | 0.27 | 1.58 |
| Fresh Cratylia | 5.47 a | 12,22 | 3,45 | 0.11 | 0.27 | 2.37 |
| Chicken manure | 5.26 a b | 11,71 | 3,00 | 0.22 | 0.26 | 1.14 |

Experiment 3: **Table 10** shows the effect on milk yield by treatment. Milk yield averaged 6.0 kg milk/cow/day and there were no significant differences between treatments. Milk fat was lower (2.7%) for the treatment which had a higher amount of sugarcane in the diet, but differences were not significant. The results show that Cratylia can be used as a substitute for chicken manure, at least to 82% of the diet.

**Table 10. Diets offered to animals and milk yields for all treatments.**

| Diets | Consumption (kg/animal/day) | Milk yield (kg/cow/day) |
|---|---|---|
| *Diet #1* | | 5.9 |
| Chicken manure | 6.0 | |
| Molasses | 2.5 | |
| *Diet #2* | | 6.0 |
| Chicken manure | 5.0 | |
| Sugar cane | 5.0 | |
| Wheat bran | 0.7 | |
| Molasses | 0.12 | |
| *Diet #3* | | 6.1 |
| Chicken manure | 1.0 | |
| Molasses | 4.12 | |
| Wheat bran | 0.7 | |
| **Cratylia argentea** | 6.0 | |

**Impact.** Most farmers with dual-purpose cattle in recent years have been producing milk during the dry season using chicken manure. Results from this work clearly show that *Cratylia* can largely replace chicken litter as a protein supplement, without a significant reduction in milk yield. This is a very important finding given that the demand for chicken litter to supplement dairy cows has increased its price in many tropical regions and farmers can no longer afford to buy it. With the introduction of *Cratylia argentea* to cattle production systems in the Pacific region, the utilization of chicken manure has declined in farms participating in the Tropileche Consortium to such degree that this year practically none was purchased. Therefore, the legume technology being promoted for dual-purpose cattle farms has the possibility of allowing small producers to have access to a farm- grown protein supplement and to increase cash flow and profits. In addition, spontaneous adoption of *Cratylia argentea* is occurring in other locations in Costa Rica. During the last 12 months 84 kg of experimental seed has been sold to 28 farmers located in three different sites in Guanacaste, Nicoya, and around Esparza.

The most economical option for a producer in the dry season is to supplement cows with fresh *Cratylia*. The next best option is to supplement with *Cratylia* as silage. The least economical option is to supplement cows with chicken manure. As a result, the use of legume silage such as *Cratylia argentea* is recommended over the use of chicken manure. In addition, the use of legume silage allows producers to utilize smaller areas because more edible biomass is produced for dry season supplementation, especially in situations where the opportunity cost for labor during the rainy season is low.

**Contributors:** M. Lobo, V. Acuña, and J. Araya (MAG), M. Ibrahim, M. Franco, D. Pezo, and A. Camero (CATIE), Costa Rica

### (iii) On- farm evaluation of new forage alternatives in dual-purpose farms in Honduras and Nicaragua.

**Rationale.** The adoption of improved pasture technology is more certain if farmers participate in the evaluation of selected and advanced pasture germplasm coming from research. Forage components based on adapted grasses and legumes have been identified by CIAT which give increases in animal productivity as well as increasing soil organic matter and activity of the soil macrofauna. Tropileche has an on-farm component that allows farmers to participate in the development of new pasture technologies and speed up the adaptive process and subsequently dissemination and adoption.

**Methods.** Component technologies developed in Tropileche have been shared with national institutions that have included their evaluation in their research and development. CIAT has collaborated by providing basic seed for experiments, in advice on pasture establishment and on-farm methodologies. The collaborating institutions have paid for seed and establishment costs and for follow-up activities.

**Results.** During 1998 and 1999, 63 ha of new pasture components were successfully established in Honduras and Nicaragua (**Table 11**). *B. brizantha* cv. La Libertad and the promising new line, *B. brizantha* CIAT 26110, either in monoculture or associated with *Arachis pintoi* (cvs. Porvenir and Maní Forrajero), are the two grasses being demonstrated. Plots have been also established of the shrub legume *Cratylia argentea* (CIAT 18668) and *Leucaena leucocephala* (CIAT 17263).

**Table 11. Areas planted with new forage options during the period July 1998-August 1999 by collaborators of the Tropileche Project in Nicaragua and Honduras.**

| Country and Collaborator | Site | Species planted | Area Planted (ha) | Farmers Involved (#) |
|---|---|---|---|---|
| **Nicaragua** (Proyecto de Desarrollo Lechero) | Esquipulas | *B. brizantha* cv. La Libertad + *A. pintoi* cv. Porvenir | 2.8 | 1 |
| | | cv. La Libertad | 6.6 | 2 |
| | Rivas | Cv. La Libertad | 21.8 | 4 |
| | | *C. argentea* | 0.7 | 1 |
| | | *L. leucocephala* | 0.7 | 1 |
| | El Rama | Cv. La Libertad | 7.0 | 1 |
| | | | (39.6) | (10) |
| **Honduras** (DICTA) | Yoro-Yorito | Cv. La Libertad + *A. pintoi* | 7.5 | 3 |
| | | *B. brizantha* 26110 + *A. pintoi* | 3.5 | 2 |
| | | Cv. Llanero +*A. pintoi* | 2.0 | 1 |
| | | *C. argentea* | 1.0 | 1 |
| | Comayagua | Cv. La Libertad + *A. pintoi* | 7.5 | 2 |
| | | Cv. Llanero +*A. pintoi* | 2.0 | 1 |
| | | | (23.5) | (10) |

Twenty dual-purpose farmers are participating in this activity. The increased forage production from the new forages in comparison with the traditional grasses, such as Jaragua and *Paspalum* spp.is self-evident. Objective monitoring of the impact on animal productivity, in particular, on the increase in milk has not been done yet due to two reasons: (a) lack of resources of the national scientists, especially transportation and per diem, and (b) the Hurricane Mitch, which damaged a significant proportion of the established pastures as well as most rural roads.

**Impact.** Progress has been made during the last year in relation to the establishment of new forage components in collaboration with national institutions and farmers in Honduras and Nicaragua. The Tropileche project has been used as a platform to test and promote new forage alternatives at the farm level. The collaboration and acceptance by farmers has been good, but the documentation of the impact on animals and soils by the collaborating institutions has not been implemented yet.

On-farm work is costly and demands not only time and effort, but also resources like transportation facilities and operating capital for gas and per diem, which are frequently scarce at the national institution level, especially in poor countries such as Nicaragua and Honduras, both considered with Haiti the poorest countries in Latin America. Given this reality, it is suggested that we need to work with these national program in obtaining sufficient resources in the form of operating capital to complement on-farm data collection and monitoring.

**Contributors:** Tito Fariñas (IDR, Nicaragua), Conrado Burgos (DICTA, Honduras), P. J. Argel and F. Holmann (CIAT).

## 2.2.3 Evaluation of new feeding alternatives to allow early weaning.

### Highlights

- Supplementing pre-weaned calves with legumes during the dry season results in more milk for sale and higher liveweight gain that with current management practice of feeding only grass
- The legumes grown for feeding calves contribute to soil N and might be incorporated in a rotational crop-legume fallow system

### 2.2.3.1 Use of *Stylosanthes guianensis* with pre-weaned calves in dual-purpose cattle systems in the forest margins of Colombia

**Rationale:** The two main outputs in dual-purpose cattle farms are (a) milk and (b) weaned calves for fattening. Under traditional management, farmers usually favor selling as much milk as possible to increase their cash flow, but as a result calves suffer from under nutrition and mortality rates are high. Therefore, development of feeding systems that allow farmers to obtain more milk for sale and the same time result in good performance of pre-weaned calves is of high priority in dual-purpose cattle systems.

The idea of using *Stylosanthes guianensis* for grazing pre-weaned calves has been tested in Pucallpa, Peru. Results indicate that with this alternative farmers can sell almost one more liter of milk/cow/day and still maintain adequate growth of their calves, which has important economical benefits. To further test the use of *Stylosanthes* for pre-weaned calves, we initiated a collaborative study this year with COPRPOICA partners in Macagual, Caqueta, Colombia.

**Methods:** A small paddock (2 ha) of *Stylosanthes guianensis* was established in the CORPOICA research station in Macagual, Caquetá to allow 1 to 3 months calves to freely graze after milking. Calves with access to *Stylosanthes* also received residual milk (milk remaining in the udder after hand milking) after each milking. Calves in the control treatment received milk from one quarter of the udder at milking and had access to a grass pasture after milking. In all cases calves remained with their dam for 3 to 4 hours after milking, before going to the grass or *Stylosanthes* pastures.

**Results:** The amount of milk for sale resulting from the use of *Stylosanthes* by pre-weaned calves was 21% higher than recorded with cows that had calves managed in the traditional systems (**Table 12**). In addition, liveweight gain of calves with access to *Stylosanthes* was 30% higher than in the control group during a 90-day period.

**Impact:** The results obtained in forest margins of Colombia on the use of *Stylosanthes guianensis* for pre-weaned calves are in agreement with those obtained in small dairy farms of Pucallpa, Perú. This technology could be very attractive to small dairy producers given that the cost of establishment of this legume is less than the establishment of legume-based pastures for the milking herd and it results in increased cash flow due to the extra milk for sale, without affecting calf performance. In addition, the *Stylosanthes* technology could form part of a crop-pasture rotation system reducing the need to fallow land for secondary forest regeneration and subsequent slash and burn for annual crop production. This is because well managed *Stylosanthes* pastures can persist for 3 or 4 years and during this time produce a beneficial effect on the soil through N fixation and nutrient cycling.

Table 12. Milk for sale and growth of pre-weaned calves with and without access to a Stylosanthes guianensis pastura in Caquetá, Colombia.

| Item | Control[1] | Stylosanthes pasture[2] |
|---|---|---|
| Milk for sale (l/cow/day) | 3.3 | 4.0 |
| Liveweight gain of pre-weaned calves (g/A/d) | 297 | 389 |

[1]Six cows with calves
[2]Six cows with calves

**Contributors:** J. Velasquez, G. Ruiz, and C. Lascano, CORPOICA and CIAT, Colombia.

### 2.2.3.2. Rice yield *(Oriza sativa L.)* as an indicator of soil fertility with the incorporation of *Stylosanthes guianensis* stubbles in Pucallpa, Peru.

**Rationale.** It has been demonstrated that pure fodder banks of *Stylosanthes guianensis* can be used for calf feeding (Tropileche Annual Report 1998). However, Stylosanthes only persists for 2-3 years under grazing and then needs to be replanted. As it is a legume that can also add N to the soil for a following crop, it was thought that its adoption by farmers might be enhanced if it could be demonstrated that it had a dual role, feed for calves and green manure in a rotation system. This study reports the evaluation of *Stylosanthes* as a legume for a potential crop-legume fallow system.

**Methods:** The experiment was conducted on a farmer's field with low fertility soils, acid pH, and highly saturated with aluminum (ultisoils). Farm is located near Pucallpa which is situated 270 m.a.s.l. and with annual mean precipitation of 2000 mm and mean temperature of 26°C. The experiment started in October of 1998 and concluded in February of 1999. Treatments were:

T 1 = rice without N fertilization,
T 2 = rice after *S. guianensis* without N fertilization,
$T_3$ = rice after *S. guianensis* with 50 kg N/ha,
$T_4$ = rice after *S. guianensis* with 100 kg N/ha,
$T_5$ = rice after *S. guianensis* with 150 kg N/ha, and
$T_6$ = rice after *S. guianensis* with 200 kg N/ha.

The variables evaluated were: rice yield, number of tillers/$m^2$, number of spiklets/$m^2$, number of grains per spiklet, and weight per 1000 grains. The rice variety planted was "Chancabanco" with a 90-day vegetative period. All treatments received a basal application of 50 kg/ha of potassium chloride and 50 kg/ha as rock phosphate. The design was a completely randomized block with 6 treatments and 5 replications.

**Results: Table 13** shows rice yield, number of tillers, and number of spiklets. Rice yield after the incorporation of *Stylo* stubble was significantly higher than the control. There were no significant differences to N fertilization above 100 kg/ha N. these results demonstrate that the incorporation of *Stylo* stubble can make a significant contribution of N to the soil for a following crop and there may be economical benefits from a rotation system incorporating *Stylo.*

**Impact.** *Stylosanthes guianensis* is a legume with the potential to benefit small farmers when used in a rotational system with agricultural crops because it can be used both as animal feed and increases crop yields through increasing available soil N.

**Table 13. Effect of incorporation of *S. guianensis* and N fertilization on rice yield, and number of tillers and spiklets in Pucallpa, Peru.**

| Treatments | Rice yield (kg/ha) | Tillers ($\#/m^2$) | Spiklets ($\#/m^2$) |
|---|---|---|---|
| Control | 380 c | 102 a | 136 b |
| *Stylo* | 520 b | 111 a | 154 ab |
| *Stylo* + 50 kg/ha N | 600 b | 119 a | 154 ab |
| *Stylo* + 100 kg/ha N | 830 a | 125 a | 174 ab |
| *Stylo* + 150 kg/ha N | 870 a | 130 a | 187 a |
| *Stylo* + 200 kg/ha N | 890 a | 136 a | 185 a |

* Values in a single column followed by equal letters do not differ significantly ($P < 0.05$)

**Contributors:** Jorge Vela, IIAP, Peru

## 2.2.4 On-farm trials established for evaluating new forages in the llanos of Colombia

### Highlights

- Demonstrated the feasibility of establishing *Arachis* in the degraded pastures on livestock farms of the piedmont of the Colombian llanos, but not on farms in the well-drained savannas with soils of lower fertility

**Purpose:** The main objective of the work is to determine the utility of new ecotypes of legume and grasses developed in the Forage Project (IP-5) to reclaim degraded pastures as compared with commercial cultivars in livestock farms of the llanos of Colombia.

**Rationale:** One major limitation for beef and milk production in Neotropical savannas is degradation of introduced grasses, as a result of nitrogen deficiency and overgrazing. Thus CIAT's Forage Project (IP-5) has been developing improved grasses and legumes that can contribute to reclaim large areas of degraded pastures in tropical regions where livestock is a major land use system.

**Methods:** In collaboration with IP-5 and CORPOICA we initiated in 1998 on-farm evaluation of new grasses and legumes in representative farms of the llanos of Colombia.

A total of four farms (two in the well-drained savannas and two in the piedmont) were initially selected to evaluate new ecotypes of the pasture legume *Arachis pintoi.* Selected farms were representative of the two sub-ecosystems and have large areas of degraded pastures. In addition, farmers participating in the Project indicated their willingness to cover some of the cost of the work done in their farms.

In each farm at least 8 ha of degraded *Brachiaria* spp pastures were used to establish the following treatments:

a) Four ecotypes of *Arachis pintoi* (CIAT 17434-control and 18744, 18748 and 22160) and,
b) Two legume planting densities (3 and 6 kg/ha)

Land was prepared using a chisel plow and a disk harrow following overgrazing of the *Brachiaria* pastures. The seed *Arachis* seed was planted using a conventional grain row planter. The fertilizer used (kg/ha: 250 rock phosphate, 250 dolomite Ca, 150 Potassium chloride, and 25 sulfur) was broadcasted in all the area.

Soil physical and chemical characteristics were measured in all farms before planting the legume. Measurements were also made on the above ground biomass (cover, botanical composition, forage on offer and presence of pest and diseases). In order to allow an estimate on changes in the soil over time, additional measurements were done in the soil (physical and chemical) after planting *Arachis*. Post-establishment measurements include: rate of germination of *Arachis* seed (30 days after planting), cover of the legume (at 45 day intervals), botanical composition and legume and grass yield (in the rainy and dry seasons).

**Outputs:** The establishment of *Arachis* sown in 1998 in association with *Brachiaria* spp was only successful in 1 of the 4 farms selected. In all farms the accession CIAT 22160 had very low germination and there were no measurable difference in the establishment rate of the other accessions (CIAT 18744 and 18748) relative to the commercial cultivar (CIAT 17434).

***Pastures reclaimed in 1998 - Piedmont:*** The farm where their was good legume establishment in association with *B. humidicola* (low to establish) is located in the piedmont with relatively good soils (2.5% OM) and a native-grass vegetation covering the degraded pasture chosen for rehabilitation. After sowing the legume-grass and applying the fertilizer a large proportion of weeds germinated together with some *B. decumbens* (the original grass introduced in the pasture) but weeds were successfully controlled with a mechanical cutter. Initial grazing began 7 months after establishment with an average stocking rate of 2.5 A/ha. Legume proportion of the pastures was not significantly affected by sowing rate and after 1 year, the botanical composition of the pasture was 34% grass, 40% *Arachis* and 26% weeds. Animal LWG has been very high (1kg/head/day) most likely due to compensatory growth.

The second farm located in the piedmont where establishment of *Arachis* was poor had relatively good soils (2.8% OM), but the area chosen to plant the legume was dominated by *B. decumbens* in poor condition. Initial establishment of the legume following land preparation and fertilization was good, but at the end of the rainy season (December 1998) the proportion was low regardless of ecotype used or sowing rate. This reduction of legume in the pastures was most likely the result of competition from the vigorous grass that germinated after land preparation. It was not possible to minimize this competition given that the farmer did not have animals to graze the pasture when needed. It was decided to re-establish *Arachis* (CIAT 18744 and 18748) in the rainy season of 1999. The amount of *Arachis* is now ranging from 7 to 12% and intermittent grazing is being applied to favor the legume.

***Pastures reclaimed in 1998 - Well - drained savannas:*** Establishment of *Arachis* was not successful in the two farms located in the well-drained savannas in spite of having good seed germination and having applied fertilizer. The lower soil fertility found in well-drained savannas as compared with the piedmont together with competition from sown grasses and weeds would explain the poor establishment of *Arachis* in degraded pastures. To obtain good Arachis-based pastures more fertilizer would have to be applied, but it is unlikely that farmers would be willing to pay the extra cost.

In the on-farm work carried out so far in the llanos of Colombia to rehabilitate degraded pastures we have learned several things, which are summarized as follows:

1. Farmers recognize pasture degradation as a major constraint for increasing milk or beef production, but have serious limitations of machinery for land preparation and sowing of new grass and legume species. In addition, farmers have limitations to invest on fertilizers and on seed of legumes, usually more expensive than that of grasses.
2. Security aspects have determined to a great extent that owners seldom visit their farms and as a consequence we have not been able to involve the owners in the on-farm work as much as we would have liked.
3. Successful establishment of *Arachis* is dependent not only on soil fertility, but also on the original vegetation in the degraded pasture, on the companion grass used and on grazing management.
4. Failures in the establishment of *Arachis pintoi* in degraded pastures in the low fertility soils of the well-drained savannas have determined that we look for other legume options.
5. Demand for new grasses with drought tolerance and for shrub legumes to supplement milking cows in the dry season.

***New plantings:*** High priority was given in 1999 to the selection of new farms to plant new grasses and legumes in degraded areas using as a criteria the willingness of resident farmers to actively participate in the evaluation. In **Table 1** we summarize the new plantings in farms of the piedmont and well-drained savannas.

**Table 1. Plantings during 1999 in farms of the llanos of Colombia**

| Sub-Region | Species planted | Area (Ha) |
|---|---|---|
| **Piedmont** | | |
| Farm 1 | *B. bryzantha* CIAT 26110<br>*B. bryzantha* CIAT 26318 | 2<br>3 |
| Farm 2 | *B. bryzantha* CIAT 26318 | 5 |
| Farm 3 | *Desmodiun ovalifolium* (mixture of 5 accessions) + *P .phaseoloides (Kudzu)* | 20 |
| Farms 4 and 5 | *Cratylia argentea* | ¼ to 1 ha |
| **Well-drained savannas** | | |
| Farm 1 and 2 | *D. ovalifolium* (mixture of 5 accessions) | 7.5 to 48.5 |
| Farm 3 | *B. bryzantha* CIAT 26318 | 5 |

As can be seen in Table 1 new plantings include ecotypes of *Brachiaria bryzantha* selected in the Red Colombiana de Brachiaria for high forage yield and drought tolerance. In addition, ecotypes of *D. ovalifolium* selected in a multilocational trial in Colombia were sown as the legume component to recuperate degraded pastures in both ecoregions. It is felt that *D. ovalifolium* is a better option to recuperate pastures in farms in well drained savannas as compared with *Arachis*, given its good adaptation to low fertility soils and low seed rates (400 to 500 g/ha) required for establishment. The shrub legume *Cratylia* was established in two farms as a fodder bank to supplement milking cows in the dry season.

**Impact:**

It is to premature to talk about impact of the on-farm work in the llanos of Colombia aimed at testing with farmer's new grass and legume options to rehabilitate degraded pastures. However, it should be kept in mind that the current economic-social conditions in the region do not contribute to the desire of farmers to make large investments on pasture renovation on their properties. Thus the work being executed will lay the groundwork for future interventions.

**Contributors:** Camilo Plazas (CIAT- PE-5), C.E. Lascano (CIAT-IP-5/PE-5), J. Miles (CIAT- IP-5), Raul Perez (CORPOICA) and A. Rincon (CORPOICA)

## *Activity 2.3 Evaluating legumes for feed supply, nutrient cycling and improved fallows*

### 2.3.1 Identification of species for cover crops and fallow improvement, Cauca, Colombia

**Highlights**

- Corn yield was increased 1-2 fold following legume cover crops in a degraded hillside soil
-

**Purpose:** Identify legumes which increase yields of subsequent crops with the participation of the community

**Rationale:** Earlier trails have shown that cover crop legumes sown into a fallow can increase the yield of a following maize crop depending on the quality and quantity of biomass of the legume used and the rainfall if there was adequate moisture for the corn crop.

**Methods:** Location: Centro Alternativo de Investigacion Agropecuaria "El Nilo" north Cauca, 3°4'N and 76° 28' W, average temperature 23.5°C and altitud 1200m masl. The area is in the foothills of the Central Andean range, with soft slopes and erodible terraces. It is used for crops and dual-purpose cattle. Precipitation is bimodal, March to May and October and December, with an average of 1600mm/an. The soil is silty clay in texture with pH 5.2, OM 5.7%, very low P (Bray II) 1.6 ppm, Ex.bases (meq/100g) are Ca = 7.2, Mg = 3.2 y K = 0.15. The site used for the experiment was a badly degraded pasture.

Treatments were. : a) Legume covers

- *Mucuna pruriens* CIAT 9349
- *Pueraria phaseoloides* CIAT 7182
- *Canavalia brasiliensis* CIAT 17009
- *Centrosema pubescens* CIAT 15160
- *Crotalaria juncea* CIAT 21709
- *Cajanus cajan* CIAT 18701
- Natural-fallow cover (witness)

b) Fertilizer applied to legumes: 10 and 30 kg/ha P
c) Natural fallow which was also fertilized

Two levels of P were applied, due to previous experience of poor legume establishment of legume at similar low soil P levels.

The research was carried out with the participation of the indigenous Cabildos from northern Cauca (ACIN) who had been resettled and had little farming experience on the particular site. There main concern was to increase crop yield so as to improve food security.

The legumes were planted in October 1998 in plows, followed by maize in May 1999, two weeks after the incorporation of the legumes, The maize crop was fertilized with basal (kg/ha element): 50P, 50K, 20Mg, 25 Boronzinco (a mixture of B, Cu, Zn) and two levels of N, 0 and 100 kg/ha N.

**Results:**

Legume Cover: The legumes established quickly reaching 70% cover at three months with the exception of *Pueraria* whose establishment was affected by weed competition and *Crotalaria* which was attacked by ants. However, after six months at the time of incorporation they were well established. There were no significant differences between the levels of P during the establishment or in biomass produced. There were differences in yield between legume accessions, the best being *C. cajan* CIAT 18701 with 4.5 t/ha (**Table 2**). The legumes *P. phaseoloides* and *C. pubescens* require more time to accumulate adequate biomass before incorporation.

*Labile soil N at planting:* The KCl extractable $NO_3$-N was increased by the legume covers. There was no significant difference to 30cm depth at the time of incorporation, but considerable differences 30 days after incorporation at of 0-10 cm and 20-30 cm (**Table 1**). Total N was 3.5 times more than that of natural fallow.

**Table 1. Total labile nitrogen ($NO_3$+$NH_4$) at time of planting and 30 days after planting**

| Legume cover | Depth | At planting | 30 days after planting |
|---|---|---|---|
| | (cm) | (ppm) | |
| *C. brasiliensis* 17009 | 0-10 | 15.0 | 21.6 |
| | 20-30 | 6.7 | 19.9 |
| *C. cajan* 18701 | 0-10 | 13.2 | 12.7 |
| | 20-30 | 5.0 | 14.4 |
| *C. juncea* 21709 | 0-10 | 8.6 | 10.9 |
| | 20-30 | 5.4 | 12.8 |
| *C. pubescens* 15160 | 0-10 | 10.7 | 12.8 |
| | 20-30 | 5.8 | 13.7 |
| *M. pruriens* 9349 | 0-10 | 8.8 | 9.9 |
| | 20-30 | 7.8 | 12.4 |
| *P. phaseoloides* 7182 | 0-10 | 10.4 | 12.5 |
| | 20-30 | 5.7 | 13.7 |
| Witness | 0-10 | 6.6 | 6.0 |
| | 20-30 | 3.3 | 5.8 |
| LSD P< 0.05 | 0-10 | ns | 7.0 |
| | 20-30 | ns | 8.0 |

**Table 2. Dry matter yields of legume covers at time of incorporation, and maize (averaged over P and N levels)**

| Treatments | Yield Covers at 6 months | Maize Grain | Maize Total |
|---|---|---|---|
| | | t/ha | |
| *C. cajan* 18701 | 4.5 | 5.1 | 16.7 |
| *M. pruriens* 9349 | 2.8 | 4.4 | 14.2 |
| *C. pubescens* 15160 | 1.4 | 4.0 | 12.5 |
| *C. brasiliensis* 17009 | 2.2 | 3.7 | 12.6 |
| *P. phaseoloides* 7182 | 1.2 | 3.6 | 11.5 |
| *C. juncea* 21709 | 3.3 | 2.7 | 9.6 |
| Control -fallow | 3.4 | 1.6 | 7.6 |
| LSD P < 0.05 | 2.4 | 2.5 | Ns |

*Maize yield:* There were significant differences in the yield of maize grain with different legume covers. Differences were not significant for total dry matter yield of maize plant MS or between levels of P applied to legume covers and N applied to maize. The yield of grain was greater following *Cajanus cajan, Mucuna pruriens* and *Centrosema pubescens* with yields above 4 t/ha. (This is surprising since *C.*

*pubescens* had a relatively low biomass yield (Table 2). The yields were higher than expected, possibly due to adequate soil moisture.

Grain yield of maize increased 2.4 times following a legume cover crop (**Table 3**). This increase in maize yield can be attributed to the effect of the legume and not only the applied N as there was no increase from an application of fertilizer N. In all cases the yield of grain was twice or greater than twice that of the control following incorporation of legume. This confirms earlier results obtained in Cauca.

**Table 3. Performance of grain and total corn yield (t/ha) after legume improved fallow[1]**

| Treatment | Level of P | Level of N | Grain | Total DM Yield |
|---|---|---|---|---|
| | kg/ha | t/ha | | |
| Legume[1] | 10 | 0 | 3.8 | 12.5 |
| Control fallow | 10 | 0 | 1.3 | 8.3 |
| Legume | 10 | 100 | 3.9 | 12.9 |
| Control fallow | 10 | 100 | 1.6 | 6.6 |
| Legume | 30 | 0 | 3.8 | 12.3 |
| Control fallow | 30 | 0 | 1.5 | 6.0 |
| Legume | 30 | 100 | 4.1 | 13.4 |
| Control fallow | 30 | 100 | 2.2 | 9.5 |

1 Average six legumes: *Cc*, *Mp, Pp, Cp, Cj* y *Cb*

**Impact:** The results show that legumes that are well adapted and established rapidly can be used as cover crops to increase yields of a following crop. The community planted and managed the covers and maize and they have indicated interest in evaluating these results on a wider scale There is considerable self regeneration of some of the legumes and it is planned to monitor the effect of this volunteer green cover. It remains to be seen whether the legumes will self regenerate in drier years.

**Contributors**: Luis H. Franco, Fredy Tabares and Peter Kerridge (CIAT)

## b) Evaluation of herbaceous legumes as cover crops in rubber and oil palm plantations, Meta, Colombia

**Rationale:** There is a need in the plantation industry of the Llanos of Colombia to find sustainable ways to reduce weed infestation, to maintain and improve soil fertility, to control erosion and increase the microfauna biomass. There is currently a trend to promote plantation systems in Colombia. In the rubber plantations the target group for this promotion are small to medium size farmers who want to diversify their farming operations. In the oil palm plantations plots of up to 5 ha are leased out to landless farmers to manage the oil palms for the oil palm industry. Productive legume covers could reduce labor inputs and contribute to soil N thus improving the efficiency of production and having an indirect effect on the welfare of resource poor farmers.

To evaluate this hypothesis, in 1999, a range of legume accessions of the species *Arachis pintoi, Desmodium heterocarpon* and *Pueraria phaseoloides* have been sown under shade and no-shade conditions to evaluate them as covers.

**Contributors:** M. Peters (IP-5), C. Plazas (PE-5).

## 2.3.2. Rotational effects of five legumes on maize-bean intercrop production, Uganda

**Highlights**

- The contribution of *Canavalia ensiformis* on maize-bean intercrop productivity was greater than for other legumes, due to more N fixation, more recovery of deep soil nitrates, and more accumulation of soil P in organic form.

**Purpose:** To evaluate the effectiveness of several legumes in the improvement of productivity, and to understand the reasons.

**Rationale:** Alternative legumes have a potential role in the maintenance of soil productivity. Several have been identified as promising including *Canavalia ensiformis, Mucuna pruriens, Crotalaria ochroleuca,* and *Lablab purpureus.* The causes of the rotational effects have not been well understood. As the rhizosphere of some vigorously growing legumes is more active than for common food crops, we thought it likely that one or more of these legumes would acquire significant amounts of P from applied Busumbu rock P.

**Methods:** The above legumes were compared to soybean in a trial of split plot arrangement over a period of five seasons, 1997a to 1999a. Main and sub-plot treatments were legume species and P treatments, respectively. P was applied at 200 kg $P_2O_5$ $ha^{-1}$ as rock P, TSP or a mixture. The comparisons were for N-fixation ($^{15}N$ atom excess with grain sorghum as the reference crop), profile soil water (monitored with neutron probe), soil nitrates and crop yield in a maize-bean intercrop, green manure rotation in a sub-humid, bi-modal rainfall system of Uganda.

**Outputs:** The legumes and the food crops did not recover significant amounts of P from the rock P. Maize-bean intercrop was most productive following canavalia and produced least after mucuna and soybean (**Table 1**). These effects generally persisted to the second season following legumes.

**Table 1. Whole plant and grain yield for intercropped maize and bean as affected by green manure of five legume species in the subsequent and second following season.**

| *Species* | **Grain yield** (kg $ha^{-1}$) Subsequent season (1997B and 1998B) | | Second following season (1999A) | |
|---|---|---|---|---|
| | ***Maize*** | ***Bean*** | **Maize** | Bean |
| Canavalia | 3678 | 658 | 3747 | 430 |
| Mucuna | 2625 | 508 | 3465 | 347 |
| Crotalaria | 2970 | 628 | 3523 | 313 |
| Lablab | 3224 | 490 | 3192 | 144 |
| Soybean | 2483 | 613 | 2516 | 443 |
| LSD 0.05 for legumes | 493 | 94 | 465 | 97 |

Canavalia produced the most biomass and accumulated the most soil P in the plant biomass. Mucuna and canavalia fixed the most atmospheric N (67 and 39% Ndfa and 155 and 133 kg N $ha^{-1}$, respectively); crotalaria fixed little N. Lablab and soybean produced the least biomass. Soil nitrate following a season of maize-bean production was highest where canavalia had been grown previously. Canavalia was the most effective legume in uptake of soil N, leaving 73 compared to 120 to 148 kg $ha^{-1}$ of nitrate in 120 cm of soil depth, with the difference largely due to less nitrate at depth following canavalia. Profile soil water status was highest under soybean and lowest under crotalaria (cycle I) and canavalia (cycle II). Surface soil moisture content was similar for all species, but differences were evident at depth. Approximately 150 and 300 mm of rain were required to replenish profile soil water during the intercrop following cycle I of crotalaria and cycle II of canavalia, respectively.

**Impact:** Canavalia and mucuna are promoted for use by farmers through training, distribution of leaflets, demonstrations and farmer-experimentation mini-kits. Canavalia is preferred by some for its ease of management. Mucuna is preferred by others who use it to feed dairy cows. Slow adoption is associated with weak extension efforts, but farmers' knowledge of the species is increasing.

**Contributors:** Charles Wortmann, Kayuki Kaizzi (NARO) and Beverly McIntyre (Rockefeller Foundation). Linked to IP2 which provided the funding.

### 2.3.3. Effects of legumes on infection of subsequent crops by rootknot nematode, Kenya

**Highlights**

- Infection by rootknot nematode (*Meloidogyne incognita*) was generally less with *Crotalaria grahamiana, Mucuna pruriens* and *Lablab purpureus* compared to other legumes, but severe following *Sesbania sesban* and *Tephrosia vogellii.*

**Purpose:** To evaluate the rotational effects of several legumes on nematode infection in subsequent crops.

**Rationale:** Alternative legumes have a potential role in the maintenance of soil productivity, fodder production, weed suppression and pest management. Tephrosia has become popular with farmers in parts of Uganda for control of mole rats. However, tephrosia, sesbania and some other legumes are known to be good hosts of meloidogyne nematodes which can be a serious pest of bean, tobacco, tomato and some other crops. Other species, on the other hand, are noted for suppression of nematodes. Better understanding of the legume-nematode relationship is needed for better integration of alternative legumes in farming systems.

**Methods:** Three trials were conducted where soil was sampled from trial and demonstration sites, which allowed a comparison of legumes for effects on nematodes. Tomato seedlings, which had been established in sterile soil, were transplanted into pots containing these soil samples. At approximately seven weeks after transplanting, nematode infection was assessed by counting the number of rootknots per 50 cm of root length and per gram of fresh root weight.

**Outputs:** Results are presented in **Tables 1-3.** *Crotalaria grahamiana* appears to very good at suppressing meloidogyne. Results for mucuna were inconsistent, having low levels of nematode infection in two trials but high infection in another where the soil for mucuna was taken from a weedy fallow. Infection rates following sesbania and tephrosia were very high. Soybean and *Crotalaria ochroleuca* also were associated with high infection rates. Subsequent observations on farmers' fields confirmed that bean had more rootknots when in close proximity to tephrosia and sesbania.

**Table 1. The effects of five annual legumes on infection of tomato roots by rootknot nematodes**

| Legume species | Rootknots | Rootknots |
|---|---|---|
| | (50 $cm^{-1}$ of roots) | ($g^{-1}$ of fresh roots) |
| *Canavalia ensiformis* | 7.5 | 10.2 |
| *Mucuna pruriens* | 0.7 | 4.7 |
| *Crotalaria ochroleuca* | 17.2 | 26.7 |
| *Dolichos lablab* | 0.5 | 6.5 |
| Soybean | 10.5 | 12.7 |
| LSD 0.05 | ns | ns |

Table 2. The effects of sesbania and tephrosia on infection of tomato roots by rootknot nematodes

| Legume species | Rootknots (50 $cm^{-1}$ of roots) |
|---|---|
| *Tephrosia vogellii* | 20.7 |
| *Sesbania sesban* | 26.4 |
| *Mucuna pruriens* | 1.5 |
| Weedy fallow | 1.9 |
| LSD 0.05 | 9.3 |

**Table 3. The effects of three perennial legumes and mucuna on infection of tomato roots by rootknot nematodes**

| Legume species | Rootknots (50 $cm^{-1}$ of roots) | Rootknots ($g^{-1}$ of fresh roots) |
|---|---|---|
| *Tephrosia vogellii*, Kawanda | 107 | 80 |
| *Tephrosia vogellii*, Senge | 193 | 93 |
| *Sesbania sesban*, Senge | 104 | 73 |
| *Mucuna pruriens*, Senge (weedy) | 77 | 54 |
| *Crotalaria grahamiana*, Kawanda | 0 | 0 |
| LSD 0.05 | 44.7[1] | 28.4[1] |

[1] Error term is based on sampling error as soil was collected from single plots of legumes; plot effects are confounded with species effects.

**Impact:** *Crotalaria grahamiana* and, to a lessor extent, mucuna and lablab should be useful in reducing meloidogyne numbers in badly infested fields, or preceding highly susceptible crops. Sesbania and tephrosia must be used with caution; non-susceptible crops should follow fallow improved with these species.

**Collaborators:** Charles S. Wortmann and Imelda Kashiija (NARO). Linked to IP2 which provided the funding.

## 2.3.4. Crop response to application of alternative plant materials for soil fertility management

**Highlights:**
Plant parts of several naturally occurring species, which are often abundant in Uganda, resulted in increased soil productivity, but the benefit varied with the quality of the material.

**Purpose:**
To evaluate several naturally occurring plant species as resources for the management of soil fertility.

**Rationale:** Resource poor farmers often have diverse but scarce resources which might be used in the management of soil fertility. Some naturally occurring herbaceous and shrub species produce abundant biomass of moderate nutrient levels. When these plants are near a cultivated field, the biomass can be transferred to supply the crop with nutrients. Earlier work indicated that farmers would be willing to use such materials if proven effective in improving productivity.

**Methods:** The effects on crop productivity of application of immature plant materials of *Tithonia diversifolia, Lantana camara, Cassia hirsuta* and *Aspilia kostchyi* was evaluated on-station over 6 seasons. The organic materials, applied at 4 t $ha^{-1}$ dry weight, were compared to inorganic fertilizers. Surface application was compared to incorporation of the materials.

Farmer-managed trials were conducted on ten farms over four seasons with two reps per farm. The test crop was maize.

**Outputs:** Tithonia and aspsilia had the highest and lowest N content, respectively **(Table 1)**. Lantana had the highest lignin (16%) and polyphenol (3.4%) content. The organic materials, except for Aspilia, supplied more N and K than the fertilizer but more P was supplied in the fertilizer treatment.

**Table 1. Nutrients (kg) supplied in 4 t of dry matter by immature plant material of four species**

| | N | P | K | Ca | Mg |
|---|---|---|---|---|---|
| *C. hirsuta* | 119.2 | 7.2 | 182.4 | 51.2 | 16.0 |
| *L. camara* | 107.6 | 6.4 | 107.2 | 34.8 | 22.4 |
| *A. kotschyi* | 53.2 | 4.4 | 160.8 | 67.2 | 10.8 |
| *T. diversifolia* | 140.0 | 11.2 | 190.0 | 52.0 | 20.0 |
| Fertilizer, full | 100.0 | 21.3 | 104.3 | 0.0 | 0.0 |

Maize yields were highest with the full fertilizer rate but bean yields with cassia and tithonia were similar to the full rate of fertilizer **(Table 2)**. Response to the organic materials appeared to be regulated by plant N and polyphenol content, with less response to aspilia and lantana. The effects of the organic materials increased with time.

**Table 2. Maize and bean grain yield (kg/ha) as affected by application of parts of various plant species and inorganic fertilizers**

| Species | **Maize yield** mean of 4 seasons (kg $ha^{-1}$) | **Bean yield** mean of 2 seasons (kg $ha^{-1}$) |
|---|---|---|
| Cassia | $3350^{bc}$ | $980^{a}$ |
| Aspilia | $2560^{d}$ | $710^{c}$ |
| Lantana | $3010^{c}$ | $740^{bc}$ |
| Tithonia | $3410^{b}$ | $860^{ab}$ |
| Fertilizer (recommended rate) | $3890^{a}$ | $880^{a}$ |
| Fertilizer (1/2 recommended) | $3490^{b}$ | $790^{abc}$ |
| Control | $2030^{e}$ | $500^{d}$ |

Mean separation by DMRT at $p < 5\%$

*Method of application did not affect crop yield*

Crop response to application of lantana was less than with fertilizer **(Table 3)**. The effectiveness of lantana increased with continued application indicating residual effects of the organic material. Applying half-rates of fertilizer and lantana in combination gave inconsistent results with less yield than the full fertilizer rate in two seasons and similar yield in the other seasons. Yield response to lantana application may have been constrained by low P availability as the median P level (Olsen method) is 3.5 ppm in this community for fields having annual crops.

**Table 3. Maize grain yield (kg/ha) as affected by application of *Lantana* residues and inorganic fertilizers (results from 10 on-farm trials in Iganga District)**

| Treatment | Maize yield | | | |
|---|---|---|---|---|
| | 1997a | 1997b | 1998a | 1998b |
| | | (kg/ha$^{-1}$) | | |
| Lantana | 2430 | 1190 | 3820 | 1870 |
| Lantana + Fertilizer (50% rates) | 2820 | 1990 | 4630 | 2320 |
| Fertilizer | 2970 | 2410 | 4700 | 3130 |
| Control | 1950 | 1010 | 2760 | 1190 |
| LSD $_{5\%}$ | 710 | 560 | 860 | 780 |

**Impact:** The impact is not predictable. Response of farmers has not been encouraging. Expectations that farmers would begin their own experimentation with organic materials were not realized. Higher quality materials such as tithonia, where abundant, might be more attractive to farmers.

**Collaborators:** Kayuki Kaizzi, Charles Wortmann. Linked to IP2 and ECABREN which funded this work. Technical input of Cheryl Palm of TSBF is acknowledged.

## *Activity 2.4 Developing integrated forage-based components for upland farming systems*

### 2.4.1 Selection of improved forages in Southeast Asia

**Highlights**

- A range of forages areavailable for different climatic and soil conditions and farming systems in Southeast Asia

**Purpose:** To identify forages suitable for different upland farming systems in Southeast Asia

**Rationale:** Livestock are an integral component of most farming systems in Southeast Asia. They are a form of diversification for accumulating capital and providing food and in their contribution to other components by providing draft power and improving nutrient cycling. With intensification, traditional feed resources are becoming scarcer or more difficult to access. Improved forages offer a means of complementing other food resources. However, they need to be well adapted to climate and soil conditions, easily manageable by farmers and able to be integrated with other forms of land use. Farmers need to learn that improved forages require management, as do other crops. Hence it was considered important that farmers be involved in the whole process of selection, evaluation and adapting forages into their particular farming system. Once farmers perceive that a particular species can make a contribution to their livestock feed requirement, they experiment with different ways to improve management of the sown species and seek other uses.

**Methods:** The Forages for Smallholder Project (FSP) has used both farmer participatory approaches and conventional 'forage evaluation' techniques to develop sustainable forage technology options for resource-poor upland farms in Southeast Asia at 18 sites in Southeast Asia. These broadly cover the main range of environments and upland farming systems of the region. Initially large numbers of potential species from CIAT and CSIRO were screened in regional nurseries, either on research stations or on-farm but under the close supervision of researchers to identify species with climatic and soil adaptation. Farmer groups were involved in the planting and management of demonstration nurseries of species that had shown potential in their own villages. Individual farmers then selected species for evaluation on their own farms. Researchers initially provided seed and advice on establishment and worked alongside farmers in monitoring the performance of species. Feedback between farmers results and researchers enhanced learning and progress in selection of species and development of an appropriate technology.

An important aspect of the selection process was to ensure that seed or planting material could be readily produced at the local level, as there is not a formal seed industry for forages.

**Outputs:** Forage species suited for different uses, climates and soils are presented in **Tables 1** and **2**. Detailed information on the best varieties of each species are available in a booklet entitled 'Developing forage technologies with smallholder farmers – how to select the best varieties to offer farmers in Southeast Asia'. This information has been collated from farmer and researcher evaluations. These forages are now being evaluated in a genotype by environment experiment to accurately map the environmental adaptation of these forages. Final results are expected in 2000.

*Brachiaria decumbens* cv.Basilisk has been identified as a promising grass for areas with a pronounced dry season in Southeast Asia. Unfortunately, this variety produces no or very little seed at low latitudes and an evaluation of a large range of *Brachiaria* germplasm is being conducted to identify varieties with acceptable seed yields and good dry season performance in northeast Thailand. Several promising accessions have been identified: CIAT accession numbers 16835, 6387, 1873, 1737, 16327, 16315, 16871, 16212, 26159, 26318, 16829,16827 and 6780. Detailed studies of the seed production characteristics and dry season performance of these accession are being conducted to identify a small range of accessions for farmer evaluation in a wide range of envirnments.

**Table 1: Forage species for different climates and soils**

| | CLIMATE | | | SOIL FERTILTIY AND ACIDITY | | |
|---|---|---|---|---|---|---|
| | Wet tropics with no or short dry season | Wet/dry tropics with long dry season | Cooler tropics (eg. high elevation) | Fertile (neutral to mod. acid soils) | Moderately fertile (neutral to mod. acid soils) | Infertile (moderate to extreme acid soils) |
| **Grasses** | | | | | | |
| *Andropogon gayanus* | ● | ●● | | ● | ● | ● |
| *Brachiaria brizantha* | ● | ●● | ●● | ● | ●● | ● |
| *Brachiaria decumbens* | ● | ●● | ●● | ● | ●● | ● |
| *Brachiaria humidicola* | ●● | ● | ● | ● | ● | ●● |
| *Brachiaria ruziziensis* | ●● | | ● | ●● | ● | |
| *Panicum maximum* | ●● | ● | ● | ●● | ● | |
| *Paspalum atratum* | ●● | | ● | ● | ●● | ● |
| *Pennisetum purpureum* and hybrids | ●● | | ● | ●● | ● | |
| *Setaria sphacelata* | ●● | ● | ●● | ●● | ● | |
| | | | | | | |
| **Legumes** | | | | | | |
| *Arachis pintoi* | ●● | | ● | ●● | ●● | |
| *Calliandra calothyrsus* | ● | | ●● | ● | ●● | |
| *Centrosema macrocarpum* | ●● | ● | ● | ●● | ● | |
| *Centrosema pubescens* | ●● | ● | | ●● | ● | |
| *Desmanthus virgatus* | ●● | | ●● | ●● | ● | |
| *Desmodium cinerea* | ● | ● | | ● | ● | |
| *Gliricidia sepium* | ●● | ●● | | ● | ●● | |
| *Leucaena leucocephala* | ●● | ●● | ● | ●● | ● | |
| *Stylosanthes guianensis* | ●● | ●● | ● | ● | ●● | ●● |

●● = highly suitable ● = possible no stars = not suitable

*Stylosanthes guianensis* CIAT 184 is one of the most promising, broadly adapted legume in the region. Although this variety is highly susceptible to the fungal disease anthracnose in its native range, it has shown remarkable resistance to this disease in Southeast Asia where there are different strains of anthracnose to those in South America. However, there is a danger that this resistance may not be durable and experiments are being conducted in Hainan, P.R. China and Los Banos, Philippines which aim to identify accessions with a higher level of resistance than CIAT184. Of 40 *Stylosanthes* spp. and hybrids with known resistance from CIAT, EMBRAPA and CSIRO, several are showing promise for use in Southeast Asia. These include the hybrids GC1579 and GC1463. By the end of 1999, the project hopes to identify a small range of resistant accessions for wider testing in the region.

**Table 2: Suitability of forages for different uses**

| | Forage Technology Options | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cut & carry plots | Grazed plots | Living fences | Hedgerows | Improved fallow | Cover crops in annual crops | Cover crops under trees | Ground covers for erosion control | Legume supplementation for long dry season | Legume leaf meal (dried) |
| **Grasses** | | | | | | | | | | |
| Andropogon gayanus | ● ● | ● | | ● | | | | | | |
| *Brachiaria brizantha* | ● ● | ● | | ● | | | | | | |
| *Brachiaria decumbens* | ● | ● ● | | | | | | ● | | |
| *Brachiaria humidicola* | | ● ● | | | | | | ● ● | | |
| *Brachiaria ruziziensis* | ● | ● ● | | | | | | ● | | |
| *Panicum maximum* | ● ● | ● | | ● | | | | | | |
| *Paspalum atratum* | ● ● | ● ● | | ● ● | | | | | | |
| *Pennisetum purpureum* and hybrids | ● ● | | | ● | | | | | | |
| *Setaria sphacelata* | ● ● | ● | | ● ● | | | | | | |
| | | | | | | | | | | |
| **Legumes** | | | | | | | | | | |
| *Arachis pintoi* | | ● | | | | | ● ● | ● ● | | |
| *Calliandra calothyrsus* | ● ● | | ● | ● | | | | | ● | |
| *Centrosema macrocarpum* | ● | | | | ● ● | ● ● | ● | ● | | |
| *Centrosema pubescens* | ● | | | | ● ● | ● ● | ● | ● | | |
| *Desmanthus virgatus* | ● ● | | | ● | | | | | | ● ● |
| *Desmodium cinerea* | ● ● | | | ● ● | | | | | | |
| *Gliricidia sepium* | ● ● | | ● ● | ● | | | | | ● | |
| *Leucaena leucocephala* | ● ● | ● | ● | ● | | | | | ● ● | ● ● |
| *Stylosanthes guianensis* | ● ● | ● | | ● | ● ● | ● ● | ● | | ● ● | ● ● |

● ● = highly suitable ● = possible no stars = not suitable

**Impact:** The impact of the selection and evaluation process is demonstrated by farmers identifying a new forage option (Table 1, Output 1.5.2). Selection and evaluation by farmers and identification of new forage options is a continuous and on-going process. Successful selection and evaluation results in a forage option for a particular need. Or a new forage option is the outcome of a successful selection and evaluation process. Thus we have only included those species that have been shown to have a role in a farming system in the table of climatic and soil adaptation (Table 2).

We consider that the species identified (Table 1) will cover most needs of farmers for improved forages in the different upland farming systems in Southeast Asia. However, as more farmers adopt these forage options, and they are used over an extended period, certain problems and also new opportunities will arise.

Such problems could be seed supply, nutrient depletion under 'cut and carry' systems and disease. Research has been initiated on selection of *Brachiaria* species which will produce high seed yields under the climatic conditions of Southeast Asia. It is proposed to initiate research with ILRI into nutrient dynamics in livestock systems. Research has also been initiated through an ACIAR project to identify alternative *Stylosanthes guianensis* species with resistance to anthracnose.

New needs may be a demand for green cover legumes for use in cropping systems and alternative shrub legumes for dry season production.

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## *Activity 2.5 Developing improved soil management practices in cassava-based systems*

### *2.5.1* New Cassava Options for Asia

#### *2.5.1.1* The Nutrient Requirements of Cassava

**Highlights**

- K is highly important in maintaining high cassava yields and high root starch content.
- Responses to K occur when the exchangeable K content of the soil drops below 0.15-0.17 me/100g
- Annual applications of 80-100 kg $K_2O$/ha are needed to offset the removal of K in the root harvest

**Purpose:** To maintain or improve soil productivity and to optimize the efficiency of fertilizer use in cassava-based cropping systems.

**Rationale:** Continued production of cassava on the same land is feasible in Asia because of the near absence of diseases and pests. However, if cassava roots (and sometimes stems and leaves) are harvested and removed from the field, this may lead to nutrient depletion and soil degradation. Thus, it is important to determine the nutrient requirements of the crop, to establish diagnostic criteria for interpreting soil and plant tissue analyses, and to develop efficient fertilizer practices for maintaining high yields and high starch contents of the roots.

**Methods:** Soil fertility maintenance through the application of NPK fertilizers. Numerous long-term NPK trials with a uniform design have been conducted with cassava in Asia since 1987. In 1998/99 only four trials were continued in three countries. The trials use an incomplete factorial design with four levels each of N, P and K in various combinations.

**Outputs:** **Figure 1** is an example of the response to annual applications of N, P and K in two cassava varieties grown for the ninth consecutive year in a rather fertile red Oxisol (Eustrotox) at Hung Loc Agric. Research Center in south Vietnam. There were no significant responses to fertilizer application during the first four years. In the ninth year, however, there were significant responses to N and K and to the combined application of NPK, which more than doubled yields from 15 to 33 t/ha. N application tended to decrease, while K application increased the starch content of roots. An annual application of 80 kg N, 40 $P_2O_5$ and 80 $K_2O$/ha maintained high yields and high starch contents, even after nine years of continuous cropping.

**Figure 2** shows the trend over the years in absolute and relative yields (average of two varieties) as well as the soil K and P contents. Absolute yields tended to increase over time, partially due to a change from low-yielding local varieties during the first three years to high-yielding new clones. Trends in the relative yield indicate that the response to K became increasingly more pronounced over time; the response to N also increased, but more slowly, while that to P did not change much over time, as cassava removes relatively little P in the root harvest. These trends are also reflected in the soil K and P contents. The response to K became significant in the 5$^{th}$ and highly significant in the 7$^{th}$ year of cropping when the exchangeable K content of the soil had dropped below 0.17 and 0.15 me/100g, respectively. This corresponds with previous results obtained in other locations. The available P content decreased only slightly when no P was applied, but increased significantly with annual application of 40 kg $P_2O_5$/ha. In both cases the soil P content remained well above the critical level of 5 ppm.

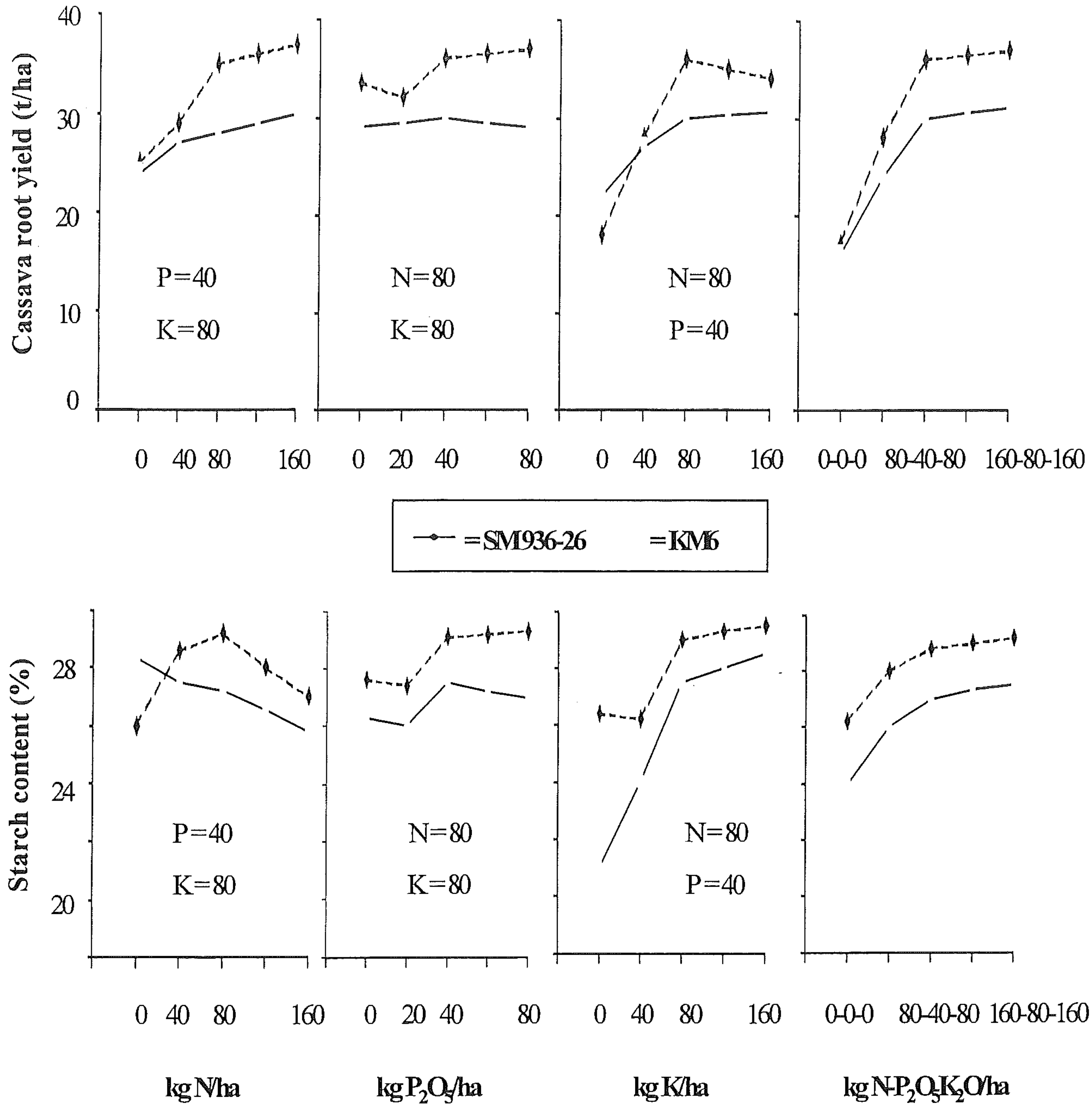


**Figure 1. Effect of annual applications of various levels of N,P and K fertilizer on the fresh root yield and starch content of two cassava cultivars grown at Hung Loc Agric Research Center in Dong Nai, Vietnam in 1998/99 (9th year).**

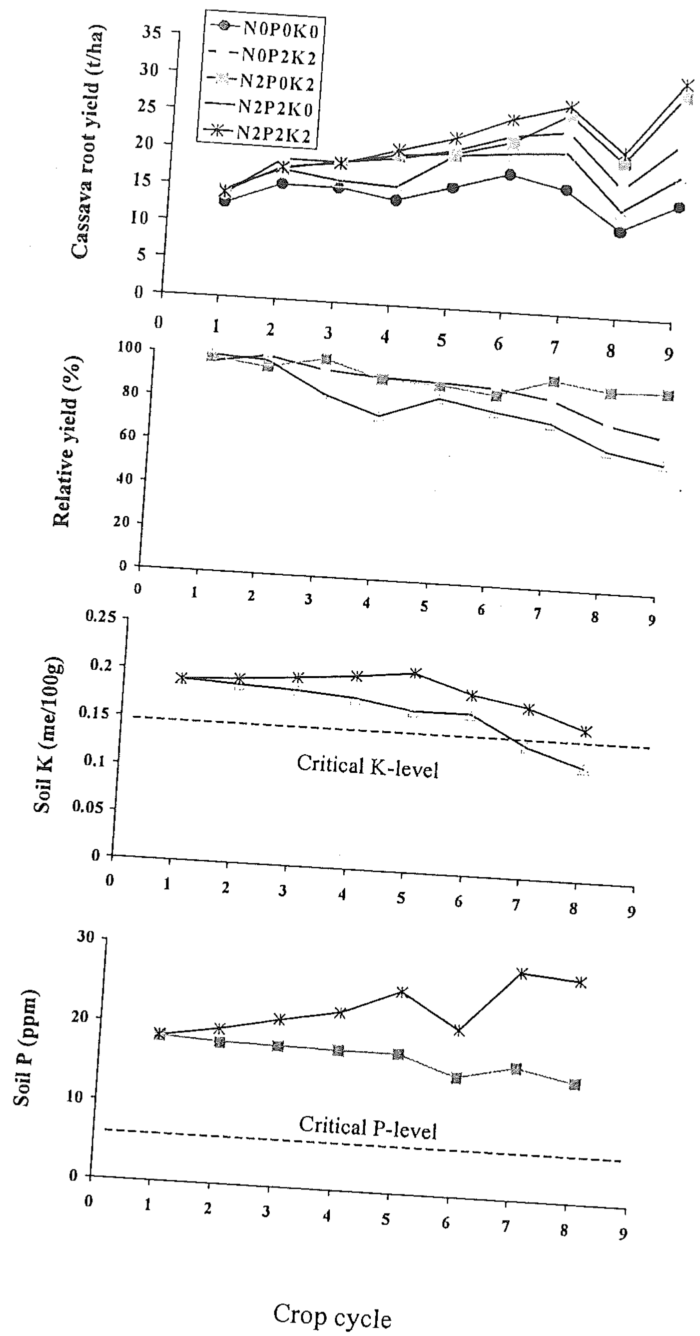


**Figure 2. Effect of annual applications of N, P an K on cassava root yield, relative yield (yield without the nutrient over the highest yield with the nutrient) and the exchangeable K and available P (Bray 2) content of the soil during nine years of continuous cropping at Hung Loc Agricultural Research Center, Dong Nai, Vietnam.**

**Impact:** The long-term fertility trials have clearly indicated the importance of K in maintaining high yields of cassava, and, at least in Asia, the low requirements for P. In soils that are very low in P, such as in Brazil and parts of Colombia, P applications are probably necessary for only a few years. Based on these and other data, the Department of Agriculture in Thailand has changed its fertilizer recommendation for cassava, from a 15-15-15 compound fertilizer to a cheaper one containing 15, 7 and 18% N, $P_2O_5$ and $K_2O$, respectively.

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### *2.5.1.2* Soil Improvement and Erosion Control by the Use of Green Manure, Intercropping and Alley Cropping

**Highlights**

- In areas of acid soils and irregular rainfall, intercropping cassava with peanut generally gives highest net income and helps to control erosion
- In high–Ca soils, alley cropping with *Leucaena leucocephala* or *Gliricidia sepium* are effective in improving productivity and in reducing erosion.
- On slopes, contour hedgerows of vetiver grass, elephant grass or Taiwan grass are effective in reducing erosion, but the latter two may compete strongly with nearby cassava plants.

**Purpose:** To evaluate green manure, intercrops and hedgerow systems for their efficiency in increasing yields or income, and for their effectiveness in controlling erosion.

**Rationale:** In areas where chemical fertilizers are not available or are out of reach for poor cassava farmers, soil fertility can be maintained or improved with the use of biological systems, such as leguminous green manure, intercrops or alley crops; these may also help to reduce erosion by quickly establishing a soil cover between cassava or by providing mulch. In addition, various grass species, when grown as contour hedgerows can be very effective in reducing soil erosion when cassava is grown on slopes, but may reduce the yield of nearby cassava, mainly through underground competition for water and nutrients.

**Methods:**

1) Several experiments were established on gentle slopes in Vietnam and Indonesia to evaluate the effectiveness of various green manure, intercrops and alley crops in increasing cassava yields and total net income, as well as in reducing erosion.
2) On 5% slope in Jatikerto, Malang, Indonesia, five grasses and one leguminous species were evaluated for their effect on cassava productivity as well as on soil erosion.

**Outputs:** The results of an intercropping trial conducted on 16% slope at Thai Nguyen University in Vietnam are shown in **Table 1**. Most intercrops slightly reduced cassava yields but increased gross and net income. Peanut and mungbean were most effective in increasing income, while peanut was also most effective in decreasing erosion. Follow-up experiments (data not shown) indicate that two rows of peanut between cassava rows (spaced at 1.0 m) produced highest net income, but 3 or 4 rows of peanut between wider-spaced cassava was slightly more effective in reducing erosion. Under the conditions of North Vietnam, with low temperatures in the spring, peanut should be planted 1-2 weeks before cassava.

**Table 1. Effect of intercropping cassava with various grain legumes on crop yield, gross and net income and soil loss due to erosion on 10% slope. Thai Nguyen, Vietnam.**

| Intercropping treatments | Yield (t/ha) Cassava | Yield (t/ha) intercrop | Gross income[1)] | Costs fert.+seed[1)] | Net income | Dry soil loss (t/ha) |
|---|---|---|---|---|---|---|
| | | | ← (mil. d/ha) | | → | |
| 1. Cassava monoculture | 18.67 | - | 7.47 | 6.22 | 1.25 | 31.2 |
| 2. C+peanut | 16.50 | 1.08 | 12.00 | 8.77 | 3.23 | 24.0 |
| 3. C+soybean | 18.42 | 0.15 | 8.27 | 7.98 | 0.29 | 28.5 |
| 4. C+mungbean | 20.83 | 0.27 | 10.49 | 7.84 | 2.65 | 28.6 |
| 5. C+black bean | 17.92 | 0.35 | 9.62 | 7.94 | 1.68 | 28.6 |
| 6. C+cuoc bean | 17.67 | 0.17 | 7.92 | 7.87 | 0.05 | 28.1 |

[1)]Prices (dong): cassava: 400/kg fresh roots; peanut 5000/kg dry pods; soybean 6000/kg dry grain; mung bean 8000/kg dry grain; black bean 7000/kg dry grain; cuoc bean 5000/kg dry grain

The long-term effect of intercropping, green manuring and alley cropping on soil fertility and cassava yields after seven years of continuous cropping in Hung Loc Center in Vietnam are shown in **Table 2.** All the soil improvement practices increased soil organic matter (OM), P and K, but the leguminous hedgerow species were most effective in this respect. Alley cropping with *Leucaena leucocephala* and *Gliricidia sepium* was also most effective in increasing cassava yields or starch contents, resulting in an increase in starch yield of 11.4 and 8.1%, respectively.

**Table 2. Effect of leguminous intercrops, green manure and hedgerow species on cassava yield and starch content (cv KM60) and soil fertility parameters following 7 years of continuous cropping Dong Nai, Vietnam, 1998/99.**

| Treatments | Soil characteristics[1)] OM (%) | P (ppm) | K (me/100g) | Cassava root yield (t/ha) | Root starch content (%) | Starch yield (t/ha) |
|---|---|---|---|---|---|---|
| Cassava monuculture | 2.5 | 9.5 | 0.24 | 25.00 | 27.8 | 6.95 |
| Cassava intercropped with peanut | 2.9 | 10.2 | 0.27 | 24.68 | 28.3 | 6.98 |
| Cassava intercropped with cowpea | 3.0 | 11.3 | 0.32 | 24.00 | 27.6 | 6.62 |
| Cassava intercropped with *Canavalia ensiformis* [2)] | 2.7 | 9.7 | 0.27 | 26.45 | 26.9 | 7.11 |
| Cassava alley cropped with *Leucaena leucocephala* | 3.0 | 19.2 | 0.38 | 25.89 | 29.9 | 7.74 |
| Cassava alley cropped with *Gliricidia sepium* | 2.9 | 11.3 | 0.37 | 27.00 | 27.8 | 7.51 |

[1)] Soil analysis before 6th cropping cycle
[2)] *Canavalia* intercropped with cassava, pulled out and mulched after two months

The effects of hedgerows of five grass and one leguminous hedgerow species on cassava and intercropped maize yields, on gross income and on runoff and erosion, when cassava was grown on 5% slope in Jatikerto, Malang, Indonesia are shown in **Table 3**. Hedgerows of vetiver grass produced the highest cassava and maize yields, as well as the highest gross income, but elephant grass, Taiwan grass and king grass were more productive and of higher quality as an animal feed. These more productive species, however, also competed more strongly with neighboring cassava plants. All hedgerows were quite effective in reducing runoff and erosion, but the grass species were generally more effective than the leguminous hedgerows, while Taiwan grass was slightly more effective than the other grass species.

**Table 3. The effect of contour hedgerows on yields of cassava and intercropped maize, hedgerow yield, gross income, runoff and soil loss on a 5% slope. Jatikerto, Malang, Indonesia 1997/98.**

| Treatments | Yield (t/ha) | | | Gross income[1)] | Soil loss | Runoff (% of |
|---|---|---|---|---|---|---|
| | Cassava | maize | Hedgerows | ('000Rp/ha) | (t/ha) | rainfall)[2)] |
| 1. No hedgerows | 18.85[3)] | 3.12[3)] | - | 4.296 | 68.92 | 30.5 |
| 2. vetiver grass hedgerows | 31.15 | 5.52 | 13.95 | 7.227 | 19.33 | 20.4 |
| 3. elephant grass hedgerows | 28.39 | 4.89 | 34.54 | 6.538 | 18.80 | 18.1 |
| 4. king grass hedgerows | 26.96 | 4.71 | 29.85 | 6.232 | 18.96 | 18.4 |
| 5. Taiwan grass hedgerows | 28.88 | 5.17 | 33.40 | 6.719 | 18.08 | 17.9 |
| 6. Benggala grass hedgerows | 24.94 | 4.42 | 17.66 | 5.787 | 20.90 | 20.0 |
| 7. *Gliricidia* (from stakes) hedgerows | 25.19 | 4.55 | 8.57 | 5.875 | 29.90 | 23.5 |
| 8. *Gliricidia* (from seed) hedgerows | 26.69 | 4.70 | 6.69 | 6.182 | 28.66 | 22.9 |

1) Prices (rupiah): cassava 170/kg fresh roots, maize 350/kg dry cobs
2) Rainfall was 1295 mm from Dec'97 to Aug'98
3) Low yields because plots had previously received no fertilizers from 1988 to 1996

### *2.5.1.3* Effective Ways to Reduce Erosion in Cassava-based Cropping Systems

**Highlights**

- Intercropping and contour hedgerows of vetiver grass or *Tephrosia candida* are very effective in increasing farmer's income and reducing erosion.

**Purpose:** To develop component technologies that are effective in reducing erosion, maintain soil fertility and increase farm income.

**Rationale:** When cassava is grown on slopes, soil erosion may be serious. Erosion can be significantly reduced by various agronomic practices, but nearly every practice has certain limitations. Research continues to look for options that are more effective in reducing erosion, less costly in establishment or maintenance, and that provide some direct income to the farmer.

**Outputs:** The results of an intercropping x hedgerow trial conducted on 5% slope in Tamanbogo, Lampung, Indonesia are shown in **Table 4**. Intercropping with maize and either rice or peanut, followed by soybean or peanut, significantly reduced cassava yields but increased net income and reduced erosion, as compared to growing cassava in monoculture. Among intercropping systems the rice-soybean system was slightly better than the peanut-peanut system in increasing net income, while there were no significant differences in terms of erosion control. Among hedgerows of vetiver grass, elephant grass and sorghum there were no or only minor differences in terms of net income and erosion control.

The results of an erosion control trial conducted on 10% slope in Thai Nguyen Univ. in Vietnam are shown in **Table 5**. Planting cassava in monoculture without ridges or hedgerows resulted in the highest soil loss by erosion and the lowest yield and gross income. Intercropping with peanut markedly increased cassava yields, increased gross income, supplied crop residues for soil improvement and decreased erosion by 45%. But erosion could be further decreased by combining intercropping with the planting of contour hedgerows of either *Tephrosia candida* or vetiver grass; this reduced erosion to about 20% of that obtained with monocropping.

**Table 4. Effect of cropping systems and live barriers on the yields of cassava, maize, rice, peanut and soybean, the gross and net income, as well as the total soil loss due to erosion during a 10-month cropping cycle on 5% slope in Tamanbogo, Lampung, Indonesia, in 1997/98.**

| | Yield (t/ha) | | | | | Gross | Fertilizer | Net | Dry soil |
|---|---|---|---|---|---|---|---|---|---|
| | cassava | maize | rice | peanut | soybean | income[1)] | costs[2)] | income[3)] | loss |
| | | | | | | ('000 Rp/ha) | | | (t/ha) |
| Cassava monoculture | 26.9 a | - | - | - | - | 4,307 e | 268 | 4,039 c | 23.8 a |
| C mono+vetiver grass h/rows | 27.7 a | - | - | - | - | 4,425 e | 268 | 4,157 c | 18.9 b |
| C mono+elephant grass h/rows | 24.2 b | - | - | - | - | 3,868 f | 268 | 3,600 d | 17.6 bc |
| C mono+sorghum h/rows | 27.4 a | - | - | - | - | 4,390 e | 268 | 4,122 c | 16.9 c |
| C+M+R-S + vetiver h/rows | 13.0 e | 0.14 | 2.51 | - | 0.79 | 6,279 bc | 664 | 5,615 b | 13.5 d |
| C+M+R-S + elephant gr.h/rows | 16.8 d | 0.15 | 2.02 | - | 0.77 | 6,547 ab | 664 | 5,883 ab | 12.0 d |
| C+M+R-S + sorghum h/rows | 14.7 e | 0.35 | 3.15 | - | 0.77 | 6,727 a | 664 | 6,063 a | 12.8 d |
| C+M+P-P + vetiver h/rows | 14.9 e | 0.40 | - | 1.79[4)] | - | 5,023 d | 612 | 4,416 c | 12.5 d |
| C+M+P-P + sorghum h/rows | 19.8 c | 0.38 | - | 2.02[4)] | - | 6,119 c | 612 | 5,507 b | 12.7 d |
| F-test | ** | | | | | | ** | ** | ** |

[1)]Prices (rupiah):cassava 160/kg fresh roots; peanut 1,400/kg dry pods; rice 550/kg paddy
maize 350/kg dry grain; soybean 3,500/kg dry grain
[2)]Prices: urea Rp 350/kg; SP-36 450/kg; KCl 500/kg
[3)]Net income = Gross income-Fertilizer costs; [4)]Sum of two harvests

**Table 5. Effect of cropping systems and management practices on the yield of cassava, intercropped peanut and hedgerow species, soil loss on 10% slope. Thai Nguyen, Vietnam. 1998.**

| | Yield (t/ha) | | | Gross | Dry soil |
|---|---|---|---|---|---|
| | | peanut | | income[1)] | loss |
| Crop/soil management treatments | cassava | dry pods | residue | (mil. d/ha) | (t/ha) |
| 1. C monoculture, no ridges, no hedgerows | 17.96 | - | - | 8.98 | 24.11 |
| 2. C+P, no ridges, no hedgerows | 21.72 | 0.39 | 5.58 | 12.81 | 13.26 |
| 3. C+P, no ridges, *Tephrosia* hedgerows | 22.38 | 0.27 | 3.81 | 12.54 | 5.60 |
| 4. C+P, no ridges, vetiver hedgerows | 21.50 | 0.30 | 3.16 | 12.25 | 5.40 |
| 5. C+P, contour ridges, *Tephrosia*+vetiver hedgerows | 21.04 | 0.38 | 3.11 | 12.42 | 5.18 |

[1)]Prices (dong): cassava 500/kg fresh roots; peanut 5000/kg dry pods

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### *2.5.1.4* Varietal Testing

**Highlight**

- A sweet variety, KM 98-1, selected from hybrid seed in South Vietnam, had high yield and high starch content when evaluated in Central Vietnam

**Purpose:** To develop high yielding and edible cassava varieties for Central Vietnam, where cassava is still an important food security crop.

**Rationale:** In the mountainous regions of Central Vietnam farmers are extremely poor and suffer from periodic food shortages due to the lack of suitable lowlands for rice production; cassava is their major food staple. Higher yielding and edible varieties, developed at Hung Loc Center in the south and at Thai Nguyen Univ. in the north, could improve food availability, while high-yielding bitter varieties may be useful for on-farm pig feeding or for starch extraction.

**Methods:** 15 cassava varieties were collected in north and south Vietnam and planted for preliminary observation and multiplication of planting material in single rows or small plots at Hue Univ. in Central Vietnam.

**Outputs:** Results of this observation trial are shown in **Table 6**. Although most varieties were bitter, developed for starch production and pig feeding, there were a few sweet and high yielding varieties, notably KM 98-1, developed from hybrid seed in south Vietnam. This variety is now being multiplied for future large-scale testing in comparison with the local varieties, and, if successful, for distribution to farmers.

**Table 6. Results of an observation trial conducted of 15 clones from north and South Vietnam. Hue 1998**

| Clone | Fresh root yield (t/ha) | Starch content (%) | Observations | Farmer acceptance[1)] |
|---|---|---|---|---|
| **South Vietnam** | | | | |
| HL 23 | 23.9 | 27.9 | bitter | NA |
| KM 94 | 34.6 | 28.0 | rather bitter | A |
| KM 95 | 23.7 | 27.7 | | NA |
| KM 98-1 | 40.1 | 29.4 | sweet, high fiber | A |
| KM 98-2 | 24.1 | 27.1 | | NA |
| SM 1447-7 | 35.2 | 28.6 | bitter | A |
| CMR 2075-18 | 31.7 | 28.4 | bitter | A |
| CMR 3608-1 | 27.8 | 28.2 | bitter | A |
| OMR 35-08-2 | 11.8 | 25.7 | | NA |
| OMR 35-15-8 | 19.4 | 26.6 | | NA |
| OMR 36-06-10 | 20.5 | 27.9 | | NA |
| OMR 36-75-13 | 16.9 | 24.5 | | NA |
| **North Vietnam** | | | | |
| Xanh Vinh Phu | 19.8 | 27.0 | sweet | A |
| SM 1717-12 | 29.6 | 28.0 | less branching | A |
| SM 1829-24 | 25.8 | 24.9 | | NA |

[1)] A = acceptable; NA = not acceptable

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## *2.5.2 Conduct Demonstrations and FPR Trials on Farmers' Fields*

### 2.5.2.1 FPR Demonstration Plots

**Purpose:** To show farmers a wide range of options, from which they can select a few practices that are considered most effective in controlling soil erosion and most suitable for the local conditions.

**Rationale:** Few practices recommended to control soil erosion have been adopted by farmers, because they were either not suitable for the local conditions or they produced no direct benefits to the farmers. By setting up demonstration plots and organizing field days for farmers to visit these plots and discuss the pros and cons of each treatment, farmers are encouraged to evaluate the various practices and select those they consider most useful for further testing on their own fields through FPR (see below).

**Methods:** In 1989/99 demonstration plots with 10 to 16 treatments were established in two sites each in Thailand, Vietnam and China, and one in Indonesia. Plots were laid out side-by-side on a uniform slope, usually without replication. Erosion losses in each treatment were determined by collecting and weighing of soil sediments trapped in plastic covered channels located along the lower side of each plot. Farmers from selected FPR pilot sites were invited to visit the demonstration plots at field days organized during or at the end of the crop cycle. Farmers were asked to evaluate each treatment and to select those they considered most useful for their own conditions.

**Outputs:** The results of a typical demonstration conducted on 8-10% slope at Thai Nguyen Univ., Vietnam are shown in **Table** 7. Cassava yields were extremely low and erosion was the most serious when cassava was grown in monoculture without fertilizers or hedgerows; this resulted in a negative net income, and none of the farmers considered this a useful practice. Farmers selected as most useful the treatments that included intercropping with peanut, application of fertilizers, and with or without hedgerows of *Tephrosia candida*; or monocropping with fertilizers but planting at a closer spacing. The latter is a simple and cheap technology, which in this case was very effective in increasing cassava yields and net income, while decreasing erosion.

Although vetiver grass hedgerows were the most effective in reducing erosion (also observed in demonstration plots in China and Indonesia) few farmers selected this as a useful practice, mainly because the grass itself is of little use to the farmers (unlike *Tephrosia candida*, which is considered a useful green manure, while stems are used as fuel), it is difficult to obtain planting material and the grass occupies some space (about 10%) of the production field in areas where land is very scarce. Interestingly, few farmers selected hedgerows of *Tephrosia* combined with pineapple, which is a recommended and rather popular practice in Central Vietnam.

**Table 7. Effect of soil-crop management treatments on cassava yield, gross and net income and soil loss on 10% slope. FPR demonstration plots at Agro-forestry College of Thai Nguyen Univ., Thai Nguyen, Vietnam, 1998.**

| Soil/crop management treatments[1] | Yield cassava | Yield peanut | Gross income cassava | Gross income peanut | Gross income Total | Production costs labor | Production costs fert. | Production costs seed | Production costs total | Net income | Dry soil loss | Farmer preference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (t/ha) | | | | | (mil. d/ha)[2] | | | | | (t/ha) | (%) |
| 1. C monoculture, no fertilizers, 1x0.8m, no hedgerows | 5.75 | - | 2.87 | - | 2.87 | 2.62 | 0 | 0.63 | 3.25 | -0.38 | 26.01 | 0 |
| 2. C, contour ridges, with fert.[4], 1x0.8m, no hedgerows | 16.25 | - | 8.13 | - | 8.13 | 3.02 | 1.12 | 0.63 | 4.77 | 3.36 | 20.67 | 29 |
| 3. C+P, with fert., 1x0.8m, no hedgerows | 15.42 | 0.73 | 7.71 | 3.65 | 11.36 | 3.03 | 1.12 | 0.91 | 5.06 | 6.30 | 21.91 | 71 |
| 4. C, with fert., 1x0.8m, vetiver+*Tephrosia* hedgerows | 16.17 | - | 8.09 | - | 8.09 | 2.74 | 1.12 | 0.99 | 4.85 | 3.24 | 13.65 | 34 |
| 5. C+P, with fert., 1x0.8m, *Tephrosia* hedgerows | 17.75 | 0.71 | 8.88 | 3.55 | 12.43 | 4.99 | 1.12 | 0.97 | 7.08 | 5.35 | 11.20 | 74 |
| 6. C+P, with fert., 1x0.8m, pineapple+*Tephr.* hedgerows | 16.50 | 0.65 | 8.25 | 3.25 | 11.50 | 4.99 | 1.12 | 1.59 | 7.70 | 3.80 | 16.57 | 34 |
| 7. C+P, with fert., 1x0.8m, natural grass hedgerows | 14.83 | 0.60 | 7.42 | 3.00 | 10.42 | 3.03 | 1.12 | 0.91 | 5.06 | 5.36 | 20.63 | 57 |
| 8. C+P, with fert., 1x0.8m, vetiver hedgerows | 15.83 | 0.63 | 7.92 | 3.15 | 11.07 | 4.99 | 1.12 | 1.31 | 7.42 | 3.65 | 11.08 | 34 |
| 9. C+P, with fert., 1x0.8m, vetiver+*Tephr.* hedgerows | 16.83 | 0.77 | 8.42 | 3.85 | 12.27 | 4.99 | 1.12 | 1.37 | 7.48 | 4.79 | 10.03 | 51 |
| 10. C, with fert., 0.6x0.8m, no hedgerows | 24.58 | - | 12.29 | - | 12.29 | 2.79 | 1.12 | 1.04 | 4.95 | 7.34 | 12.64 | 71 |

[1] C = cassava (cv. Vinh Phu), P = peanut

[2] Prices:

| | | | |
|---|---|---|---|
| cassava | d 500/kg fresh roots | pineapple | d 100/plant |
| peanut | 5000/kg dry pods | *Tephrosia* seed | 5000/kg |
| labor | 15000/day | peanut seed | 7000/kg dry pods |
| vetiver grass | 20/plant | urea (46%N) | 3000/kg |
| cassava stake | 50/stake | SSP (16%$P_2O_5$) | 1000/kg |
| | | KCl (50%$K_2O$) | 2000/kg |

[3] Percent of farmers (out of 35) considering the treatment as "good"

[4] Fertilizer = 60 kg N + 40 $P_2O_5$ + 120 $K_2O$/ha

### 2.5.2.2 FPR Trials on Farmers' Fields

**Highlights**

- During 1989/99 132 farmers in eight pilot sites in Thailand, Vietnam, China and Indonesia conducted FPR trials on erosion control, varieties, fertilization and intercropping practices.
- For control of soil erosion farmers prefer:
  - in Thailand planting of contour hedgerows of vetiver grass;
  - in Hainan, China, hedgerows of vetiver or sugarcane;
  - in Vietnam, intercropping with peanut combined with hedgerows of *Tephrosia candida;*
  - in Indonesia, hedgerows of elephant grass, *Leucaena leucocephala* or *Gliricidia sepium.*

**Purpose:** To develop and then facilitate the adoption of appropriate integrated crop/soil management practices for more sustainable cassava-based cropping system, by involving farmers directly in the testing of those practices they consider most useful under their own conditions.

**Rationale:** Continuous production of cassava on poor soils, especially on slopes, without appropriate soil/crop management results in nutrient depletion and soil erosion Recommended fertilization and erosion control practices are seldom adopted by cassava farmers because they don't have the resources, are not aware of degradation or it's importance, or the recommended practices are unsuitable for the local conditions. To enhance the use of more sustainable production practices, and safeguard the productivity of the soil resource for future generations, it is considered important to involve farmers directly in the development of effective soil conserving practices by involving them in the evaluation of selected practices. Once farmers have selected and adapted suitable practices for their own conditions, they are more likely to adopt those practices and convince others of their long-term benefits.

**Methods:** Researchers and extensionists from collaborating national institutions helped farmers in selected pilot sites to set up simple FPR trials on erosion control, varieties, fertilization and intercropping practices. Farmers in the pilot sites volunteered to do these trials and decided as a group about the type of trials to be conducted and the treatments to be tested. Researchers and extensionists supplied some of the planting materials and trained farmers in conducting simple trials.

**Table 8. Types and number of FPR trials conducted with cassava in Asia in 1998/1999.**

| | **Thailand** | | **Vietnam** | | | **China** | **Indonesia** | |
|---|---|---|---|---|---|---|---|---|
| **Type of trial** | Sahatsakhan Kalasin | Phanom Sarakham Chachoengsao | Pho Yen Thai Nguyen | Thanh Ba Phu Tho | Luong Son Hoa Binh | Baisha Hainan | Malang East Java | Blitar East Java |
| Erosion control | 7 | 7[1] | 5 | 6 | 3 | 6 | 10 | - |
| Varieties | 8 | 3[2] | 15 | 13 | 2 | 8 | - | - |
| Fertilization | 10 | 6[2] | 4 | 4 | 3 | - | 5 | - |
| Intercropping | - | - | 7 | - | - | - | - | - |
| **Total** | 25 | 16 | 31 | 23 | 8 | 14 | 15 | 0 |

[1] planted in early 1999; [2] planted in late 1998

Erosion control experiments, usually with 4-5 treatments without replication, were laid out along the contour on land with uniform slope. Erosion losses in each treatment were determined by collecting and weighing of soil sediments trapped in plastic-covered channels below each plot. At field days during or at the end of the crop cycle, farmers visited each other's trials and were encouraged to discuss and evaluate the usefulness of each treatment. At time of harvest, yield and soil losses were determined and the results of the trials discussed and evaluated with participants and other members of the community; after this, farmers selected the best practices for further testing or for adoption during the following year. **Table 8** shows the type and number of FPR trials conducted in each pilot site during 1989/99.

**Outputs:** Tables 9, 10 and 11 show results of FPR erosion control trials conducted by farmers in pilot sites in Vietnam, Indonesia and Thailand. In Vietnam, highest net income was obtained with the farmer's traditional practice of cassava monoculture and application of 10 t/ha of pig manure (**Table 9**). However, this practice also resulted in the highest level of erosion. Intercropping cassava with peanuts, applying fertilizers in addition to manure, and planting hedgerows of either pineapple or vetiver grass slightly decreased net income but decreased erosion by about 90%; these were preferred by farmers.

**Table 9. Effect of crop management treatments on the yield of cassava and intercropped peanut, gross and net income and soil loss in trial conducted by six farmers. Kieu Tung village, Thanh Ba district, Phu Tho province, Vietnam 1998.**

| Treatments[1] | Dry soil loss | Yield | | Gross income | | | Prodn. cost | Net Income | Farmers' ranking |
|---|---|---|---|---|---|---|---|---|---|
| | | cassava | peanut[2] | cassava | Peanut | total | | | |
| | (t/ha) | (t/ha) | | | | (mil. d/ha)[3] | | | |
| 1. C monoculture, (TP) | 18.4 | 25.8 | - | 10.30 | - | 10.30 | 4.00 | 6.28 | 6 |
| 2. C+ P | 13.3 | 18.2 | 0.47 | 7.26 | 2.58 | 9.84 | 5.90 | 3.94 | 5 |
| 3. C+P+fert. | 14.0 | 20.3 | 0.51 | 8.13 | 2.80 | 10.93 | 7.42 | 3.51 | 5 |
| 4. C+P+fert.+ *Tephrosia* h/row | 5.3 | 21.6 | 0.51 | 8.64 | 2.80 | 11.44 | 7.67 | 3.77 | 3 |
| 5. C+P+fert.+ pineapple h/row | 0.8 | 23.3 | 0.73 | 9.33 | 4.01 | 13.34 | 7.67 | 5.67 | 2 |
| 6. C+P+fert.+ vetiver h/row | 3.1 | 26.5 | 0.38 | 10.61 | 2.09 | 12.70 | 7.67 | 5.03 | 1 |
| 7. C mono+fert.+*Tephrosia* h/row | 6.3 | 25.1 | - | 10.02 | - | 10.02 | 5.77 | 4.25 | 4 |

[1] All plots received 10 t/ha of pig manure; TP = farmers traditional practice = cassava mono + 10 t/ha of pig manure fert. = 60 kg N+40 $P_2O_5$+120 $K_2O$/ha ; C= cassava, P = intercropped peanut

[2] Dry pods

[3] Prices (dong):
| | | | | |
|---|---|---|---|---|
| cassava | d 400/kg fresh roots | urea (45%N) | 3,000/kg | → 60 N = 0.400 mil. dong |
| peanut | 5,500/kg dry pods | SSP (16%$P_2O_5$) | 1,000/kg | → 40 $P_2O_5$ = 0.250 mil. dong |
| labor | 7,500/day | $K_2SO_4$ (50%$K_2O$) | 2,800/kg | →120 $K_2O$ = 0.672 mil. dong |
| pig manure | 200/kg (incl.trans.& applic.) | | Total fertilizers | = 1,322 mil. dong |

In Indonesia ten farmers compared four practices in FPR erosion control trials (**Table 10**). The net income

**Table 10. Average results of ten FPR soil erosion control trials conducted by farmers in Sumbersuko village, Dampit, Malang, East Java, Indonesia, 1997/98.**

| Treatments[1] | *Yield* | | Gross income | Prod. Costs | Net Income[3] | Dry soil loss |
|---|---|---|---|---|---|---|
| | cassava | maize | | | | |
| | (t/ha) | | ('000 Rp/ha) | | | (t/ha) |
| 1. C+M; farmer practice, in-line mounds followed by up/down ridging | 18.9 | 1.20 | 6,063 | 1,200 | 4,863 | 18.10 |
| 2. C+M; recommended practices, contour ridging, vetiver hedgerows | 22.2 | 1.35 | 7,060 | 1,900 | 5,160 | 6.40 |
| 3. C+M; recom. practices; contour ridging, lemon grass hedgerows | 21.1 | 1.50 | 6,897 | 1,900 | 4,997 | 9.45 |
| 4. C+M+P-Cp[2]; recom. practices, contour ridging of cassava row | 7.6 | 0.85 | 6,962 | 2,370 | 4,592 | 14.65 |

[1] C = cassava, M = maize, P = peanut, Cp = cowpea

[2] Yields of peanut: 620 kg/ha; cowpea: 360 kg/ha

[3] Prices: cassava Rp 270/kg fresh roots; maize 800/kg dry grain on cob
peanut 4,500/kg dry grain in pod; cowpea 4,000/kg dry grain

was highest with vetiver grass contour hedgerows; this also reduced erosion by about 65% compared with the farmer's traditional practice. Nevertheless, farmers showed little interest in planting vetiver grass hedgerows, because the grass does not provide other benefits to them. Instead, they preferred planting lemon grass or elephant grass, which are almost equally effective in controlling erosion, while these can be used in cooking and as animal feed, respectively.

In Thailand seven farmers tested five common treatments in addition to one treatment of their own individual choice (**Table 11**). Among the five common treatments, intercropping with sweet corn or planting at closer spacing produced the highest gross income and intermediate levels of erosion. Lowest levels of erosion were measured in two trials where farmers had selected vetiver grass hedgerows as the additional treatment. While vetiver grass produces few other direct benefits, many farmers in Thailand still prefer this grass to other options because once planted it requires relatively little maintenance, is very drought resistant and not very competitive.

**Table 11. Average results of seven[1)] FPR erosion control trials conducted by farmers in Sahatsakhan district, Kalasin, Thailand, 1998/99.**

| Treatments | Yield | | Gross income ('000B/ha) | | | Dry soil loss |
|---|---|---|---|---|---|---|
| | cassava (t/ha) | intercrop (t/ha) | cassava | intercrop | total | (t/ha) |
| 1. Farmer's practice (up/down ridges) | 29.74 | | 30.93 | - | 30.93 | 12.48 |
| 2. Contour ridges | 29.42 | | 30.61 | - | 30.61 | 8.44 |
| 3. Lemon grass hedgerows | 32.81 | | 34.12 | - | 34.12 | 9.60 |
| 4. Closer plant spacing (0.8 x 0.8 m) | 35.66 | | 37.09 | - | 37.09 | 10.91 |
| 5. Intercropped with sweet corn | 25.76 | 7944 ears | 26.79 | 12.17 | 38.96 | 13.36 |
| 6. Vetiver grass hedgerows | 31.35 | | 32.61 | - | 32.61 | 7.35 |
| 7. Intercropped with pumpkin | 31.19 | 3400 pumpkins | 32.44 | 18.36 | 32.44 | 14.13 |
| 8. Intercropped with peanut | 15.70 | 1.20 | 16.37 | 18.00 | 34.37 | 29.64 |

1) Only four trials for treatment 7, two for treatment 6, and one for treatment 8

Tables 12 and 13 show results of FPR variety trials conducted in Vietnam and Thailand, respectively. In Pho Yen district of Thai Nguyen province 15 farmers tested five promising new clones in comparison with the local variety, Vinh Phu (**Table 12**). All new varieties had higher yields than Vinh Phu, and farmers were particularly impressed with SM17-17-12, which produced a 50% higher yield than the local variety. This variety has consistently outperformed Vinh Phu and is now rapidly being multiplied for further distribution.

**Table 12. Average results of 15 FPR variety trials conducted by farmers in Tien Phong and Dac Son villages of Pho Yen district, Thai Nguyen province, Vietnam in 1998.**

| Variety | Cassava yield (t/ha) | Gross income[1)] | Fertilizer costs | Net income | Farmers' preference (%) |
|---|---|---|---|---|---|
| | | ← | (mil. dong/ha) | → | |
| 1. Xanh Vinh Phu | 16.89 | 8.45 | 2.90 | 5.55 | 7 |
| 2. KM 60 | 20.40 | 10.20 | 2.90 | 7.30 | 65 |
| 3. KM 95-3 | 18.45 | 9.22 | 2.90 | 6.32 | 0 |
| 4. CM 4955-7 | 24.62 | 12.31 | 2.90 | 9.41 | 82 |
| 5. KM 94 | 21.91 | 10.96 | 2.90 | 8.06 | 50 |
| 6. SM 17-17-12 | 25.44 | 12.72 | 2.90 | 9.82 | 100 |

1)Prices: cassava d 500/kg fresh roots

In Sahatsakhan district of Kalasin province in Thailand seven farmers compared four new clones with the traditional variety Rayong 1 (**Table 13**). All new clones produced higher yields and had higher starch contents than Rayong 1. The best new clone, CMR-81, produced a gross income over 30% higher than the local variety; this line is likely to be released this year under the name of Rayong 72.

**Table 13. Average results of seven FPR variety trials conducted in Sahatsakhan district of Kalasin, Thailand in 1998/99.**

| Varieties | Cassava root yield (t/ha) | Starch content (%) | Starch yield (t/ha) | Gross income[1)] ('000B/ha) |
|---|---|---|---|---|
| Rayong 1 | 21.76 | 26.4 | 5.74 | 21.37 |
| Rayong 5 | 24.61 | 29.4 | 7.23 | 26.33 |
| Rayong 90 | 23.34 | 29.6 | 6.91 | 24.97 |
| Kasetsart 50 | 25.72 | 29.5 | 7.59 | 27.52 |
| CMR-81 | 27.04 | 28.2 | 7.62 | 28.12 |

[1)] Cassava price: Baht 1.10/kg fresh roots at 30% starch

shows average results of three FPR fertilizer trials conducted in Dong Rang village in North Vietnam (**Table 14**). Cassava yields and net income increased with application of chemical fertilizers, especially with a well-balanced fertilizer of 40 kg N, 40 $P_2O_5$ and 80 $K_2O$/ha. Potassium was the most limiting of the three macro-nutrients.

**Table 14. Average results of three FPR fertilizer trials conducted by farmers in Dong Rang village of Luong Son district, Hoa Binh province, Vietnam in 1998.**

| Fertilizer treatments[1)] | Cassava yield (t/ha) | Gross income[2)] | Fertilizer costs[2)] | Net income |
|---|---|---|---|---|
| | | ← (mil. dong/ha) | | → |
| 1. Farmer's practice | 10.95 | 4.38 | 0 | 4.38 |
| 2. Cassava + NP | 12.40 | 4.96 | 0.518 | 4.44 |
| 3. Cassava + PK | 13.40 | 5.36 | 0.640 | 4.72 |
| 4. Cassava + NK | 15.35 | 6.14 | 0.678 | 5.46 |
| 5. Cassava + NPK | 16.50 | 6.60 | 0.918 | 5.68 |

[1)]Farmer's practice = no fertilizer. N = 40 kg N/ha; P = 40 kg $P_2O_5$/ha; K = 80 kg $K_2O$/ha
[2)]Prices: cassava d 400/kg fresh roots; urea (46%N) 3200/kg
Fused Mg-phos (15% $P_2O_5$) 900/kg; KCl (50% $K_2O$) 2500/kg

## *2.5.2.3* Adoption and Dissemination of Improved Practices

After conducting FPR trials on their own fields for a few years farmers will often try out some selected practices on parts of their production fields, make certain adaptations if necessary, and then implement these improved practices on their whole fields as rapidly as possible.

In the pilot site in Baisha county in China, farmers have been replacing the local variety SC205 with a range of new higher-yielding clones selected in their FPR variety trials. Among these, the most popular are SC8013, SC8634, SC8639 and OMR35-70-7. Farmers are also applying some chemical fertilizers in combination with chicken manure. Contour hedgerows of sugarcane to control erosion were found to be less effective than vetiver grass. Farmers having land on steep slopes are now increasing planting material of vetiver grass to be able to expand the areas planted with vetiver hedgerows, and prevent further erosion of their soil.

In the two pilot sites in Malang and Blitar districs of E. Java, Indonesia, most farmers still prefer their local varieties, Menyok (sweet) or Faroka (bitter) and Ijo, respectively, over any of the newly introduced clones. In Malang, however, some farmers are increasingly planting a bitter and early bulking variety called "Caspro", which produces very high yields on good soils; this variety was introduced many years ago to a neighboring village in an IDRC-sponsored project. In Blitar, more and more farmers are now planting the bitter variety Faroka, introduced from Malang, as it is high yielding and can be used for sale to starch factories. While farmers in both districts recognize the effectiveness of vetiver grass for erosion control, they still prefer planting hedgerows of elephant grass, *Gliricidia* or *Leucaena,* which are more useful to feed cattle or goats. The limited amount of planting material of vetiver grass presently available is being used to stabilize gulleys or protect natural drainage ways.

In the two pilot sites in Thailand farmers have already replaced the local variety Rayong 1, as well as previously introduced Rayong 3 and 60, with the higher yielding varieties Rayong 5 and 90, as well as Kasetsart 50. The soon-to-be released Rayong 72 (CMR-81) will further replace mainly Rayong 60, as it has a higher starch content. Many farmers are now applying 150-300 kg/ha of compound fertilizers, mostly 15-15-15, but increasingly also 15-7-18, as recommended by the Dept. of Agric. and Agric. Extension. In Wang Nam Yen district of Sra Kaew province, farmers who had previously planted FPR erosion control trials are now planting contour hedgerows of vetiver grass; in 1998 about 50 ha had already been planted. In Soeng Saang district of Nakorn Ratchasima province, a village adjacent to the former FPR pilot site observed the effectiveness of vetiver grass in FPR erosion control trials; subsequently, they requested help from the Dept. of Agric. Extension to plant 320 ha of cassava fields on sloping land with contour hedgerows of vetiver; in 1999 about 50 ha were planted.

In the three pilot sites in Vietnam, farmers are rapidly incrementing planting material of KM 60, KM 94, KM 95-3, SM 17-17-12 and SM 17-17-40 to replace their local variety Vinh Phu. They also now intercrop cassava, mostly with peanut but also with black bean, and apply about 80 kg N, 40 $P_2O_5$ and 80 $K_2O$/ha in addition to 5-10 tons of pig manure. In one of the sites, in Dong Rang village, farmers are planting contour hedgerows of *Tephrosia candida* to control erosion and improve soil fertility. Vetiver grass is planted only on a small scale (partially due to a lack of planting material), and mainly to stabilize gulleys or to protect waterways or paths.

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## *Activity 2.6 Establish and maintain databases of information and results*

### Progress in establishing databases of results of PE-5

The information from trials in Cauca with small producers on legume establishment, P fertilizer management with P and residual effects and use of legumes to improve fallow and crop performance, were analyzed and stored in the forages database. User friendly software its being developed to make it available to other members of CIAT and later on to outside users.

The information on Carimagua trials has been organized and analyzed to be included in the database.

# Output 3. Models/frameworks developed to target research, integrate results, assess impact and extrapolate results

## *Activity 3.1 Adapt and evaluate integrated simulation models for smallholders systems*

### Highlights

- Link between DSSAT and the soil-organic-matter/crop-residue module of CENTURY validated. It will become a new standard option in the next DSSAT version.
- New *Brachiaria decumbens* model option made available to become a new standard crop option in the next DSSAT version.
- DSSAT applied to maize systems in Honduras in order to determine the best management options.
- Limitations identified for adding a new *Arachis pintoi* option to DSSAT.

**Purpose:** Adapt DSSAT for smallholder systems and analyze such systems in Honduras, in order to better understand their strengths and weaknesses, and to identify opportunities for improvement.

**Rationale:** Agronomic simulation models are an important tool for [i] understanding system dynamics, [ii] quantifying relationships that are not easily measured [iii] quantifying effects of different management strategies, [iv] predicting problems and results of management strategies and [v] extrapolating results over larger geographical areas. They therefore help to plan research and integrate research results, and enhance collaboration.

For smallholder systems in Central America, such a model may help in analyzing different options of land use and farm management. This will result in a better understanding of how crop production varies with environmental conditions (weather, soil), and of which management strategies (e.g. fertilization, planting date) are best under different conditions and most suitable to reduce weather risks. This will allow designing management strategies at the plot or whole-farm level that pay maximum care to the biophysical sustainability of the agricultural system and its economic viability.

Modeling is therefore an important tool for research planning and interpretation of results. It also helps to ensure that CIAT is *not reactive but proactive* when dealing with long-term sustainability issues.

**Methods:** The Decision Support System for Agrotechnology Transfer (DSSAT) is a widely used agronomic model, which allows evaluating germplasm-by-environment interactions without the need to do expensive and time-consuming multi-site, multi-treatment experiments. Experimental data from one site can thus be extrapolated to other areas, having a different soil type or climate, or where farmers use other crop varieties. In low-input agricultural systems, plant nutrients mainly come from soil-organic-matter (SOM) decomposition. DSSAT has a module for the simulation of SOM dynamics, but is limited in what is simulated, in particular with respect to the above- and below ground cycling of organic residues. A more complete SOM module in the CENTURY model was linked to DSSAT.

Using DSSAT with the modified SOM module, low-input maize-bean systems at different altitudes in the watershed in Honduras, where the Hillsides Project has its main focus, have been analyzed. The simulations considered the optimum management system (e.g. planting date and limited N application), yield levels over a 20-year cycle and the longer-term effect on the system sustainability as reflected in the soil's organic matter content.

differences between *Arachis* and the common peanut that have to be dealt with in the model's source code. The peanut-model's author (Ken Boote – Univ. Florida), who assisted in this modification, has indicated an interest in following up on the problems encountered through student research.

The *Brachiaria decumbens* grass growth option we developed for DSSAT last year has been made available to the DSSAT authors to be included as a standard option in a future version of the model.

Experiments were carried out in Colombia and Honduras for estimating so-called 'genetic coefficients' of various legume species, data that are needed to simulate these crops' growth and development. These data have been made available to Univ. Georgia and CIMMYT, who are working on a DSSAT crop module for these species. These modules will be applied for analyzing smallholder systems in Central America.

### 3.1.3 DSSAT application to Honduran maize systems

Preparing the input data sets on soils, climate and cultivars has been a major effort, because data were either not accessible, incomplete or did not exist. For a long-term research effort in Central America, it is important that CIAT give database management sufficient attention. Since there are only two years of weather data available for the watershed where we are working, the new MarkSim weather generator program (Peter Jones, unpublished data, project PE-4) was used to produce daily estimates of maximum and minimum temperature, precipitation and solar radiation. Daily rainfall data for 20 years was generated for three weather stations at different altitudes within the watershed (San Antonio – 420 m; El Guaco – 790 m; Las Lagunitas – 1123 m). Soil data were taken from earlier analyses by CIAT-Honduras.

Simulated maize planting was done when the soil moisture levels were suitable for planting, i.e. when the topsoil should have had adequate water to ensure germination and establishment. The question was how to define 'an adequate soil moisture level'? This will, amongst other things, depend on the risk a farmer is willing to take. Three levels were set: 40%, 50% and 60% of maximum available-water holding capacity. The planting window allowed was from May 20 to July 10 (*i.e.* between Julian days 140 – 191; a 'Julian day' is the day number from 1 till 365 – or 366 in leap years – counting from January 1). For San Antonio, simulated planting was mostly done in late May (days140-145; **Figure 2**), a very narrow range. Whether San Antonio farmers indeed plant during this narrow planting window is uncertain, because there often is a dry spell between day 150 and 170, which may kill the just-emerged seedlings. Low-risk farmers may postpone planting till after that date. At the other two sites, planting occurred somewhat later. At El Guaco the range of planting dates was much wider, because the rainfall is more uncertain until around day 170.

Time to maturity for maize is presented in **Figure 3**, which clearly shows that there was no relationship between planting date and time needed to mature. In San Antonio, the crop always matured within 120 days and most of the time within 100 days, but in El Guaco and Las Lagunitas this may take up to 150 days, even if planting was done on the same day (e.g. day 140-142). Late maturing gave a much higher yield in these two sites. Planting after day 150 did not give a good yield in El Guaco and Las Lagunitas.

At San Antonio, yields were very similar every year (**Figure 4**), with a mean and median around 1000 kg/ha and a maximum of 1500 kg/ha. In one out of four years the yield was only 500 kg/ha. This narrow yield range may partly reflect that the planting window was very narrow (Figure 2). The two other sites had a wider planting window and consequently a wider yield range. For El Guaco, average yield was 800-1300 kg/ha, depending on the available-water content at planting; for Las Lagunitas it was 1300 kg/ha. Peak yields were around 6500 kg/ha (El Guaco) and 7000 kg/ha (Las Lagunitas), which occurred only once in 20 years time; this is indeed quite high for unfertilized conditions. The data for El Guaco show an interesting point: farmers who are early planters (at 40% maximum available-water content) and don't wait until the soil is wetter, loose on average some 500 kg/ha compared with more patient farmers who postpone planting until the soil has 50% or 60% of it maximum available-water content.

## Outputs:
### 3.1.1. Validation of the DSSAT-CENTURY link

The soil-organic-matter (SOM) module of the CENTURY model was successfully incorporated into DSSAT. Comparing the original (PAPRAN-model-based) SOM module with the new CENTURY-based module (**Figure 1**) there was a satisfactory congruence between observed and simulated data with a set of experiments on legume residue decomposition from Brazil. By incorporating the CENTURY-based SOM module into DSSAT, the model should be more suitable for simulating low-input systems where most nutrients come from $N_2$ fixation by legumes or plant residue decomposition. The new module has been accepted by the DSSAT coordinating group to become a standard element of the next model version.

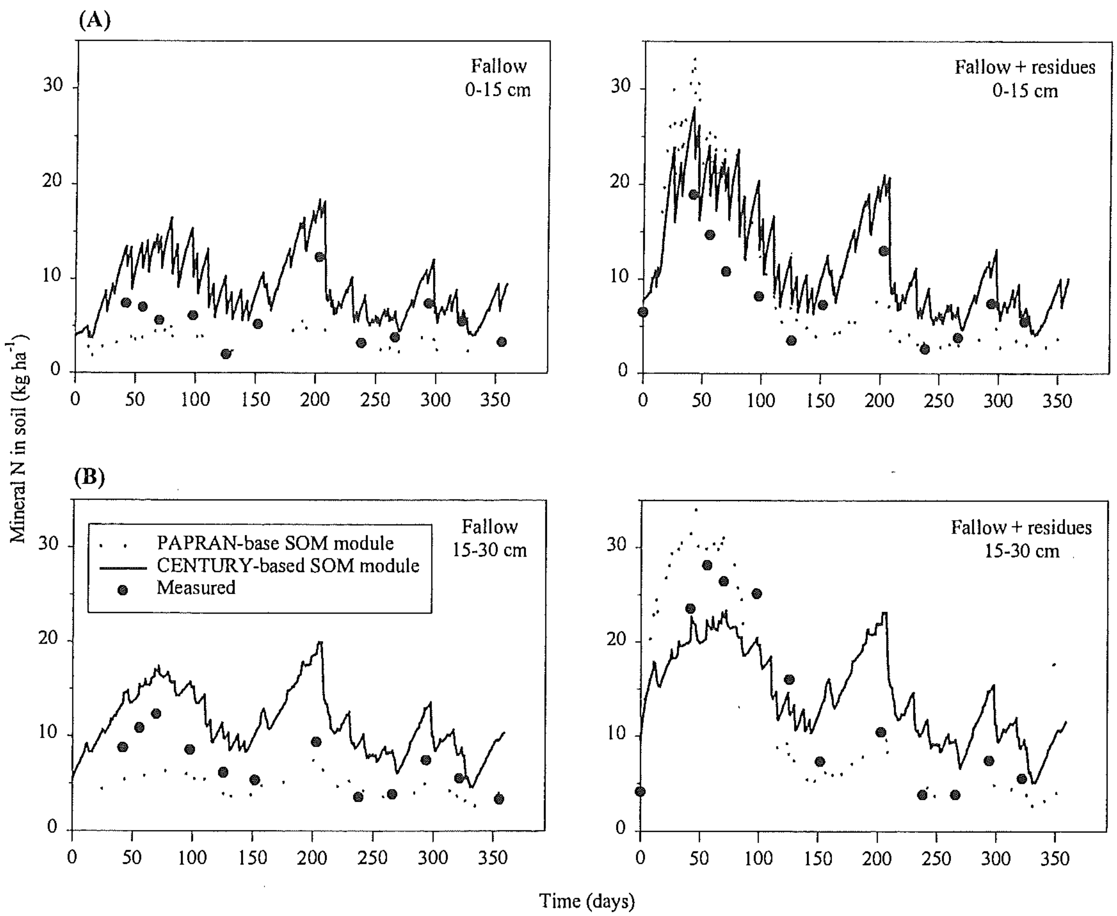



**Figure 1:** Mineral N content of the 0-15 (A) and 15-30-cm (B) soil layers under fallow, without or with residues, as measured (•) and as simulated with the DSSAT, using the PAPRAN-based (dotted line) and CENTURY-based (full line) SOM modules. The residues applied were 5907 kg $ha^{-1}$ of *Mucuna* spp. tops with a N concentration of 2.37%.

### 3.1.2 Other modifications to DSSAT

Modifications were made to the existing peanut model in DSSAT for the perennial forage peanut *Arachis pintoi*, a species of importance in humid tropical pasture systems and as a cover crop in plantation and fruit crops. Calibrating the new model option with five data sets from different sites in Colombia that were part of the International Network for the Evaluation of Tropical Pastures (RIEPT), revealed several

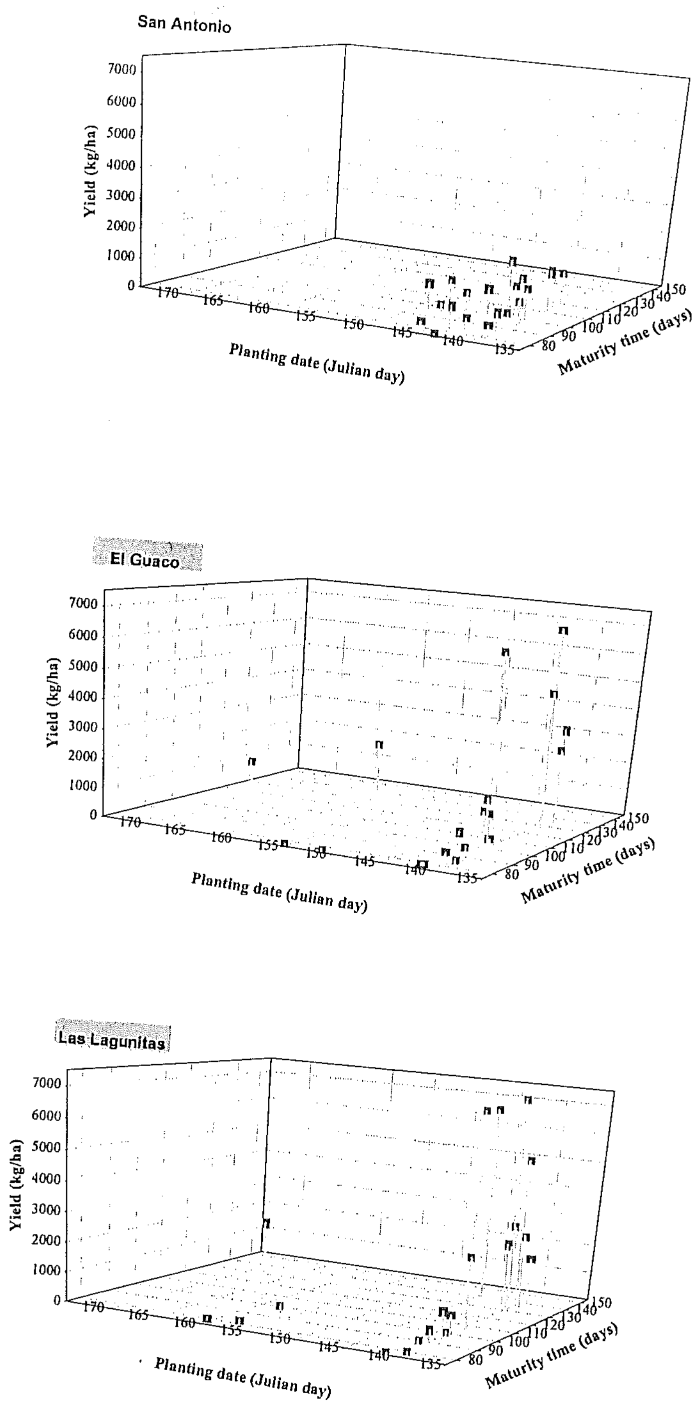



**Figure 3**: Planting date, maturity time and yield of maize, as it results from the optimum planting conditions of 50% maximum available-water content.

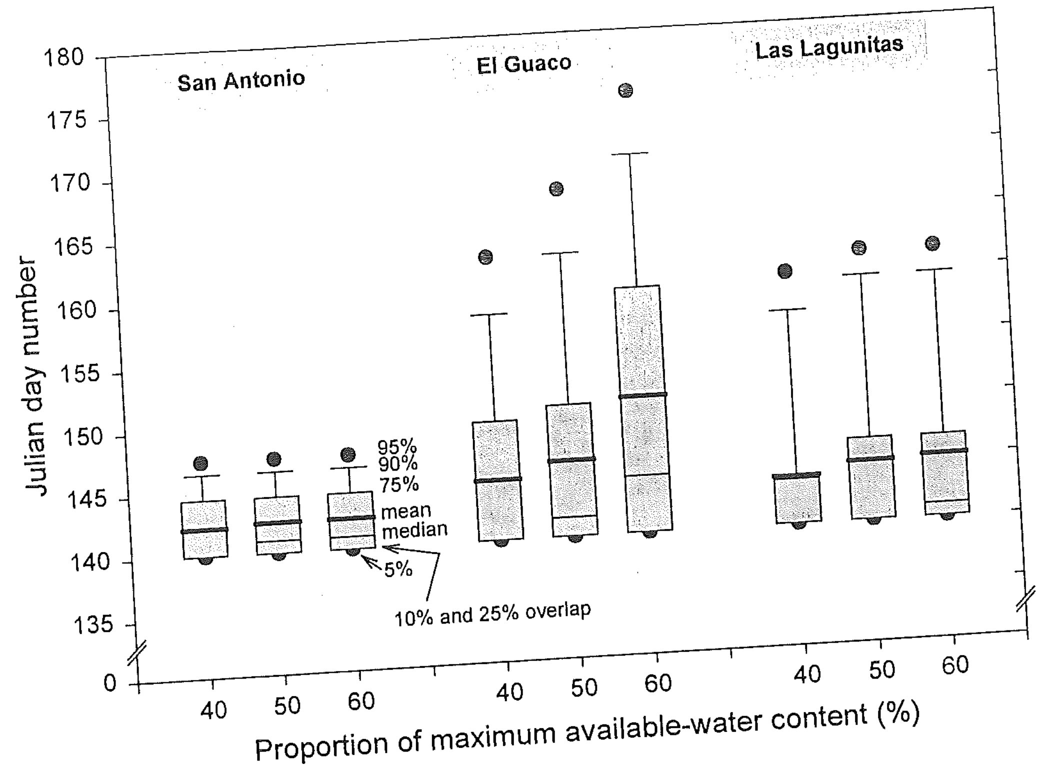



**Figure 2**: Optimum maize planting date, if 'optimum' is defined as (a) 40%, (b) 50% or (c) 60% of the maximum available-water content of the soil.

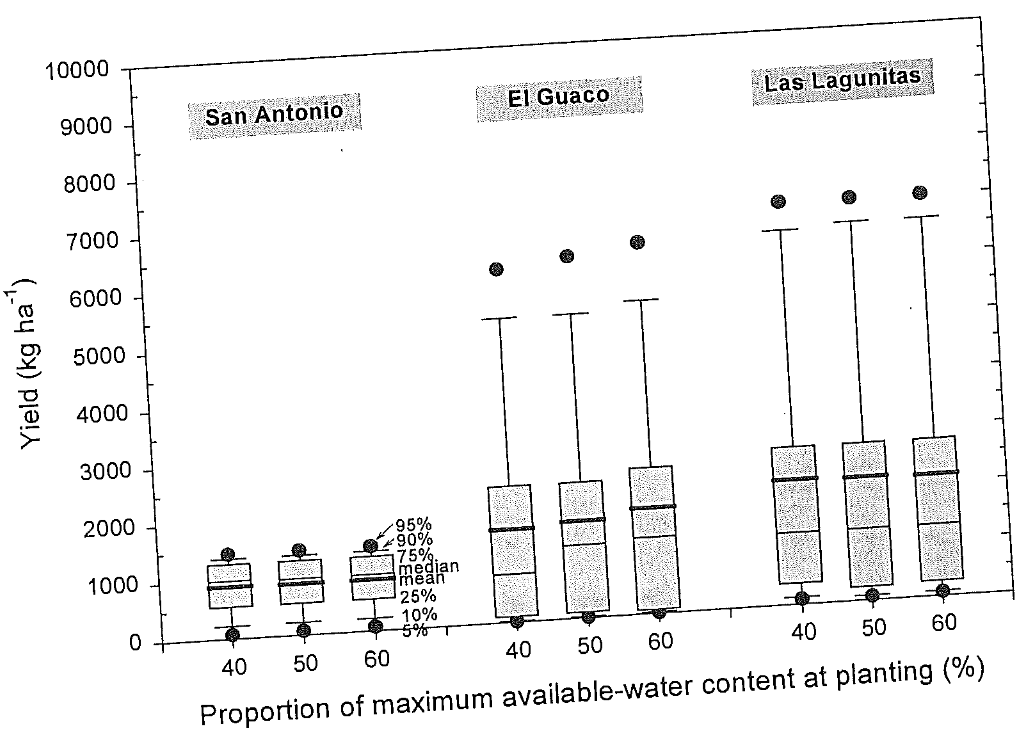



**Figure 4**: Maize yield that results from the optimum planting conditions of Figure 2.

Model calculations are no replacement for experimental research; they give predictions of what is likely to happen given certain environmental and farm-management conditions. Simulation models can supply answers to "what-if" questions (*e.g.* what is the likely yield going to be if the farmer applies fertilizer?). Used in interaction with researchers who know the systems well and who are able to provide input data for crop management and assess the validity of model predictions compared to actual on-farm results, a simulation model is a very valuable research tool. It can be used for evaluating farm-level management strategies and estimating yields for economic analyses. In particular, a simulation model can be used to assess the use of improved germplasm in association with improved natural resource management, an important objective of CIAT's NRM research.

**Contributors:**

- CIAT project PE-5: Arjan Gijsman, Luís Horacio Franco
- CIAT project IP-5 (I.M. Rao): Identifying parameters needed for adding the forage legume *Arachis pintoi* to DSSAT.
- CIAT project IP-5 (Carlos Lascano): Identifying and analyzing a livestock decision-support model for its suitability to CIAT.
- CIAT project IP-5 (Michael Peters): Carrying out an experiment in Honduras for measuring parameters needed to add new legumes to DSSAT.
- CIAT project PE-3 (Rubén Darío Estrada): Collaboration on adding the *Arachis pintoi* option to DSSAT, because Estrada is setting up an *Arachis* seed production project with small farmers.
- CIAT project PE-3 (Bruno Barbier & Marco Tulio Trejos): Obtaining DSSAT input data for estimating crop yields under various environmental and management conditions in Honduras. In turn these data provide input to PE-3 for evaluating farm-level management strategies and economic analyses.
- CIAT project PE-4 (various): Applying the MarkSim weather simulator and interfacing DSSAT with GIS-georeferenced data on soil and weather conditions.
- University of Caldas (Colombia): Two students who worked on the *Arachis pintoi* model for DSSAT.
- University of Georgia and University of Florida (USA): Modifying the source code of DSSAT to incorporate a new SOM module needed for applying the model to low-input smallholder systems.
- International Fertilizer Development Center (IFDC; USA): Estimating maize genetic coefficients for DSSAT and estimating climate data.
- ILRI (Kenya) and University of Edinburgh (UK): Collaboration on adding a livestock grazing option to DSSAT.
- University of Edinburgh (UK): Invited me to collaborate on writing a book chapter for the Tropical Pasture Management and Utilization Workshop in Bolivia.
- CIMMYT (Mexico): Estimating maize genetic coefficients for DSSAT and collaborating for adding a new crop option for the legume *Mucuna pruriens* to DSSAT.

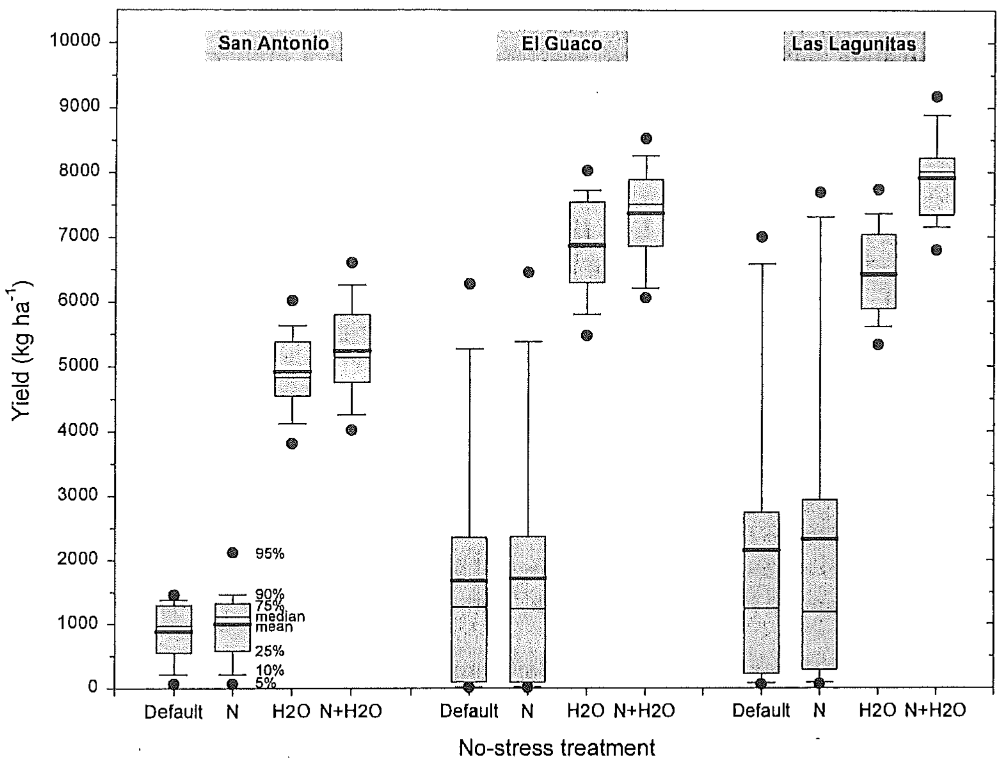



**Figure 5**: Potential maize yield under conditions of no N stress (N), no water stress (H2O), and neither N nor water stress (N + H2O), as it results from the optimum planting conditions of 50% maximum available-water content. The yields from under unfertilized and non-irrigated conditions are indicated as reference points (Default).

Running DSSAT with an option where nitrogen is automatically added every time when there is a need for N (zero N-stress conditions), yields are scarcely increased compared to unfertilized maize (**Figure 5**; NB: these are runs with 50% maximum available-water content at planting). Only the peak values increase with added N in San Antonio and Las Lagunitas. Frequent irrigation, in contrast, greatly increased yields at all sites; yield variability, which initially was high at El Guaco and Las Lagunitas, was reduced considerably with irrigation. Eliminating both water stress and N stress gave a further yield increase, in particular in Las Lagunitas.

**Impact:** Agronomic field studies cannot cover the wide range of natural conditions that one encounters in an area. Further, how can experimental results from one site be interpreted for use at sites with different soil, climate or management conditions? Agronomic simulation models such as DSSAT can play an important role here to ensure that recommendations that follow from research are not of a "blanket" type for a wide area, but are well targeted to the specific local conditions.

mix of cropping activities. To reflect the local situation of slash-and-burn farming, the model includes other restrictions such as a minimum land area for subsistence crop production.

The model employs the use of two labor sources in order to calculate the maximum labor available in an average farm. The first, family labor is based upon the number of persons older than 14 years who can conduct farm activities. The second source is hired labor. For example, in the Ucayali there are several months when farmers need to hire labor (January, February, April, July, August and September). During these months, farmers typically hire two laborers. These model parameters are based upon research experience and personal communication with farmers.

**Impact:** The use of an agro-economic model, which employs profit-maximizing linear programming techniques, permits a more complete understanding of how production factor scarcity (land, labor and capital) can affect farming systems. Furthermore, the model measures the impact of technological changes such as new crops and varieties upon farm earnings.

**Contributors:** Douglas White, Ricardo Labarta, SN-1, INIA, MinAg-Ucayali, DEPAM, ICRAF

# *Activity 3.2 Develop economic models to assess technology/land use options*

## 3.2.1 Economic model for ex-ante evaluation of research interventions in Aguaytia watershed

### Highlights

- A user-friendly computer model, using common electronic spreadsheets, is functioning and being fine-tuned by local researchers and extensionists.

**Purpose:** To provide an opportunity for local researchers and extensionists to examine interactions among crops within complex slash-and-burn farming systems via the use of a computer model.

**Rationale :** National and international institutions in Ucayali have developed many technological alternatives for small farmers, but the adoption of these alternatives has been mixed at best. Even though researchers and extensionists have expertise in one or more crops, they commonly have an incomplete understanding of the farming system functions with respect to scarce inputs as land, labor and capital.

**Outputs:** Modeling of the region's farming systems involved required two stages of research. First, crop- and farm-level data were collected to create enterprise budgets. These data were then used for the second modeling stage of farming systems. A third stage of model refinement and the interpretation of results are being conducted with local researchers.

Crop and farm system information came from two sources. The first source, national and international researchers, provided farm management data. The second source was direct information provided by farmers about their resources and economic returns of their farming system. The initial research focused upon three distinct agroecological areas. Surveyed were 21 flat-uplands farmers, 13 riverine farmers and 17 from the upland hills. (**Table 1**)

**Table 1. Main crops and agricultural and production systems in the Ucayali Region, Peru**

| Flat Uplands | Riverine | Upland Hills |
|---|---|---|
| Rice | Rice | Rice |
| Maize | Maize | Maize |
| Plantain | Plantain | Plantain |
| Bean | Bean | Cotton |
| Cassava | Soybean | Cassava |
| Pasture | Watermelon | Pasture |
| Peanuts | Camu Camu | Cacao |
| Oil palm | Fishing | Reforestation |
| Poultry | | Poultry |
| Pineapple | | |
| Peach palm | | |
| Citrus | | |

The agro-economic data included specific information regarding crop benefits and costs. A key component of the enterprise budgets was information regarding monthly labor requirements. All information was organized and placed in electronic spreadsheets.

The agro-economic data serve as parameters for the farming system model. With the objective of maximizing farm profit subject to restrictions of land, labor and capital, the model determines the optimal

Since not all institutional outputs reach the final goal of having an impact upon development, there exists a gap between the two pillars. To illustrate via an example, the production of agriculture technologies is a tangible output yet if there are low rates of adoption, little development impact has been made. Thus a minimum requirement for research to have a known impact is that its results can be linked clearly to the development goals. The adding of activities, which increases the probability of an output making development impacts, is what (Smutylo, 1998) terms as improving the "reach" of an output. Hence, as for the case of agricultural technologies, research should identify ways to increase the likelihood of adoption in order to bridge the gap between merely producing research outputs and making significant development impact.

To increase the reach for each of the six key institutional outputs, the workshop participants identified extra activities called intermediate steps. An example helps illustrate the detail required to develop the extra activities that form the bridge (**Figure 2**). For the case of the key institutional output, *Policy Analysis and Formulation*, it becomes evident that a research output such as a model, which identifies the relationship between policy and land use change, is insufficient to have impact upon the goal of sustainable development. Other activities, which increase the reach, improve the chances of making impact. For example, the policy making process and actors must first be understood and identified. Subsequent steps of creating communication channels between the researchers and policy makers permit the research results to be shared and discussed. Then policy makers can make informed choices to formulate and implement policies that can aid in reaching the environment and well-being goals.

**Figure 2. Policy Analysis and Formulation**

***Output*** *Research identifies relationships between policy and land use change*

**Intermediate Steps of the Bridge**

Policy making processes understood
Identification of influential policy makers
Channels of communication established
Information regarding problems and opportunities disseminated
Policy makers understand information to make informed choices
Formulation and implementation of appropriate policies
Follow-up research of policy impact (a feedback loop)

***Goals*** *Improved conditions of environment and human well-being*

Reach and control are inversely related. As extra activities along the bridge reach further from the original output, control by the researcher/institution wanes. For instance, dependence upon others such as the policy maker is nearly absolute at the policy formulation and implementation stage.

The complexity and tangibility of these bridges differed according to each key institutional output. For example, while these intermediate steps may be sequential, some may need to be taken concurrently. With the key output *Business Development,* bridge construction was a relatively straightforward endeavor, while *Institution Strengthening* proved to be more complex and less tangible. Discussion of such minute subtleties had the possibility of derailing progress of the workshop. Thus, the task of refining the sets of intermediate steps and indicators was left for the working groups established for each of the six key outputs.

## *Activity 3.3 Develop a framework for monitoring and assessing impact of research in the forest margins*

**Highlight:**

- A three day workshop was convened with national and international partners to develop an indicator framework that identified: i) opportunities for institutional collaboration and ii) restrictions inhibiting research and extension efforts from having on-the-ground development impact.

**Purpose:** To improve the effectiveness of research and extension efforts by institutions working in the Forest Margins, Pucallpa Perú.

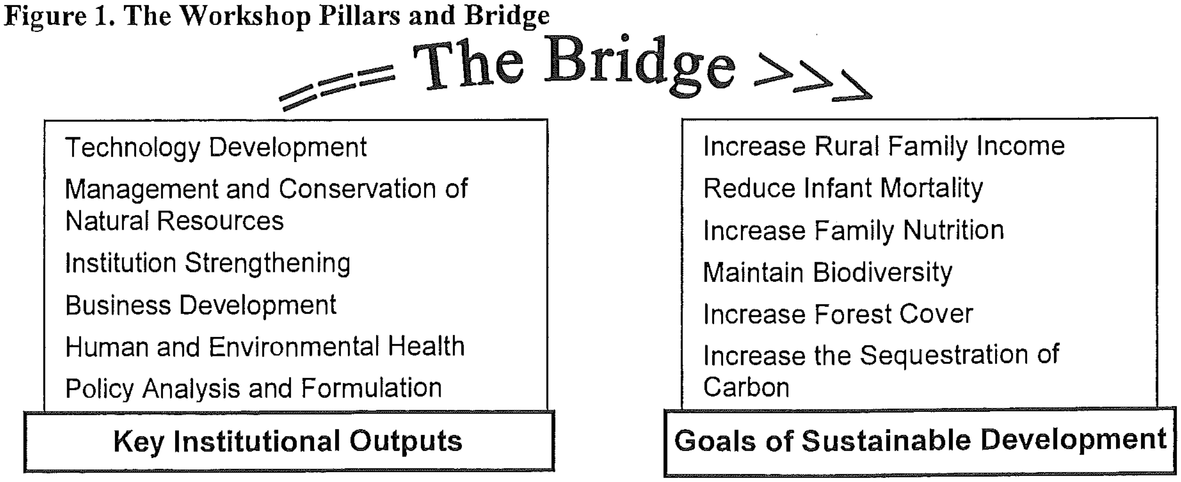
**Rationale:** Although institutions working in the Pucallpa region have specific mandates, they all strive toward a common goal of sustainable development. Yet at times the target of sustainable development is elusive. Not only it is problematic to define; it is still more difficult to attain. Institutions often maintain a focus on specific research and extension outputs whose linkages to or impact upon development goals are not clear. A system of impact analysis enables the planning and prioritization of research and extension activities in a logical and easily understood manner within a framework of sustainable development goals. (Pachico et al. 1998). Such a framework also permits continuous monitoring of research in progress.

To measure research impact in and across different benchmark sites, CIAT is creating an extensive system of indicators. Although this is useful for the international center, the outcome is likely to be too complex to be of interest to local national scientists and policymakers. Hence PE-5 researchers, together with national and international partners at the Forest Margins reference site, developed a methodology to create a framework of indicators that will allow analysis of the impact of collaborative research.

This workshop was a follow-up to the 1998 PPO (Participatory Planning by Objective) entitled "A Common Agenda of Research and Development for the Central Amazon". In the first workshop, institutional representatives prioritized four specific themes crucial to the region: biodiversity, marketing of Amazonian products, professional training, and participatory development of technologies. To aid in goal definition and to organize outputs, the logical framework methodology was employed to assist goal definition and organize outputs. However, even with the logical framework, it remained difficult to relate institutional efforts with the final goal of sustainable development.

**Outputs**: This second workshop on impact assessment was based upon two pillars, one representing the ***supply*** of institutional outputs and the other the ***demand*** of development goals. (**Figure 1**). The first workshop provided the inputs for the second pillar, i.e. the six development goals. Construction of the pillar to represent the institutional outputs was the task of the impact assessment workshop. This required synthesis of numerous, detailed activities of the various institutions to produce the six institutional outputs.

**Figure 1. The Workshop Pillars and Bridge**



## *Activity 3.4 Develop participatory monitoring and evaluation methods for technology development*

### 3.4.1 Participatory monitoring and evaluation of new technologies developed with smallholders.

**Highlights**

- Impact assessment workshops carried out with stakeholders at the national, regional, and farmer level.
- Village level spatial mapping and socio-economic indicator census conducted.
- Benchmark and forage technology adoption surveys conducted.

**Purpose:**

1. To develop and apply a framework and methods to assess concurrent and ex-post impacts of forage innovations.
2. To study the process in which farmers experiment with, adapt, and finally adopt forage systems innovations.
3. To compare impacts of participatory versus conventional research approaches.

**Rationale:** There have been many projects aimed at reducing rural poverty by increasing productivity and maintaining the natural resource base. While participatory approaches to technology development ensure that new technologies meet farmers' needs, there has been a lack of assessment of adoption and the impacts or outcomes on farm productivity and the natural resource base.

While other studies of impact have focused on key productivity increases at the regional level there are few 'user-friendly' methods that assess environmental and economic impact at the farm level during early stages of adoption. Any framework for monitoring progress or assessing impacts of new technologies must be related both to the problems/needs expressed by farmers as well as expected outcomes at different scales (farm, community, region). With this capability farmers and researchers can modify technology development to better target and meet both local and regional needs.

**Methods:** The project uses a mix of participatory and conventional approaches in developing a methodology for concurrent and ex-post impact assessment at each of the project village sites (**Table 1**).

**Table 1 List of Sites and Activities**

| List of Sites | Spatial Mapping | Problem Diagnosis | Impact Assessment | Case Studies | Surveys |
|---|---|---|---|---|---|
| Tagmaray | X | | X | X | X |
| San Migara | X | | X | X | X |
| Kaluluwayan | X | X | X | X | X |
| Kalingking | X | | | X | X |
| Pat-Pat | X | | | X | X |
| Santa Inez | X | | X | X | X |
| Silo-o | X | | | X | X |
| Paitan | | X | X | | |
| Bilayong | | X | X | | |

**Impact:** There were three physical outputs of the workshop that served as a first stage of information sharing and generation for the institutions working in the region.

- A summary of all the research that is being carried out in the Pucallpa region.
- Diagrams (bridges) demonstrating the links between key outputs and development goals.
- A common indicator framework to measure impact upon sustainable development.

Ironically throughout most of the workshop, the direct development of indicators was eschewed. Rather, the indicators were a product of the local institutions' need to measure success with respect to research outputs, the intermediate steps and development goals. As part of this workshop, the participants also discovered opportunities for inter-institutional collaboration and revealed limitations or challenges that impede activities from having an impact upon development goals.

**Contributors***:* Douglas White, Sam Fujisaka, Ricardo Labarta, Dean Holland, Peter Kerridge, ICRAF, CIFOR, CODESU and national researchers and extension staff.

**References:**

Pachico, D., Ashby, J.A., Farrow, A., Fujisaka, S., Johnson, N. and Winograd, M. (1998) Case Study and Empirical Evidence for Assessing Natural Resource Management Research: The Experience of CIAT.

Smutylo, Terry. Rethinking Impact Measurement: IDRC's Experience. 1998. Ottowa Canada, International Development Research Centre. Evaluation Unit.

Workshops will be held with municipal, regional and national level agricultural officers to develop and strengthen institutional expertise in impact assessment and project monitoring and evaluation.

**Outputs:**

1. GIS maps of project villages have been constructed along with spatial databases of socio-economic indicators and wealth rankings.

2. Identification of constraints on the farming system facing smallholder farmers has been obtained from consultations with farmers in the project site (**Figure 1**).

3. Indicators of impact of forage technologies have been obtained from consultations with the various stakeholders (**Figure 2**). The identified impacts were collated from each of the stakeholder focus groups and each of the farmer groups was asked to weight the impacts according to importance. There was a wide distribution of responses from each site but several impacts stood out as being most important to all the farmers (**Figure3**). The importance of these impacts to the smallholders in the project area have been statistically analyzed (**Figure 4**). The impacts that were considered very important to the farmers included:
   - The ability to provide feed to counter seasonal and overall shortfalls,
   - The opportunity to ensure the safety of animals against theft and accidental death by tethering closer to home.
   - The ability of forages to fatten animals, and
   - The soil erosion control potential of forages.

4. A database has been developed storing the results of the Benchmark Survey and the Adoption Tree Survey. This database will enable statistical analysis of impacts and adoption to be carried out for the project sites. The Adoption Tree Survey is also being conducted at other FSP sites in SouthEast Asia and the results stored in the database as well. The database will be linked with the GIS maps to provide a spatial dimension to the data analysis and presentation.

**Impact:** Apart from the training of local extension staff in participatory methods of project monitoring and evaluation the project impacts at this stage of the project cycle are minimal. While all milestones set out in the project documentation have been achieved, results are expected after the second stage of the project. The likely impacts include the development of a methodology for identification of project impacts in a participatory framework as well as a methodology for benchmarking, concurrent, and ex-post project monitoring and evaluation.

**Contributors:** Tim Purcell and Rob Cramb (NRSM, University of Queensland, Australia); Werner Stür, Francisco Gabunada and Louie Orencia (CIAT, FSP Philippines); Sam Fujisaka, Peter Kerridge (CIAT, Cali, Columbia); Willie Nacalaban, Gaspar Velasco, Pinky Ojales and Judith Saguinhon (LGU, Malitbog, Philippines).

The approaches taken include conventional case studies and surveys combined with participatory techniques of data collection, focus groups and community mapping exercises (**Table 2**). The results of the impact assessment exercises and surveys will be analyzed using conventional statistical techniques such as Multivariate Analysis of Variance and Multinomial Logit and Probit models.

**Table 2 List of Activities and Approaches Taken**

| Activity | Approach | | Methodology | Outputs | Participants |
|---|---|---|---|---|---|
| | Participatory | Conventional | | | |
| Spatial Mapping | X | | Community mapping and socio-economic census by focus group | GIS village level maps. Socio-economic indicators and wealth rankings. Population data for survey sample stratification | Focus groups at project villages. |
| Problem Diagnosis | X | | Flowcharting, weighting of importance | Indicators of Farming systems constraints and their relative importance. | Focus groups at project villages. |
| Impact Assessment | X | | Flowcharting, weighting of importance | Indicators of intermediate and final impacts of adoption and their relative importance. | Forage developers, municipal level agricultural officers and national level FSP coordinators focus groups. |
| Case Study Interviews | X | X | Semi-structured interviews, partial budgets | Farm, group, and village level farming systems information. | Purposively sampled farmers in project villages. |
| Participatory Methods Training | X | X | Participatory approaches, interview techniques | National Institution building and training. | Municipal level agricultural officers, community development workers, survey enumerators. |
| Benchmark Survey | X | X | Socio-economic indicators, matrix weighting, adoption decisions, farming system outputs and inputs | Database for concurrent and ex-post analysis of impacts and technology spread. Baseline information for monitoring and evaluation of farming system | Multistage proportional stratified sample of smallholders in project villages. |
| Forage Adoption Survey | X | X | Forage evaluation, forage development, expansion plans | Database for concurrent and ex-post analysis of forage and species adoption and development. | All forage adopters in project villages. |

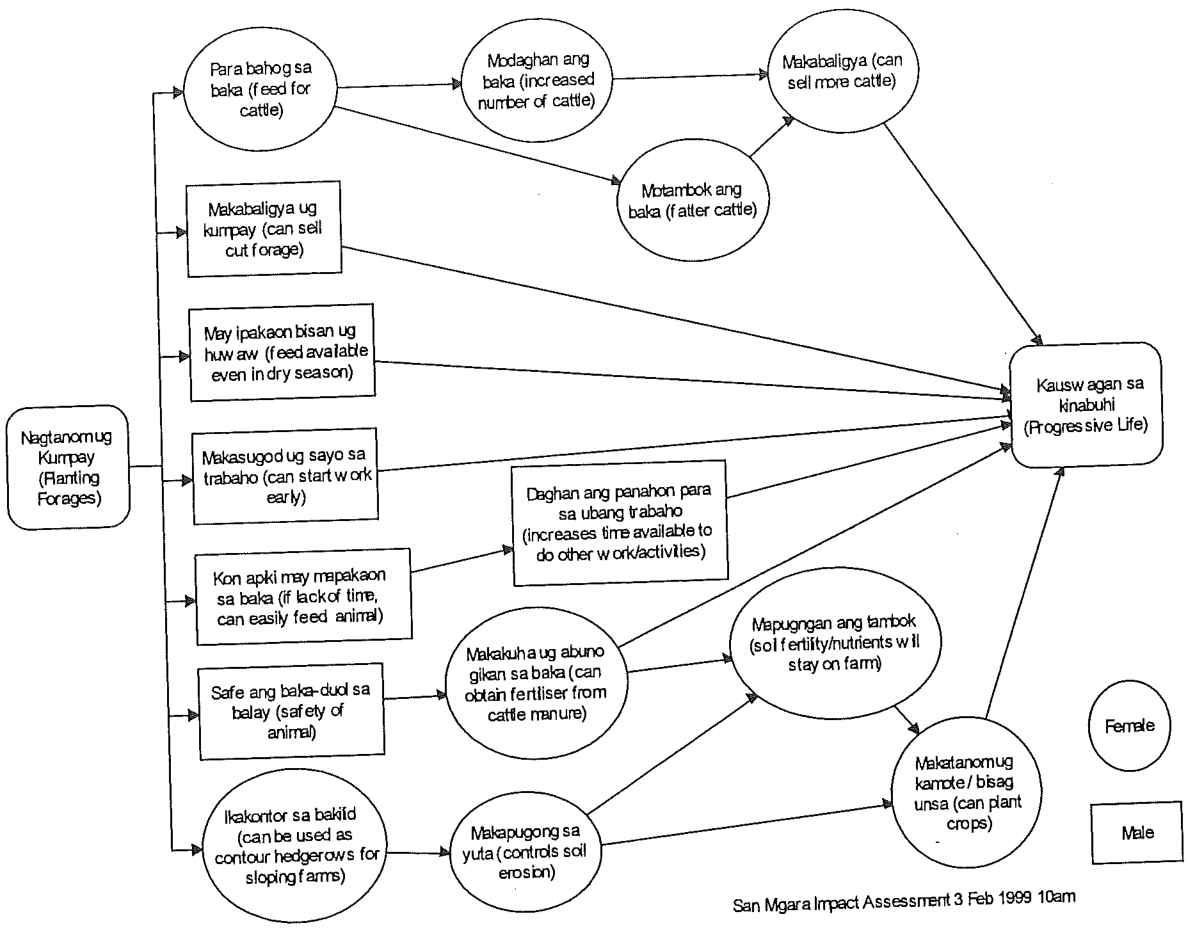



**Figure 2 Impact Assessment of Forage Technologies**

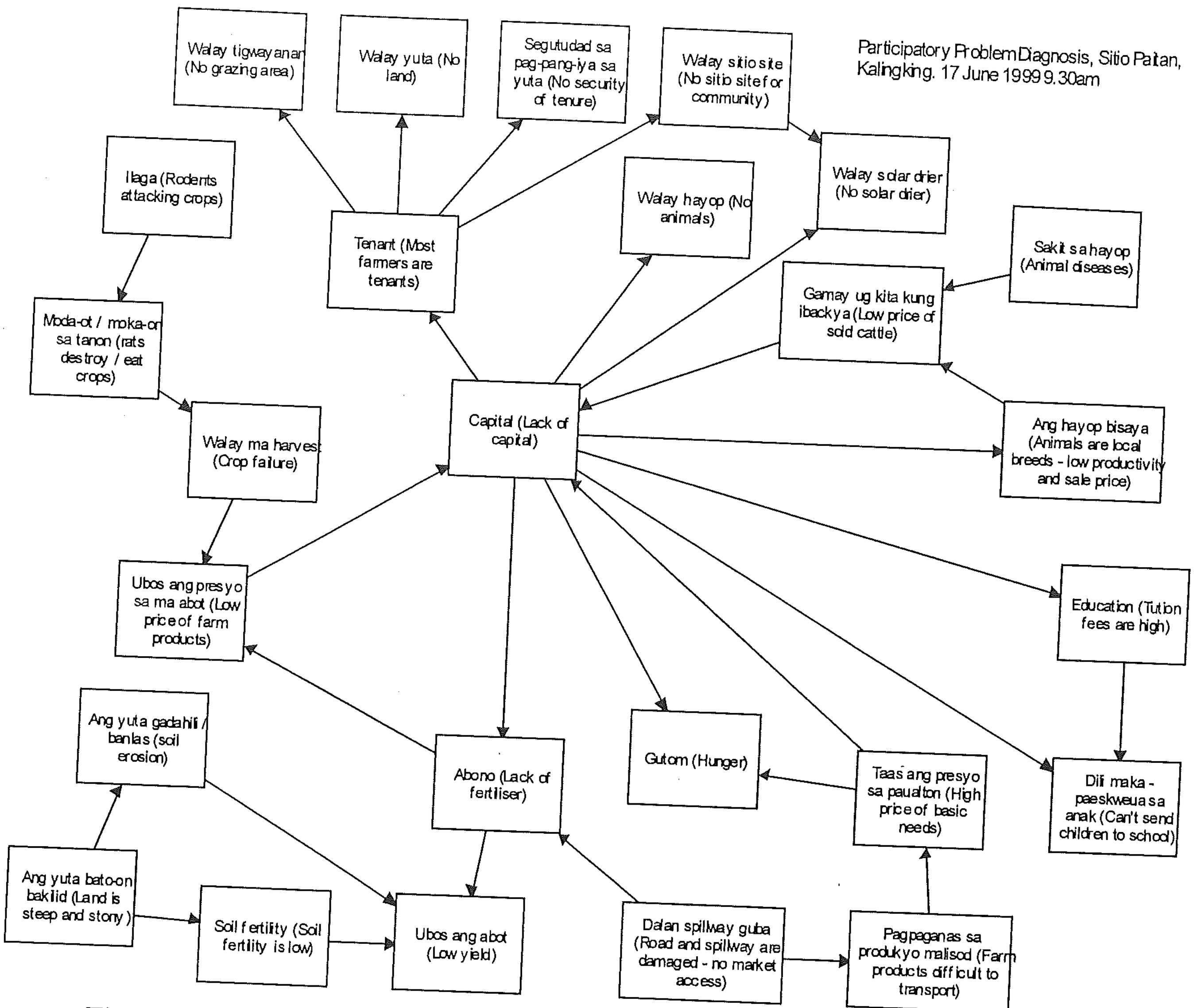
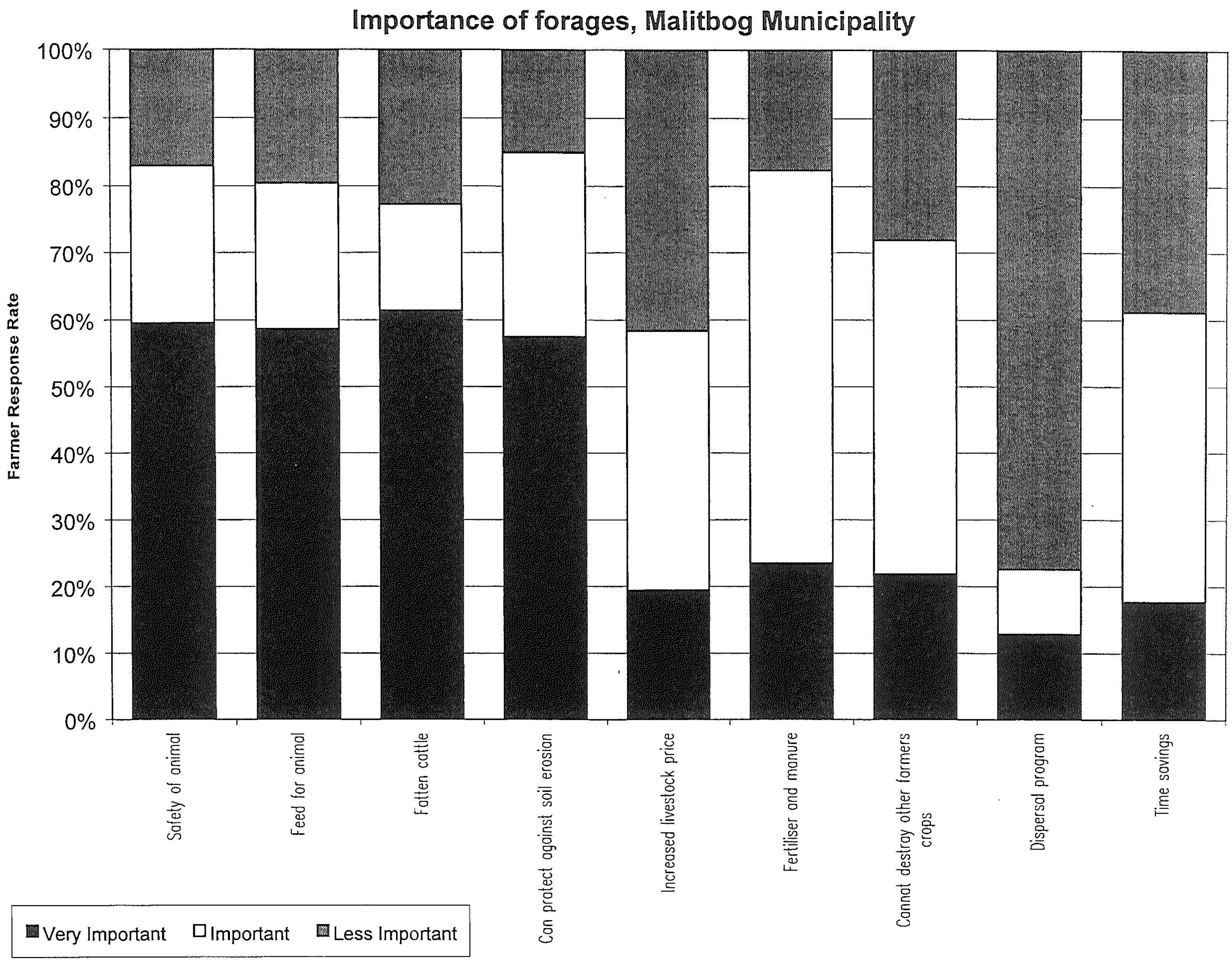



**Figure 1 Constraints on Farming Systems within the Malitbog Municipality**

**Figure 4 Analysis of Importance of Impacts of Forages in Smallholder Farming Systems**

| Impact | Mean Importance (1=Important, 10=Least Important, >11= Not Important) | Least Significant Difference (p<0.05) | | | |
|---|---|---|---|---|---|
| Provides Feed for Livestock | 5.79 | X | | | |
| Animal Safety (Theft, Accident) | 6.15 | X | X | | |
| Fattens Livestock | 6.68 | | X | | |
| Soil Erosion Control | 7.64 | X | | | |
| Provides Manure and Fertilizer | 8.12 | X | X | | |
| Increased Livestock Price | 8.33 | X | X | X | |
| Cut&Carry prevents straying | 8.67 | | X | X | X |
| Sell Feed | 8.69 | | X | X | X |
| Livestock Numbers | 8.85 | X | X | X | X |
| Soil Fertility | 8.97 | X | X | X | X |
| Time Savings | 8.97 | X | X | X | X |
| Help with Finances | 9.09 | X | | X | X |
| Crop Yield | 9.11 | X | | X | X |
| Healthy Animals | 9.12 | X | X | X | X |
| Education and Tuition Fees | 9.29 | X | X | | X |
| Labor reduction for women and children | 9.37 | X | X | | X |
| Livestock Dispersal Program | 9.62 | X | X | X | |
| Animal/Human Health | 9.63 | X | X | X | |
| Landscaping | 9.99 | | X | X | |
| Land Tenure | 10.42 | | | X | |

**Figure 3 Importance of Impacts of Forages to Smallholders**



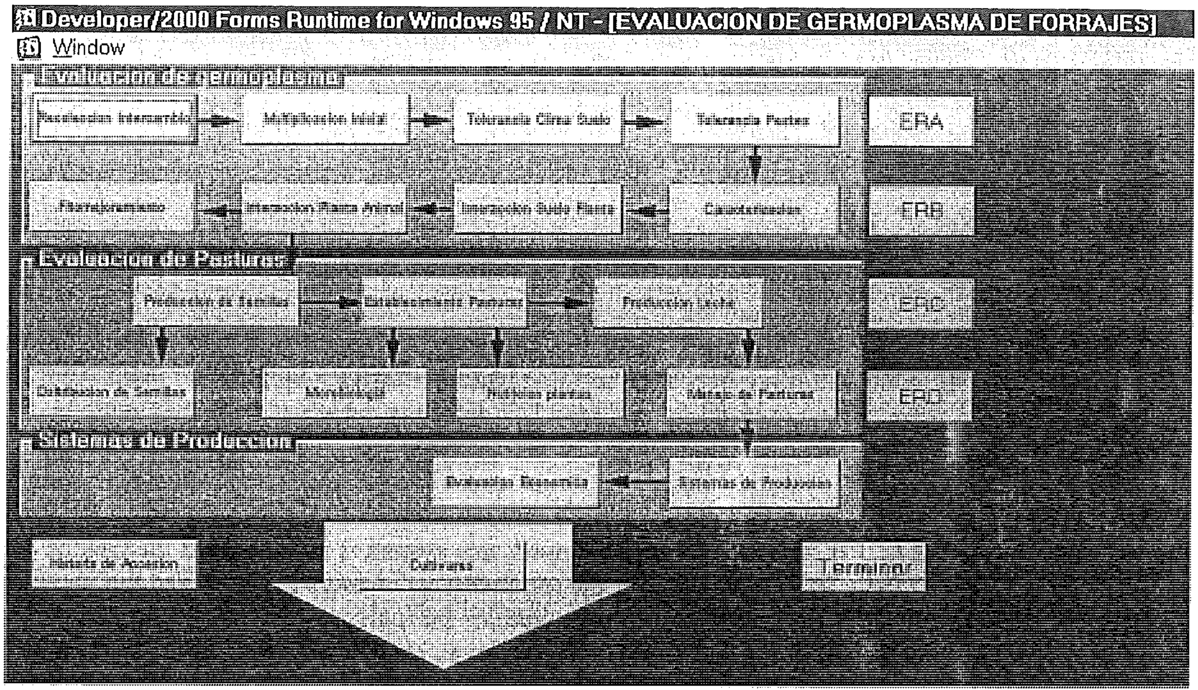



**Figure 1**. Main screen of the forage database in an attractive graphic platform developed in ORACLE DEVELOPER 2000

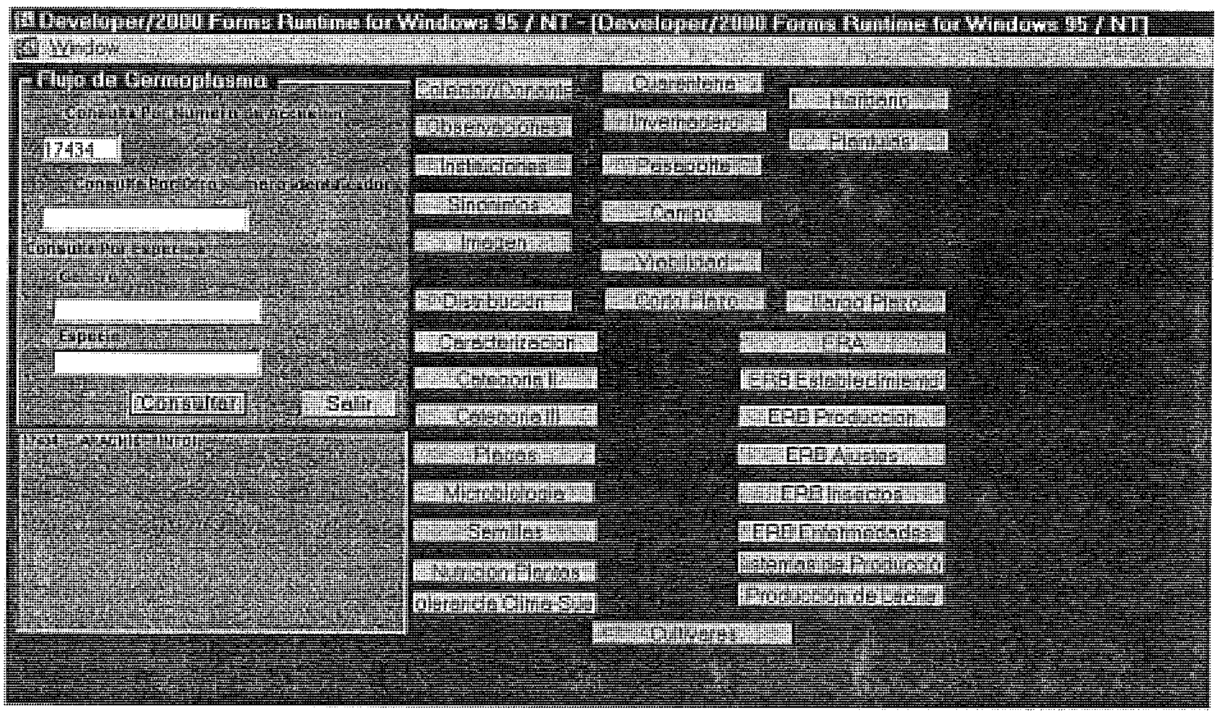



**Figure 2**. Second screen showing the type of information available for a specific accession

## *Activity 3.5 Integrate information on variety adaptation and appropriate technologies with GIS databases to target germplasm use*

### 3.5.1 Converting the forage database to a graphical platform

**Highlight:**

- Trial version of database on a graphical platform accessible to selected scientists via the Intranet

**Rationale:** The Tropical Forage Program in CIAT has generated an information system for the evaluation of germplasm, right from collection or exchange to the release of cultivars by national institutions. A great part of this information has been entered into an ORACLE database, which at present is available for CIAT scientists.

For the actualization, inquiries and searches of forage data, an information system based on the fourth generation language ORACLE FORMS 3 was developed; this system is available via the Calima Server. However, in view of the technological advances, the requirements of users in CIAT and the importance of sharing all the research results with other partners institutions through the internet or via magnetic means, it is important to convert this information system to a graphical, user-friendly and attractive platform.

**Methods:** The programs in ORACLE FORMS 3 are converted to ORACLE DEVELOPER 2000, with emphasis on user-friendliness and on an attractive platform. In the first phase, the old programs with information available in character mode are transferred to graphic mode. In the second phase new modules are added. Once completed, the database will be tested via CIATs Intranet and through Internet and CD-Rom versions developed.

**Results and discussion:** An initial trial version was developed. In figures 1 and 2 screenshots of the current versions are shown. The actual version was tested for year 2000 compatibility.
Next steps include the further refinement and testing of the database for Intra- and Internet use and the development of a CD-ROM version. Target group for this CD Rom are mainly Nars and NGO's in Latin America. In the future an English version of the database is planned.

At present, the database contains a total of 1537 accessions, evaluated in 315 sites. In many of these sites, available information is incomplete and therefore a great effort is being made to update the database through capturing information from existing publications and through obtaining data directly from scientists in the forage and Production systems projects.

**Impact:** A preliminary version of the graphically and user-friendly database is available for selected scientists through the Intranet. During 2000 this database will be refined for utilization via the Internet on for a CD-Rom. This database will also be utilized in developing the Decision Support Tool for the targeting of forage germplasm (see section below).

**Contributors:** IP-5 (Martha Herrera, Arturo Franco, Carlos Lascano, Michael Peters), PE-5 (Luis Horacio Franco), SB-1

## *Activity 3.6 Develop decision guides on soil fertility management*

### 3.6.1. Conceptual frameworks to guide research and extension efforts for integrated nutrient management.

**Highlights**

- NARS researchers from eight countries developed conceptual frameworks, using a decision guide format, and prioritized activities for research and extension for 14 agro-ecological zones.

**Purpose:**
To improve the efficiency of research and extension for integrated nutrient management by applying information available from various sources in consideration of the temporally and spatially diverse situations of farmers.

**Rationale:** Small-scale farming systems are often agronomically and biologically diverse. The farmers have diverse but scarce resources to use in soil fertility management. They need to get very high rates of return on invested money, as the opportunity cost is high.

Information for an Agro-Ecological Zone (AEZ) is often scarce but information from other places may be applicable. Application of such information to typical situations in the AEZ, coupled with preliminary economic and agronomic analyses, enables the researcher to make reasonable estimates on how best to use scarce resources. Information needs and adequacies are identified, and priority activities for research and extension are identified.

**Methods:** Members of the technical working group of ECAABREN for research on integrated nutrient management met to develop conceptual frameworks for improved soil fertility management for selected AEZ's. Information from diverse sources was integrated and interpreted in consideration of characteristics of farming systems in the AEZ. Preliminary agronomic and economic analyses were done. Conceptual frameworks were developed following a decision guide format. Priority research and extension activities were proposal and operational plans were developed.

**Impact:** Conceptual frameworks were developed for farming systems of:

(i) The Bukoban High Rainfall Zone of NW Tanzania
(ii) Sandy loam soils of the Western Transect of Mount Meru, in N. Tanzania
(iii) The Mbozi Palteau in the Southern Highlands of Tanzania
(iv) The Dedza Hills of Malawi
(v) Four AEZ's of South Kivu, D.R. Congo
(vi) Areka, SW Ethiopia
(vii) The Andranomanelatra AEZ, Antsirabe, Ethiopia
(viii) Gikongoro AEZ, Rwanda
(ix) Crete Congo AEZ, Rwanda
(x) Lake Victoria Crescent, Uganda
(xi) Northern Moist Farmlands, Uganda
(xii) Vihiga District, W. Kenya

Various field activities are being implemented in most of these AEZs.

**Collaborators:** C. Wortmann, Kayuki Kaizzi and the technical working group of ECABREN on integrated nutrient management. Linked to IP2.

## 3.5.2 Use of GIS models for better targeting of forage germplasm for end users

**Rationale:** The overall approach which intends to integrate agro-ecological, economic and social information, is based on the following main assumptions:

- a wealth of information on the agro-ecological adaptation of forage germplasm is available in CIAT's-held forage databases but access and hence utilization of this information is poor;
- there is a need to take account of socio-economic factors that influence adoption as well as adaptation to environmental conditions.

Based on these assumptions, a new approach to targeting forage germplasm needs to enhance the utility of existing information, allow for integration of environmental adaptation and socio-economic factors influencing adoption, and for multiple end-uses. It is anticipated, that this approach will allow a more accurate and client-oriented prediction of entry points for forage germplasm into farming systems.

**Methods:** A working group was formed to carry out the work and agreed to follow a step-wise procedure for the development of the system:

- Incorporate the existing RIEPT (Red International de Evaluación de Pastos Tropicales) database – for regional trials A+B into the GIS system to describe the agro-ecological adaptation of forage germplasm in Latin America
- Incorporate supplementary information of agro-ecological adaptation existing in CIAT-held forage databases e.g. the RABAOC database.
- Incorporate experiences of CIAT and NARS partners on adaptation
- Incorporate socio-economic information from characterization studies on a regional level (e.g. Central America).

**Results:** Parameters for the description ecological adaptation and agronomic performance of accessions across environments were identified. Currently the group is in the process of revising the classification of agro-ecosystems to be utilized for the database as the classification of agro-ecological zones developed by Thomas T. Cochrane may not be suitable for use in the GIS tool to be developed.

**Impact:** It is believed that the system to be developed will greatly enhance the availability of integrated information on the agro-ecological and socio-economic adaptation of forage germplasm for multiple uses. The integration of information from different sources will allow the improved targeting of forages to farmer's conditions and demands. As a result it is likely that:

- efficiency and client-orientation of future research will be enhanced, and
- the dissemination of existing and future research results will be improved.

Progress has been made in data preparation of the database underlying the GIS model and some trials have been run. For better targeting, of climatic and soil conditions the classification of agro-ecosystems is being revised.

**Contributors:** IP-5, PE-4, PE-3, PE-5 (M. Peters, Glen Hyman, Luis Horacio Franco, Arturo Franco, Belisario Hincapie, Gerardo Ramirez, Alexander Gladkov. P. Jones)

# Output 4. Increased effectiveness of CIAT and partners to conduct appropriate research for developing productive and sustainable land use practices

## *Activity 4.1 Coordination and Funding*

This has involved coordination of CIAT activities at the agro-ecoregional site for the forest margins in Pucallpa, Peru and activities of project PE-5

### 4.1.1 Forest margins ecoregional site – Pucallpa

**Highlights**

- A second Participatory Planning Meeting was organized and held in Pucallpa with all institutional stakeholders to jointly link research through a set of intermediate and development indicators
- CIAT research in forest margins gained a new momentum with the location of a resource economist and a specialist in participatory approaches in Pucallpa
- A meeting between CIAT, CIFOR and ICRAF researchers to share research results and plan future research was organized and held in Pucallpa

**Outputs:** This year we have continued to develop closer working relationships with both our international and national partners based in Pucallpa. CIAT research efforts have been increased in areas of economics and participatory research (with staff located in site), in land use studies, in agroenterprise development and in the area of community health in relation to land use.

- A framework was developed for choosing a set of intermediate and development indicators that unify the research and development programs of all institutions located in Pucallpa.
- This led to the formation of working groups to refine both research objectives and indicators so that they were logically linked with a set of common development goals.
- Research was initiated on the trade-off between productivity and environmental goals
- 11 multi-institutional projects were initiated by the Participatory Research Team (DEPAM).
- DEPAM is a non-sectarian platform for facilitating demand driven research and making the most efficient use of resources of the locally-based institutions.
- A training series on participatory research was initiated.
- Research commenced on an analysis of poverty in relation to location and land use.
- Market studies have been completed of exotic crops and are commencing on the more traditional crops of the area.
- A survey has commenced of the health of 6 contrasting communities in the forest margins
- A improved communications system has been set up for the Ecoregional Center using an internal network and a dedicated telephone line for internet connections

**Impact:** CIAT is leading the research in areas of economics, participatory research, land use, and agro-enterprise development and has facilitated many coordination activities

**Coordinator:** Peter Kerridge (CIAT-Palmira) and Doug White (CIAT-Pucallpa)

### 4.1.2 PE-5 – Sustainable Systems for Smallholders

**Highlights**

- Systems research at the watershed level has been consolidated in the forest margins site, Pucallpa, and with at an indigenous community site in Vietnam
- Commodity oriented research is producing new forage and cassava management technologies with wide application

**Outputs:** The project workplan was revised, individual workplans developed and assessed mid-year, and an annual report prepared. The Project Manager visited with scientists at sites in Asia (Laos, Philippines, Thailand and Vietnam) and Latin America ( Peru).

Coordination was focussed on consolidating CIAT research at the forest margins reference site near Pucallpa, Peru, in providing support to a national team in Vietnam facilitating community management of natural resources, in liaison with donors, in developing project proposals for continuing research with a commodity focus in forages and cassava, in seeking integration with other CIAT projects in geographical or commodity areas where the PE-5 is active, and in providing support to younger staff, in particular, those who are outposted. Support was provided to those directly responsible for coordination of the DEPAM project, Tropileche, Forages for Smallholders, Integrated Cassava Cropping Systems projects and Ecosystem health. Monitoring and evaluation activities have been commenced in all areas where the project is active.

**Impact:** PE-5 continues to have effective teams developing component technologies within a systems context for forages and cassava using utilizing new germplasm from the Cassava and Forage Germplasm Improvement projects. Systems research has been consolidated at the watershed level in the forest margins and in Asia. Feedback from staff suggests that they are receiving adequate support in their activities.

**Coordinator:** P. C. Kerridge

### 4.1.3 Funding

#### 4.1.3.1 Existing special projects

*Forages for Smallholders* (Southeast Asia). CIAT and CSIRO.
Funded by AusAID. Jan 1995-Dec 1999.

*Integrated Cassava-based Cropping Systems in Asia: Farming Practices to Enhance Sustainability.* CIAT.
Funded by the NIPPON Foundation. Jan 1999-Dec 2004

*Improved Legume-based Feeding Systems for Smallholder Dual-purpose cattle production in Tropical Latin America.* CIAT and ILRI under the SLP.
Funded by BID and the SLP. Jan 1998 to Dec 2000.

*Addressing Poverty and Protecting the Environment in the Peruvian Amazon: The Interaction of Technological Innovation, Policy and Market Opportunities.* CIAT and CODESU.
Funded by IDRC May 1998 to Dec 2000. Extension expected to Dec 1999.

*Health, Biodiversity and Natural Resource Use in the Western Amazon Lowlands: an Integrated Agroecosystem approach.* CIAT and Univ. Guelph. Funded by IDRC. Dec 1998 to May 2001.

*Community-based Upland Natural Resource Management in Hong Ha commune, Thua Thien Hue Province, Vietnam.* University of Hue and CIAT. Oct 1998 to Jun 2001.

*Evaluation of Leucaena in Central America and Southeast Asia* Contract with Oxford Forestry Institute. Apr 1997 to Mar 1999.

*Participatory Monitoring and Evaluation of New Technologies Developed with Smallhollders* CIAT and University of Queensland, Funded by ACIAR. Jan 1999 to Jun 2000

*An assessment of the impact of smallholder cassava production and processing practices on the environment and biodiversity.* CIAT. Funded by IFAD

#### 4.1.3.2 Projects near approval

*Developing Sustainable Forage Technologies for Resource-poor Upland Farmers in Asia.* CIAT. To be funded by ADB. Jan 2000 to Dec 2003.

#### 4.1.3.3 In discussion with donors

*Improving livestock production systems through the integration of forages on smallholder farms in northern Lao PDR.* CIAT and CSIRO. Donor is AusAID.

#### 4.1.3.4 Proposals developed

Forest margins research

Collaboration in developing the Alternatives to Slash-and-Burn Phase III proposal

*Promoting Partnerships for Improved Livelihoods and Environmental Management in the Amazon Forest Margins of Perú.* Moriah Fund Concept Note. Not approved.

*Socio-Economic Analysis of Farming System Technology Options in the Aguaytia Region, Perú.* Presented to Winrock International, Lima, Peru by CIAT-ICRAF, Pucallpa.

Tropileche

*Evaluation of options for the development of the dairy industry in tropical Latin America.* Submitted to Fontago. Not approved.

*Integrating biodiversity conservation and smallholder livestock production in subhumid tropical landscapes.* ILRI and CIAT. Submitted to CRUSA and the SLP.

Southeast Asia

*Integrating forages into upland farming systems of Vietnam.* Prepared on request of AusAID. AusAID decided not to go ahead with development of the proposal.

## *Activity 4.2 Facilitate multi-institutional and participatory research at the watershed level*

### 4.2.1 Multi-institutional research in the Aguaytia watershed through the DEPAM project, Pucallpa, Peru

**Highlights**

- A multi-institutional participatory research team is taking an active role in testing new ways of working jointly across institutions, and with farmers.

**Purpose:** To evaluate processes for developing a multi-institutional and participatory research model involving international and national research centers in Pucallpa, Peru.

**Rationale:** Pucallpa is a difficult place to catalyze development through agricultural research. It is dynamic and transient: more than half of the current farmers arrived in Pucallpa in the last 10 years (Fujisaka *et al.* 1997), yet up to a third of farmers wish to leave in search of areas with better soils (Yanggen, 1997). In frontier areas, a hectare of land can cost less than a bag of fertilizer, possibly making intensification a fantasy while cash resources are so low and labor is relatively cheap (White *et al.* 1999). Effective solutions for dispersed populations in these conditions are likely to be interdisciplinary and community-implemented, yet research has continued to take a disciplinary and supply-driven approach.

In response, CIAT has catalyzed a multi-institutional and demand-driven approach to research in Pucallpa in two complementary ways (i) through its normal role as a lead or associate agency following a specific research agenda in collaboration with local institutions and (ii) through facilitating the development of a Participatory Research Team (DEPAM) whose leadership is in local hands (see Output 2.1.1).

This presentation focuses on the processes and research activities involved with multi-institutional research through the Participatory Research Team. Output 4.5 "Institutionalizing a Collaborative Research Approach in Pucallpa through the project DEPAM" focuses on the parallel management structures.

**Methods:** DEPAM provides a vehicle for influencing the following levels of activity relating to agriculture:

| 1<br>**Farmer Capacity and Control** | 2<br>**Researcher Professional Development** | 3<br>**Improving Research Design and Implementation** | 4<br>**Organizational Space** |
|---|---|---|---|
| • Supporting the development of farmer organizations<br>• Awareness-raising of technologies, resources and institutions available<br>• Linking farmers around needs and resources | • Tools for Participation<br>• Processes for Evaluation<br>• Helping people to do participation, and to know if it has worked<br>• Bringing a gender focus<br>• Bringing a community focus | • Support in participatory project design and implementation<br>• Putting participation in the picture | Creating space to institutionalize participatory and multi-disciplinary research |

The approaches at all levels are similar, i.e. to open spaces for action, critical reflection, and deliberate learning strategies based on experience. DEPAM currently focuses its systematic activities on levels 2, 3, and 4, but all levels are closely linked in practice. The effects of these interventions alone and in combination form the basis of action research into strategies for sharing multi-institutional and participatory approaches in Ecoregional sites.

**Outputs:** At the project/institutional level, DEPAM provided seed funds for proposals for small multi-institutional participatory research projects in July 1998, and a second round of projects in April 1999. These projects are detailed under Output 2.1.1. Through a competitive system, project proposals were evaluated by both an advisory committee of local researchers, and a committee of farmers who represent producers throughout Ucayali.

For professional development, DEPAM facilitated a course in tools and approaches for participatory research in October 1998 with 24 researchers, and is currently responding to researcher demand with a second course with 18 researchers which started August 1999. In addition, the participatory research team selected two members to attend a workshop "Gender and Stakeholder Analysis for Participatory Research", and held a workshop among themselves to feedback and analyze the outcomes of the course.

CIAT is providing continual field level support and mentoring to DEPAM projects through staff in Pucallpa. Members of the DEPAM participatory research team have met on two occasions to evaluate jointly their progress within the projects. They identified the following difficulties with implementing participatory approaches:

- Overcoming the pressure to obtain immediate positive results
- Lack of institutional freedom
- Maintain institutional interest in participatory research (financial interest)
- Maintaining the scientific rigor of participatory research
- Achieving and maintaining interest and enthusiasm of farmers
- Understanding farmers' problems
- Pitching participatory research at an appropriate level of complexity

**Impact:** Members of the participatory research team are planning and carrying out field activities, such as field days that include researchers from several institutions. In addition, the participatory research team is starting to make joint decisions regarding the use of DEPAM resources, such as training opportunities. Team members are taking increasing responsibility for their own learning. They have identified the following learning goals, and are designing a process to achieve these through a "learning project", which is facilitated by DEPAM:

- Simple methods to include both men and women in projects
- Techniques for empowerment
- Adapting participatory methods to reality
- Techniques of social evaluation, including gender aspects and families

Projects are experimenting with their processes of research, and changing them as a result. For example, the levels of participation in the small grant projects was evaluated on a scale of 0-10 and gave an average of 3.8 (range 0-8). Researchers are jointly designing and implementing a conscious learning strategy to diagnose and improve levels of participation, which currently includes their own upskilling, and consultation with farmers and with research managers.

**Contributors:** Dean Holland, Sam Fujisaka, Peter Kerridge, Douglas White, Glenn Hyman, Scott Cechi, Carlos Bruzone, Carlos Ostertag, Mark Lundy, Ann Braun, Maria Fernandez from:
CIAT projects PE-5, PE-4, IP-1, SN-1, SN-3, inter-center project Participatory Research and Gender Analysis Program.

### 4.2.2 Impact assessment workshop in Pucallpa - the process

(See also Output 3.3)

**Highlights**

- The formation of inter-disciplinary multi-institutional working groups in Pucallpa to refine impact indicators and collect required data.

**Purpose:** To facilitate and enable national and international research partners to develop a feasible framework for impact analysis of research and development outputs in the Forest Margins reference site, Pucallpa.

**Rationale:** While scientific papers and books containing lists of development and sustainability indicators abound, their actual use is rare (Amazon Cooperation Treaty, 1995; Dumanski et al. 1998). Not only are these works too generalized to represent a particular geographic area, their formulation often has omitted to include those who compile and use the data. Hence there exists a detachment between available information frameworks and the needs of local institutions.

**Outputs:** The PE-5 research team developed a process to include personnel from all research and development institutions located in Pucallpa in the development of an impact analysis framework. This " participatory institutional" approach helped address their informational needs by ordering and priortizing a plethora of available data.

The identification of incentives so that national institutions were willing to embark upon the process analyzing impact themselves was an implicit but central task of the workshop. For example, impact measurement is a useful monitoring and accountability system for local national and international directors, be they from government or donor institutions. The provision of an information system, which displays accountability and impact, can assist local institutions in acquiring additional funding.

While the structure used to organize the workshop and indicators appears like a logical framework matrix, it is distinct. The framework contains five boxes and the order in which to work them is crucial. Instead of beginning with a ***supply*** of institutional activities and then defining the goals of development, in a self-justifying manner, it was decided to begin with the ***demand*** or goals side. Thus the workshop commenced by identifying the components of sustainable development (Box A). Results of the 1998 PPO workshop (see Output 3.2) provided the input for this box. Measures of development to the goal or where the region wants to arrive.

Discussion next moved to the supply side, the research and extension activities of the institutions (Box B). Participants filled out cards representing what they do and placed them on the walls. The following task required generalizing these activities to form key institutional outputs. (Box C). This was accomplished in a group manner by moving the cards into thematic groups signifying the reasons for performing the activities. Although a key output from one institution may be an activity to another institution, the exercise distilled the main themes thus providing a common language. The development indicators (Box A) and key outputs (Box C) correspond to the pillars of Figure 1 in Output 3.3.

The next exercise planned is to elaborate measures of success for institutional activities. However instead of using details of the specific activities, it was decided that the indicators be selected for the more general level of key institutional outputs. (Box D). Subsequent refinement would take place at a later stage in the working groups. The final stage of filling the workshop

**Figure 3 Framework used at the Workshop**

| Key Outputs: C | Output milestones: D | Intermediate Steps: E | Development Indicators: A |
|---|---|---|---|
| Activities:<br>1)<br>2)<br>3) B<br>.<br>.<br>. | | | |

**Working Order of the Boxes:**

- **A: Development Indicators**- measures of where to arrive
- **B: Activities**- what the institutions do
- **C: Key Outputs**- reasons for performing the activities
- **D: Output Milestones**- results of the key institutional outputs
- **E: Intermediate Steps**- the bridge between the activities and the development goals

structure required identification of the intermediate steps between key institutional outputs and the goals of sustainable development (Box E). Participants formed six groups to construct a bridge for each the key outputs. It soon became apparent that more activities were needed to increase the probability of having impact upon the sustainable development goals.

**Impact:** The most important outcome of the workshop was the processes of facilitating collaborative research. An example was the formation of inter-disciplinary and multi-institutional working groups to refine the impact indicators. Subsequent meetings of these groups have brought together scientists and administrators to discuss how change can be made. Through the process of developing the indicators and impact analysis product, ownership rests within the institutions in Pucallpa. The work of distributing tasks amongst the participants to compile existing data and collect field data remains.

**Contributors:** Douglas White, Sam Fujisaka, Peter Kerridge, Dean Holland, Ricardo Labarta, Mario Lanao-ATINCHIK, ICRAF, CIFOR, CODESU

**References:**

Tratado de Cooperación Amazonica Proposal of Criteria and Indicators for Sustainability of the Amazon Forest: Tarapoto. 29, Lima, Peru: TCA: Pro Tempore Secretariat. (1995)

Dumanski, J., Pettapiece, W. and McGregor, R. (1998) Relevance of Scale Dependent Approaches for Integrating Biophysical and Socio-Economic Information and Development of Agroecological Indicators. *Nutrient Cycling in Agroecosystems* 50: 13-22.

### 4.2.3 Facilitating Inter-Center collaboration in the forest margins, Pucallpa

**Highlights**

- An Inter-Center meeting between CIAT, CIFOR and ICRAF came up with a resolution and agenda to develop collaborative research projects for joint submission to donors.

**Rationale:** Pucallpa is the reference site for research in CIAT in the forest margins of the Amazon, i.e. it is a CIAT ecoregional reference site. It also is a reference site for the Alternatives to Slash and Burn Program led by ICRAF. CIFOR also has research program on this site. IPGRI has expressed an interest in undertaking research on genetic resources of indigenous crops such as cassava provided it can obtain funding. The Centers individually have collaborative links with the national organizations in Pucallpa. Hence it is logical that the Centers themselves should have strong collaborative links with each other.

**Outputs:** There are two levels of outputs. The most common is informal collaborative research between scientists with common or complementary skills. The second level of collaboration have been meetings to acknowledge and make use of complementary skills in order to make efficient use of resources. Joint meetings or more formal activities:

- November 1997 – Inter-Center meeting of DG's from CIAT, CIFOR and ICRAF who agreed on a Common Vision for research at the Ecoregional Reference site at Pucallpa.
- February 1998 – The Centers moved into a common office building on the grounds of INIA, the national research organization under the Ministry of Agriculture and now share other common facilities such an electronic network.
- July 1998 – Research of CIAT, CIFOR and ICRAF was put into a common logframe that used the Common Vision as a framework. This allowed everyone to see what others were doing but did not result in any increase in collaboration between scientists. CIAT requested and organized in ...
- June 1999 – A meeting of research scientists from CIAT, CIFOR and ICRAF to share and discuss research outputs and research agenda. The outcomes of this meeting were:

  i) a better understanding of our goals that lead to a vision for the direction of future research
  ii) Better understanding of each other's research with areas for future collaboration identified.
  iii) An agreement and agenda to develop three research proposals for joint submission and funding.

**An emerging vision -**

"Our role is to diminish the undesirable trajectories and increase introduction of diversified land use systems, facilitate sustainable soil and crop management, capacity building and inter-institutional change, produce global goods, undertake "trade-off" analysis and develop political support for desirable policies, and contribute to improved health and nutrition of local people."

was developed from the following table which was put together following a short brain storming session.

### (i) Vision of the direction for future research

| Desirable | Undesirable |
|---|---|
| Diversified land use systems<br>Land systems based on improved zonification, -<br>Mix of perennials and long term falloffs,<br><br>Sustainable rotational systems(where demand for intensification)<br><br>Diversified production systems,<br>Agroforestry systems/Forest based production systems in farmland<br>Mosaic pattern of land use systems<br>High quality germplasm available,<br>Harvesting the rain forest,<br>Profitable secondary forest production,<br>Production areas of forest under management by i) forest enterprises and ii) rural communities | Inappropriate agriculture<br>Expansion of cattle ranching at expense of SF, RF due to policy signals,<br><br>Annual food crop production?<br><br>Unsustainable forest use<br>No management of primary forest<br>Destructive extractionism,<br><br>Deforestation<br>ueva ley sobre desarrollo amazonia,<br>Tree monoculture |
| Global goods delivered<br>Biodiversity protected<br>Increase in C sequestration | Biodiversity Loss<br>Monocultivo,<br>Loss of genetic diversity |
| Improved soil and crop management<br>Better tools for soil management,<br>Easy alternatives for small farmers | Soil degradation |
| Political support<br>Better informed targeted policies | Inappropriate policies<br>New law sobre desarrollo amazonia,<br>Forestry law of land tenure Vs management |
| Improved market mechanism | Lack of markets<br>Poor access to markets |
| Trade-off analysis available | Lack of Trade-off analysis<br>Agricultural incomes Vs forest cover and biodiversity,<br>Short rotation improved falloffs Vs secondary forest cover |
| Community control<br>Farmer initiated research,<br>Community ownership of action | Lack of community control<br>Disempowered, apathetic and poor people |
| Capacity building and institutional change<br>Acopió de mas investigacion, NARS-increased capacity in NRM, Centers and others collaborating in R&D | Mistargeting research<br>Research defined independent of national organizations, Inappropriate agriculture,<br>Research not used by local producers, poor collaboration among Centers and others |
| Improved health and nutrition<br>Improved nutrition,<br>Reduced child mortality and child morbidity | |

**(ii) Recent, current and proposed research and gaps**

(Under themes of the Common Vision)

This summary is presented as a record of the discussions and as a basis on which more definite research plans might be developed. IT IS NOT COMPLETE.

**1. Policy and institutional environment**

Recent Pasture technology and deforestation study (CIAT)

Current Farm level and maximization model w/ ex-ante analysis of technical innovations
Economics and policy analysis of fallow management strategies
Poverty –market access or resource access (CIAT)
Nutrition programs with DRS (CIAT)
Institutional structures for multi-disciplinary research (CIAT)
Potential for participation in C markets (CIFOR)

Future Riverine farm risk analysis (CIAT)
Landscape mapping re land use trajectory scenario (CIFOR)
Landscape level research (CIFOR, CIAT, ICRAF)
Political economy secondary forests and policy (CIFOR)
Evaluate farmer organizations (operational mgt) (CIAT)
Diagnosing and strengthening of support system for local economic activity (CIAT)

Gaps Understanding trade-off and targeting to the appropriate content
Forest sector policies

**2. Managing biodiversity**

Recent Plant community biodiversity and land use (CIAT, ICRAF, INIA)
ICRAF- Priority setting of agroforestry trees, economic evaluation of agroforestry trees, local knowledge about agroforestry trees, farmers use and management of germplasm, molecular genetic diversity in agroforestry trees, Calycophyllum

Current Crop geography and agricultural development (ICRAF)
Ecological footprint (nutrition and biodiversity) (CIAT)
Importance of fish in diet of riverine communities (CIAT)
ICRAF- Molecular genetic diversity in agroforestry trees- Guazuma crinita
Effect of domestication on genetic diversity- Inga edulis
Genetic variation among provenance, Calycophyllum, spriceanum, Guazuma crinita
Genetic variation among families – Bactris gasipaes
ICRAF- Effectiveness of phenotypic selection – Inga edulis, Calycophyllum spriceanum
Germplasm production systems –secondary orchards
Economic valuation of germplasm production systems

Future Ethnobotany and ecology of social and economic important biodiversity (ICRAF)
ICRAF – Genetic variation among provinces/families 4 species
Genetic diversity within species
Reproductive ecology of species G. crinita, C. spruceanum
Silvicultural management of trees in secondary forest – G. crinita, C. spruceanum
Secondary forest – G. crinita, C. spriceanum
Indigenous knowledge about trees

Gaps Methods to manage and maintain biodiversity
Implications of biodiversity change
Intellectual property rights
Local utility of biodiversity
Ethnobotany and equity of social and economic important biodiversity

**4. New options for diversified land use systems**

Recent CIAT- Proposals for methodologies – market identification, Integrated agroenterprise projects, design of support system
Selection of exotic portfolio-agronomic, commercial and economic characterization
Inventory of – development projects, native processing, key non-exotic products
Establishment of Rural Agroenterprise Development Committee
CIFOR Dynamics of secondary forests in new and old colonization areas
Inventarios floristicas en purmas mayores de 4 anos en unidades agrarias en tres sectores (semuya, nueva requena, neshuya)
Patrones de uso de tierra y su impacto sobre los bosques secundarios

Current CIAT On-station rice testing
FPR rice testing
Participatory evaluation of exotic market options
Market study of non-exotic products
ICRAF FPR improvement of fallows, organic inorganic fertilizer, contour rows, multistrata
Applied research (farm site) improved fallows
CIFOR Rehabilitation methods for degraded secondary vegetation and pasture lands INIA/CIFOR
Farmer management of secondary forests CIFOR/CATIE/UNALM
Composition Floristica Vs intensidad de uso de suelos
Bosques secundarios en sistemas productivos de pequenos productores –investigaction participativa D Current/ V Colan
Caractization economica financiera de unidades agrarias (beneficios/costos)

Future CIAT K A P surveys of yuca and beans
Evaluacion genotipos de arroz para sistema barrizales
Silvo-pastoral
Participatory design of integrated agro enterprise projects for selected portfolio
Analysis of current marketing and distribution system
CIFOR -Improving the value of residual forests – silvicultural options to regenerate RF – socioeconomic and policy research

Gaps Improving the value of residual forests – silvicultural options to regenerate RF – socioeconomic and policies

**5. Strengthening individuals, communities and institutions in NRM**

Recent CIAT Training for farmer participatory research and extension

Current CIAT-Farmer participatory rice testing
Strategies for integrating participatory and multi-institutional research in Pucallpa
Human welfare, poverty and NRM environment and welfare
University course on health and nutrition for UNU
Dietary guidelines
ICRAF- Training in NRM soils, genetic resources of trees

Future Fertility capability classification (ICRAF)
Analysis of NRM research policy (CIAT. ICRAF, CIFOR)

Gaps Creative space for institutional change
Collaborative research con socios y entre IARC's
Graduate education for L.A> scientists
Research at the community level
Training on diversified forest management system
Community development – awareness and structures
Fortalicimineto de las organizations
Analysis of NRM research policy

**6. Assuring and measuring impact**

Recent None

Current CIAT -Impact indicators framework
Community indicators of health
Assessment of health and nutritional status (food security)
Key variables affecting malnutrition
CIFOR- C sequestration on land use systems

Future CIAT Methodologies for measuring impact of policy research
Factors that influence adoption of methodologies
ICRAF Valor de beneficios intangibles (e.g. Biodiversidad)
Gas emissions
FCC classification
Vincular estudios de politicas y analysis de impacto (CIAT, CIFOR, ICRAF)
Monitoring system for impact assessment of improved land use production systems CIFOR

Gaps Factors that influence adoption of methodologies
Valor de beneficios intangibles (biodiversidad etc)
Appropriate methodologies for measuring of policy research

**(iii) Issues for discussion that arose from individual presentations:**

**Research areas**

Vision for future land use
Gaps
General discussion themes
Collaborative Studies In Marketing
Study of indigenous knowledge on value of forests
Where to focus research -Improving crops is not assisting in replacing the current system
Strategy? From intensification of agriculture to emphasis on political economy, non-agricultural sectors?)
Research riverine as well as upland
Ecological research on weeds

**Information sharing**

**Joint research report**
List of projects
Coordinate and list encuestos
Data sharing and data base
Sharing annual reports

**Is Pucallpa being integrated with other Forest Margin research?**

**(iv) Summary of project proposals, collaboration and responsibilities**

*Title: Identify elements for improving the value of residual forests, secondary forests, and fallows*

Team: John Weber, Joyotee Smith, Doug White, Violeta Colan (Facilitator), Carlos Ostertag, Cesar Sabagal (Leader), Julio Alegre, Ricardo Labarta, Tamsyn Murray, Sam Fujisaka

Themes to consider including:
i) Management of secondary forests in areas of socio-economics and genetics
ii) Evaluation and management of fallow and the trade-off

Possible components: Trade-off y policy. Technology and Genetics

*Title: The sustainable use and conservation of biodiversity*

Team: John Weber (Leader), Glenn Hyman, Tamsyn Murray, Sam Fujisaka, Carlos Ostertag, Cesar Sabogal, Violeta Colan, Joyotee Smith, Carmen (Facilitator)

Themes to consider including:
i) Use and conservation of biodiversity
ii) Local conservation and knowledge

The project would needs to define biodiversity and identify indicators for monitoring biodiversity in different land use systems

**Title: Identify factors that affect decision making by producers and policy makers and enable the process of change to demand-led research and development.**

Dean Holland (leader); Keneth Reategui (facilitator)

**Team: Dean Holland (Leader), Keneth Reategui (Facilitator), Carlos Ostertag, John Aviles , Ricardo Labarta, Julio Alegre, Miguel , Violeta Colan**

**Themes to consider including:**
i) Strengthen inter-institutional capacity
ii) Factors that affect adoption
iii) Determine the best manner of collaboration

Suggested that the project revise adoption in the past to obtain an idea of what methods function

**Contributors:**
ICRAF – Dale Bandy, Julio Alegre, John Weber, Polly Ericksen

CIAT – Peter Kerridge, Sam Fujisaka, Dean Holland, Ricardo Labarta, Glen Hyman,Tamsyn Murray, Carlos Ostertag, Doug White,
CIFOR – César Sabagol, Joyotee Smith, Violeta Colán Colán,
DEPAM - Keneth Reátegui

### 4.2.4 Facilitating Community-based Natural Resource Management, Vietnam

**Objective:** To provide technical and mentoring support to a University of Hue team carrying out research to improve food security and ensure long-term stability of natural resources of an ethnic community in the mountainous region of Thua Tien Hue Province, Vietnam.

**Rationale:** CIAT was invited by IDRC and the University of Hue to collaborate in a project on community management of natural resources through providing improved germplasm, technical input, and training and advice in problem diagnosis, setting research priorities, interpreting data and reviewing research.

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**Output:** Specific inputs by CIAT have been:

- Reviewing and editing the research proposal
- Providing improved germplasm of cassava, forages and beans
- Technical input into research design of agronomic experiments
- Problem diagnosis and data interpretation
- Research planning
- Coaching in the use of tools for diagnosis and analysis of data

**Impact:** The University of Hue team has established good rapport with the community and completed characterization of the physical and agricultural (forestry, livestock, fish, crops and home gardens) resources, cultural characteristics, social and gender issues, economics, and the institutional setting. Interventions through participatory research of rice varieties, vegetables and pulses and small livestock show promise of increasing productivity.

It is hard to assess the impact of the role of CIAT in the project at this stage. CIAT sees this as a collaborative research venture rather than a consultancy and is gaining experience as well as contributing from our own resources and experience. We see community-based natural resource management as a strength that CIAT can develop and/or support through the skills it has in upland agronomy in Asia, use of participatory approaches in research, and experience in agro-enterprise developments.

**Contributors:** P. Kerridge, S. Fujisaka, R. Howeler, P. Horne, C. Wheatley (CIAT). The Hue team is listed with Output 1.1.2.

## *Activity 4.3 Facilitate regional partnerships/ networks*

### 4.3.1 Coordination meetings of Forage for Smallholders Project

**Highlights**

- Plans were discussed to synthesize findings at an international workshop and to publish them in different languages of the region
- A strategy was discussed for continuation of FSP activities with reduced donor support

**Purpose:** Review achievements and plan activities of the project.

**Rationale:** Regional meetings bringing together major partners in research are a vital part of effective coordination of multilateral research.

**Outputs:** The fourth annual meeting of the FSP was held in Nha Trang, Vietnam from 26-28 January 1999 and attended by 33 participants from 9 countries (Australia, China, Colombia, Indonesia, Laos, Malaysia, Philippines, Thailand and Vietnam). The meeting reviewed experiences with on-farm forage development and discussed options for continuing the work at each site after December 1999 when the project concludes. Topics discussed during the two days of presentations and discussions included forage technology development, new forages for particular uses, assessing impact of forage technologies and future directions for the FSP. The participants visited the nearby field site at M'Drak, where more than 90 farmers are planting forages to provide supplementary feed for their cattle at times of year when feed is scarce or labor is in short supply.

**Impact:** The regional meetings have proven to be an effective way of exchanging information between scientists in the region more so than through the Newsletter and electronic means.

**Contributors:** FSP staff and national partners from 7 countries.

**Coordinators:** Werner Stur (CIAT) and Peter Horne (CSIRO)

### 4.3.2 The Asian Cassava Research Network

**Purpose:** To improve the efficiency of cassava research conducted in Asia for the benefit of cassava farmers in the region.

**Rationale:** Cassava programs in national research institutions in Asia are often small and have very limited budgets for research. By exchanging cassava germplasm and information, and by coordinating the research to be conducted, the efficiency of these programs can be markedly improved. Moreover, by stimulating more collaboration between research and extension institutions, the research becomes more focussed on practical problems while the quality of extension improves.

**Methods:** The Cassava Advisory Committee, consisting of one representative from each major cassava producing country in Asia, with the CIAT Regional Coordinator acting as secretary, decides about the country that will host the next Regional Cassava Workshop and the topics to be discussed. These workshops have been held every three years since 1984. The 6$^{th}$ Workshop will be held in Ho Chi Minh city, Vietnam, in Feb 2000. The papers presented at these workshops are edited and then printed as Workshop Proceedings. The 5$^{th}$ Proceedings was printed in 1998.

**Outputs:** During the past ten years the Thai-CIAT cassava breeding program has supplied the breeding programs of other countries with sexual seed, advanced lines or clones in the form of tissue culture or occasionally as stakes; this, in addition to the sexual seeds supplied by CIAT/Colombia. After passing through many stages of selection, these seeds have yielded many promising clones, which were eventually released as new varieties by national programs. In 1997, new higher-yielding varieties were planted in 660,000 ha in Thailand, corresponding to 63% of the cassava growing area. For the whole of Asia, it is estimated that the area under new varieties will surpass 1 million ha in 1999.

In the 2nd phase of the Nippon Foundation Project on Sustainable Cropping Systems, which started in early 1999, the emphasis will be on developing and then disseminating more effective production practices that are acceptable to farmers, through farmer participatory research and dissemination. The project will concentrate on Thailand and Vietnam. In both countries workshops have been organized to plan future activities and to coordinate the work of six collaborating research and extension institutes and universities in Vietnam and six in Thailand; in the latter country IBSRAM is also a partner. The project is not only strengthening the collaboration among various research and extension organizations within each country, but also a vertical collaboration among researchers/extensionists at various levels of administration, from national down to the local level.

**Coordinator:** R. Howeler (CIAT)

### 4.3.3. Tropileche - Workshops and meetings to analyze and plan research activities

**Highlights**

- The workshop held in Peru in July 1999 established the research agenda for the forest margins for the next two years and set the principles for expanding the collaboration with other partners in Ecuador and Bolivia.

**Annual Workshops 1999**

**Rationale:** Annual meetings to discuss workplans, current research and future challenges as well as constraints are important in order to increase the efficiency of research and interchange ideas. This year separate workshops have been organized for South America (July 1999 in Peru) and Central America and the Caribbean (Costa Rica in October 1999).

**Results:** Tropileche held a workshop to plan and discuss present and future activities in South America during June 27 to July 2, 1999, in Moyobamba, Peru. The objectives of the workshop were to: (a) present the research achievements obtained by the Consortium and pose future challenges; (b) present research results achieved in Peru and to discuss new activities for 1999 and 2000; (c) participate in a field visit to understand and identify opportunities in current animal production systems in the Moyobamba region of the Peruvian Amazon; (d) review strategic and participatory research based on needs and constraints; and (e) analyze and discuss new forms of collaboration with other institutions and in other countries of South America, especially Ecuador, Bolivia and Brazil.

Invited participants in the workshop included 22 researchers from Peru, Colombia, Ecuador, Bolivia, and Brazil. The workshop proceedings will be distributed during the month of October. Mayor outcomes of the workshop were:

(1) Tropileche will continue to reduce research activities in Pucallpa in 1999 and 2000 and increase activities in Moyobamba. Potential for adoption of new forages activities in Pucallpa is low due to an oversupply of forage from a reduced herd inventory. In addition, the dual-purpose herd has a low

genetic potential for milk yield which reduces economic benefits from investing in new forage technologies and the market potential for milk in Pucallpa is severally limited as there is no milk plant. The situation in Moyobamba is the reverse. A cooperative milk processing plant has been opened, farmers are improving the genetic potential of their herds for milk production and there is a demand by farmers for improved feeding systems.

(2) The Consejo Transitorio Agricola Regional (CTAR), through the Fundacion para el Desarrollo Agricola del Alto Mayo (FUNDAAM) will be our partner in Moyobamba and the institution responsible to carry out all of the research activities agreed during the workshop. The CTAR also agreed to invest as matching funds 35% of the resources that Tropileche delivers to Moyobamba.

(3) There are good possibilities to expand research activities in Ecuador with our partner INIAP by accessing Wold Bank funds bilaterally and in Bolivia with CIAT-Santa Cruz through a collaborative project with DFID. Tropileche agreed with both INIAP and CIAT-Santa Cruz to follow up and develop project proposals for submission to both WB and DFID to access bilateral funds.

**Collaborators:** F. Holmann, C. Lascano. P. Kerridge and A. Ramirez, CIAT, Colombia.

## *Activity 4.4 Compare effectiveness of different institutional models for effecting change in natural resource management*

### 4.4.1 Participatory systems research: towards the future

**Highlights**

- Compilation and publication of the book *"Systems and Farmer Participatory Research: Developments in Research on natural Resource Management"*

**Purpose:** The book records presentations at an internal workshop held at CIAT in November 1997 to review the different facets of systems and participatory research conducted in CIAT.

**Rationale:** Different systems and participatory and systems research had been conducted without an analysis of what had been accomplished, what directions were being taken, and what directions appear to be the most appropriate for the future.

**Methods:** Researchers met in a workshop in November 1997 to exchange experiences and ideas. Each participant or team of participants were then invited to submit papers for review and inclusion in the book. Considerable follow-up work with authors and researchers led to the publication of the book.

**Outputs:** A concluding chapter synthesized experiences and future directions which is reported here. The general theme through the book is how agricultural research is striving to make problem-solving more effective and efficient through integrating germplasm and natural resource management (NRM) research, developing and applying farmer participatory research (FPR) approaches, and establishing new forms of partnerships for research. The chapters provide a clear view of what has been achieved and reasons for successes and failures. Expected future impacts are implicit in much of the work, as are strategies needed to achieve them.

*Integration of germplasm andNRM research.* The projects described indicate substantial progress in the integration of germplasm and NRM research. Researchers are introducing new forage materials, especially legumes, and small-scale farmers in Asia and Africa are testing and using them as green manure, cover crops, and in improved fallow rotations. These uses of forages in low-input systems seek to improve nutrient cycling, maintain soil structure, combat weeds, and reduce soil erosion. In the Latin American savannas and forest margins, researchers are working with farmers and ranchers to develop animal feeding systems that are both more productive and more sustainable through the introduction and farmer testing of new forage mixtures. Work on integrated crop-livestock systems based largely on new multipurpose legumes in the savannas has sought to solve problems associated with low soil fertility, pasture degradation, soil compaction and erosion, build-up of pests and weeds, and water contamination. FPR in cassava-based systems in Latin America and Asia has successfully combined the testing of new cassava varieties with soil erosion control and integrated crop and pest management.

Successes have been based on:

- Research commitment to integrating germplasm and NRM research and to form needed multidisciplinary teams.
- Sufficient resources to support long-term germplasm and strategic research.
- Availability of seed or planting materials of new varieties or cultivars identified as potentially appropriate for farmers' systems.
- The natural willingness of farmers to test new varieties.

Making new varieties available is often an incentive to participate in the testing of NRM innovations. Also implicit in the research presented is that successful systems research is focussed and conducted in carefully selected appropriate benchmark or reference sites in targeted agroecosystems. The agroecosystems that CIAT targets are the forest margins, Latin American hillsides, and Latin American savannas. Although research is conducted at levels ranging from farm to agroecosystem, much of the fieldwork is done at the watershed level.

Failures are less clear. CIAT's commitment to integrated germplasm-NRM research (i.e., to systems research) has contributed directly to the shaping of the systems projects described in this volume. The papers show how the NARS partners were conducting systems research in these same projects, but do not indicate if changes of approach from separate research on germplasm/commodity and NRM to integrated research was taking place in NARS as a whole. The implicit, desirable impact for the future would be the NARS' adoption of systems approaches; and the similarly implicit strategy would be to continue and strengthen partnership research and demonstrate the successes of systems research approaches.

***Participatory Research.*** The chapters in the book reveal a range of participatory approaches and show the development such approaches over time. The FPR approaches include:

- Selected farmers individually conduct trials and provide feedback to researchers. Treatments are largely researcher-designed. In the case of the Colombian forest margins, this initial researcher-led FPR led to other farmer-initiated experimentation.

- Individual farmers test researcher-developed innovations (e.g., for soil erosion control). At the same time, researchers in Cauca, Colombia, tried to make the adoption of soil erosion control measures more economically attractive by assisting in the commercialization of new products resulting from adoption. Cassava researchers in Asia supplied innovations more immediately attractive to farmers (new varieties and management options) for testing as a way to generate interest in soil conservation.

- A committee for local agricultural research (CIAL in Spanish) selected by and representing members of a given community, conducts FPR, based on participatory diagnosis. Field days are held to allow wider participation in evaluating results and planning for further research. Work with cassava farmers in Brazil and with small-scale hillside farmers in Colombia demonstrates the effectiveness of this approach.

- Researchers provide new materials and information to farmers, who then individually test and adapt innovations to their particular needs and situations. Forage research in Asia and farmers' independent experiments with green manure and cover crops in Uganda have led to systems-level innovations unforeseen by researchers.

- FPR is extended to innovations in the local institutional structure to further empower local communities and to allow communities to find new, needed ways to interact with each other and with outside agencies. Organizing discussions between upper and lower watershed users in Cauca, Colombia, allowed a change from conflicting resource-use interests to negotiation and working toward mutual benefits. Successful initiation and organizing of small-farmer seed production in Uganda has led to recognizing the need for further institutional change in the seed sector.

The chapters in the book document several types of success in FPR. First, as the above indicates, researchers working with farmers steadily made innovations in the FPR approach itself. They improved methods and, overall, expanded the idea of participation from feedback from farmer-managed trials to the incorporation of farmers in problem diagnosis, selection of research problems, and community-based evaluation of results, leading to local choice in the direction of further experimentation. The encouragement and documentation of farmers' independent experiments based around introduced "unfinished" technology components reflects a growing respect for farmer traditional knowledge, farmers' natural tendency to experiment to solve problems, and the idea that only farmers can adapt innovations to particular local conditions. Finally, participation has started to encompass institutional change and local empowerment.

The second success and impact of FPR has been increased adoption of the approach by partner NARS. The work in Brazil, conducted by a wide range of NARS, began with a great deal of skepticism and ended with NARS changing policy in favor of using FPR in most, if not all, on-farm research. The research networks and consortia functioning in Asia are expressly working to institutionalize FPR and systems approaches throughout the region. Much of the effort to date has been both in the conduct of field projects and in training (of trainers, extension workers, researchers, and, importantly, NARS decision makers). The development of committees for local agricultural research in Colombia has led to both projects and NARS in several countries of Latin America adopting the approach.

Third, the different forms of FPR are clearly effective and efficient in solving agricultural problems in an integrated and locally appropriate fashion; and such effectiveness is starting to have impact through adoption of technologies and the benefits brought about by such adoption. The adaptation and adoption of new crops, varieties, legume-based improved NRM at the local level, pest and crop management practices, and livestock feeding systems are described in the various chapters.

Fourth, FPR appears to lead to greater farmer confidence in their own abilities, first in the conduct of problem-solving research, and later in new organizational and management skills. Recognition and encouragement of farmers' experiments, organized or not, has led to greater farmer-researcher interaction and increases in research efficiency.

The various papers have also identified constraints to effective FPR.

Obviously, in many cases, researchers need to provide sound, appropriate technical alternatives. Examples are cassava varieties that are actually superior to local varieties in Brazil, *Arachis* cultivars suited to poorer soils in the Colombian forest margins, or contour hedgerow species such as broom grass and lemon grass, which can bring real economic benefits. Once alternatives are identified as viable and valuable, planting materials often need to be made available. Lack of cassava planting materials in Asia and lack of legume seed in many projects has slowed the rate of FPR work at a time when farmer enthusiasm was relatively high.

For projects having a predetermined set of technology innovations (e.g., soil erosion control measures, legume cover crops, and green manure), sites and participating farmers must be carefully selected. Those more likely to participate are farmers suffering from, recognizing, and trying to solve the problem to be addressed (i.e., soil erosion or a need for improved nutrient cycling). Real and effective participation does not occur if farmers are not interested in the given problem. As a variation on the need to properly select sites and participants, the work in the Colombian forest margins encountered the interesting case of lack of effective participation because farm managers were not owners; the owners being largely absentee.

NARS and local development or extension workers must have sufficient interest, training, commitment, and resources to work with farmers. They need to make field visits, provide (at times) farmer training, initially help organize local agricultural research groups or support individual experiments, and help farmers with evaluation and further planning. Lack of financial and institutional support can grind FPR projects to a halt.

Projects "tied" to particular commodities and/or management innovations may be unable or unprepared to work with farmers on their more pressing problems and needs. Such a limitation may result in farmers' lack of interest in participating in the project. A solution has been to increase the web and reach of participating institutions. The work in the hillsides of Cauca, Colombia, organized all interested external agencies to coordinate efforts and resources to better address the range of local needs and problems.

Agricultural research appears to be at an intermediate stage in terms of impact. FPR methods are being developed and tested. FPR is being integrated into the work of partner NARS. Farmers in project communities are empowered both to experiment and to deal more effectively with outside agencies. And new technical and organizational innovations are being adopted at project sites. The most important impact, however, is in the future: wider use of FPR beyond project areas, wider adaptation and adoption of technical alternatives developed, and local benefits derived by participating farmers and society as a whole.

The strategy for reaching such impact is to continue projects that lead to strengthening the integration of FPR approaches in NARS; and then, and with more difficulty, to find ways of achieving wider impact with less initial support. That is, the important question remains as to how to achieve wider impact with less initial project support and "hand holding". The move toward devolution of power and responsibilities to local communities in many areas of the world, and as a philosophy of increasing numbers of development and donor agencies, may be the needed step in the right direction.

*New forms of team and partnership research.* Each of the projects described in the book reflects interdisciplinary teamwork and partnerships with NARS, NGOs, and others. Teams ranged from collaborations of agronomists and geographers/GIS specialists to teams comprised of entomologists, plant breeders, pathologists, social scientists, soil scientists, livestock and forage specialists, and agronomists. Projects have ranged from international center collaboration with a major NARS, to partnerships among international centers, various NARS, universities (both local and international), NGOs, and local organizations. CIAT researchers in Asia, Africa, and Latin America have also helped to propose, seek funding for, and develop research networks and consortia intended to work on systems, employ FPR methods, and promote both international center-NARS partnerships and effective partnerships among participating countries. Partnership research reflects the fact that CIAT and its partners have comparative advantages in different complementary areas, and that partnerships are integral to promoting the sustainability of new ways of conducting research by the NARS.

As in the use of systems approaches, the projects described in the book were designed as team and partnership based activities. As such, the papers did not address the lack of such partnerships in other projects. Certainly, however, funding for international agricultural research now supports new and more inclusive partnership relationships. Support has dried up for the lone international center scientist conducting independent research. Support is lessening for bilateral center-NARS agreements, but is increasing for proposals for partnerships among international centers, the various NARS (e.g., ministries and departments of agriculture, forestry, and natural resources rather than only agriculture), NGOs, and local community groups. The story unfolded in the different chapters indicates that progress is being made and that, in terms of strategy, although progress may have initially been rather "donor driven", current steps forward are being taken because of the demonstrated benefits.

Finally, agricultural research appears to have reached mid-stream, but is still heading in the right direction. Germplasm and NRM research will continue to be conducted separately where appropriate (e.g., in generating new breeding lines or in monitoring the effects of current land uses on greenhouse gas emissions or biodiversity). In helping to solve problems where small-scale farmers want increases in production and in systems' sustainability, and where society also has desired outcomes, the integration of germplasm and NRM research is natural, appropriate, even obvious. A crucial future goal of systems research (reaching the far side of the stream) will be to develop effective ways of dealing with trade-off between local or farmer goals for increased productivity and societal goals of maintaining the global environment intact.

Although not addressed in the book, CIAT's work on systems also includes analyses of policies that have i) contributed to current resource use patterns at different scales, affected farmer adoption of different types of innovations, and 2) sought a balance between increased productivity and environmental protection. A goal of such research is to be able to inform policymakers as to the effects of policy on NRM decisions at various levels.

The projects have shown a trend of improvements in FPR approaches. The challenge will be to make the participation of farmers and local communities more self-sufficient and self-sustaining. While local empowerment in its various forms appears to be the model for the future, considerable "political will" is needed to facilitate wide-reaching genuine change. In forming effective teams and partnerships, however, agricultural research seems to be nearing the far side of the stream. New partnerships and new forms of funding are emerging; at first only considered acceptable but now desirable and effective by participating researchers and institutions.

A future volume on this topic will hopefully demonstrate that with few missteps the goals identified here will have been reached and what has already been achieved will have been consolidated and furthered.

**Contributors:** S. Fujisaka and authors.

## *Activity 4.5 Facilitate a policy enabling environment that ensures adoption of appropriate policies and technologies*

### 4.5.1 Institutionalizing a Collaborative Research Approach in Pucallpa through the DEPAM project

**Highlights**

- DEPAM is developing a multi-level approach to institutionalizing collaborative research among institutions in Pucallpa.

**Purpose:** To investigate structures and processes that allow institutionalization of multi-institutional and participatory research approaches among national and international research centers in Pucallpa.

**Rationale:** Diagnoses with researchers involved in DEPAM in Pucallpa have found that institutional policies, structures, and freedom often present a barrier to researchers' abilities to respond flexibly to the needs of farmers and of other institutions. Participatory and multi-institutional research will remain a fringe activity until it is understood and integrated as a valued approach into organizational structures and log-frames.

This section focuses on the support and changes to research management. Output 4.2.1 "Multi-institutional research in the Aguaytia watershed through the DEPAM project, Pucallpa, Peru" focuses on the parallel field-level research activities associated with multi-institutional research and Output 2.1.1 describes that research.

**Methods:** The organization of DEPAM provides a space to test new institutional arrangements for supporting participatory and multi-institutional research, and to investigate the effect of these changes on participating institutions. DEPAM introduces several innovations to research management in Pucallpa:

- A multi-institutional research team designed to coordinate activities.
- A farmer committee to evaluate project proposals and monitor and evaluate ongoing projects
- A multi-institutional advisory committee to oversee scientific rigor of activities.
- Development of a Rural Agroenterprise unit which can help create the market and business links necessary to take advantage of agricultural research
- Learning resources and a supportive learning environment

**Outputs:**

- The DEPAM advisory committee and the farmer committee reviewed 18 project proposals that were submitted following a second call for DEPAM small projects in April 1999.
- Unity and skills in the farmer committee were strengthened by the committee selecting one of its members to attend a course "participatory plant breeding" in Quito, Ecuador.
- There is increased awareness of participatory approaches among researchers and research managers, and managers actively support the involvement of their researchers in the DEPAM participatory research team.

**Impact:** Researchers and research managers are beginning to discuss the effects of the *processes*, and *organization* of research on its record of field-level success. Three of the 11 projects in DEPAM have substantially changed their focus or organization in response to diagnoses with farmers or with participating institutions. The field-level effects of such changes will be measured in the following year. This is an embryonic learning system.

There is increased support for participatory processes by heads of institutions. Three institution heads have asked for their own course on participatory research (currently in planning) and some have wanted to dedicate 7 days to join the course in participatory research for researchers. The courses for researchers and research managers will culminate with a joint day to openly discuss how to integrate multi-institutional and participatory approaches into the institutional framework of organizations in Pucallpa.

The system of competitive research grants for sub-projects has been successful in providing DEPAM with an entry-point with local institutions, and many of the sub-projects show great improvement in their incorporation of participatory research. A key indicator is that the projects themselves are able to report their difficulties with participatory methods, and are analyzing their needs and actively requesting assistance both from each other and from DEPAM.

However, the system of research grants that was used as an incentive to participate has also made some aspects of inter-institutional collaboration difficult. National institutions have had different degrees of success in integrating the "project-focused" structure of DEPAM with their existing "institution-focused" structure. They have their own research agendas, often set up within a national rather than local context and only a limited amount of resources to carry them out. The DEPAM project members have themselves identified remaining challenges in the limited freedom of many Ucayali research institutions from national mandates, and with a historical non-transparent, personal focus to project management. Again it has been questioned whether research grants should be open to any agenda or only to specifc demand-led agendas.

The Farmers Committee has been effective in setting strategic directions for DEPAM, and in advising in the selection of research projects. However, they represent a large area, and have few links with the farmers who are involved in the DEPAM research projects, agreeing that they cannot adequately represent these farmers. DEPAM is looking for mechanisms to strengthen the committee, possibly by inclusion of farmer representatives from all DEPAM projects, and supporting their role to evaluate the content and processes of the projects.

**Contributors:** Dean Holland, Sam Fujisaka, Peter Kerridge, Douglas White, Glenn Hyman, Scott Cechi, Carlos Bruzone, Carlos Ostertag, Mark Lundy, Ann Braun, Maria Fernandez in CIAT projects PE-5, PE-4, IP-1, SN-1, SN-3, and the Inter-Center Participatory Research and Gender Analysis Program.

## *Activity 4.6 Develop training approaches and materials on targeting, development and diffusion of new technologies and provide training for partners*

### 4.6.1 Approaches to targeting and developing new forage technologies

**Highlights**

- Effective participatory approaches have been implemented and adapted in four Southeast Asian countries. 170 national partners have been trained in these approaches since July 1998.

**Purpose:** To improve the effectiveness of adaptation and adoption of forage technologies by smallholder farmers in Southeast Asia

**Rationale:** Until recently, the approaches used for developing agricultural technologies on smallholder farms were too prescriptive. The role of research organizations was seen to be to provide technology packages to an extension service, which then delivered them to 'model' farmers with an expectation that the technology would spread to other farmers. Most of this process was controlled or driven by researchers and policy makers with little or no input from farmers. The technologies delivered in this manner were often not appropriate for many of the smallholder farmers and adoption was poor. Improving the adaptation and adoption of agricultural technologies on smallholder farms required a change in approach to involve farmers more actively in the process of technology development.

**Outputs:** The Participatory Technology Development (PTD) approach used by the Forages for Smallholders Project (FSP) in Southeast Asia has been synthesized from similar approaches developed by CIAT. The approach uses many of the principles of Participatory Rural Appraisal, but extends the involvement of farmers well beyond the initial stage of appraisal through to forage technology development and evaluation on farms (**Figure 1**).

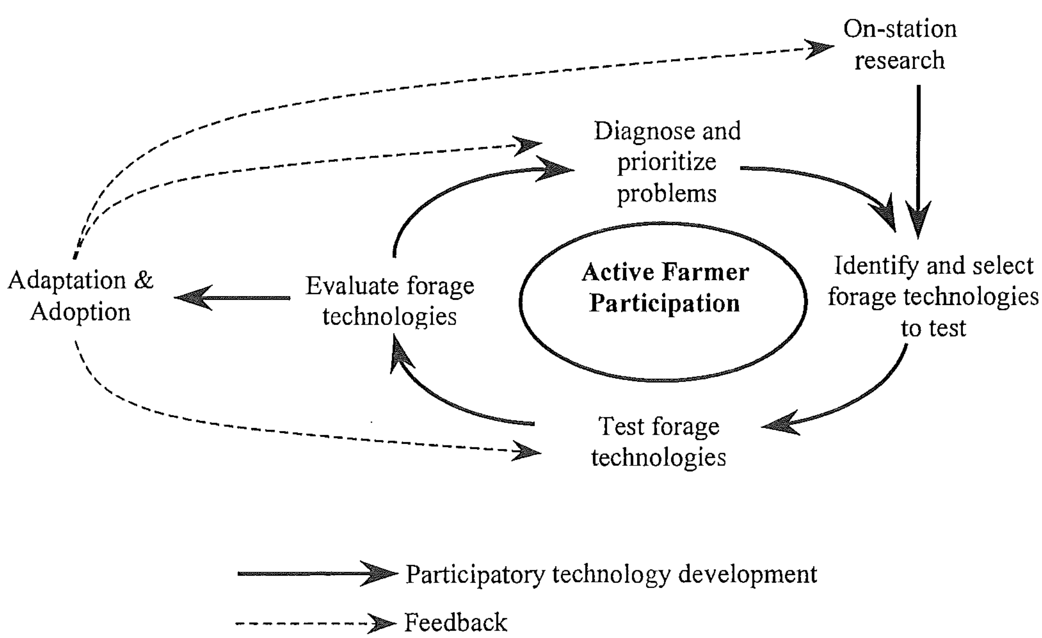


**Figure 1. The key stages of Participatory Technology Development used by the FSP.**

PTD begins with diagnosis of livestock-related problems by the farming community, in partnership with field workers from the FSP. Commonly, a problem tree is developed and discussed to help the community define, group and prioritize their main problems. Potential solutions to these problems are then discussed and plans made about how to test and evaluate promising forage technologies. As farmers experiment with these, their experiences are monitored and assessed so that changes can be made to the technologies being evaluated as necessary.

The key principle of this process is active, decision-making involvement of farmers at all stages of forage technology development, with technical input and facilitation by government staff. Other important factors that have contributed to successful implementation in the field are:

*(i) Careful selection of sites and farmers*
A small quantity of seed distributed to farmers with a genuine need for forages will be far more successful than large quantities distributed where there is no need. The FSP has developed criteria for site and farmer selection to identify sites and farmers with the greatest potential to benefit from forages.

*(ii) Active local partners*
To work actively with farmers requires considerable commitment from local development workers. A promising site with enthusiastic farmers can fail if the local development worker is not supportive.

*(iii) Regular visits to farmers*
Visiting farmers regularly and providing informal training during the early stages of PTD is crucial. Working with a small number of enthusiastic farmers whom you can support is usually more successful than working with many farmers with little contact.

*(iv) Close collaboration with 'farmer advocates'*
Some farmers are especially active in experimenting with and championing locally-successful forage technologies. Identifying these 'farmer advocates' and encouraging them in the process of forage development can result in rapid adoption and spread of forage technologies.

(v) *Linking with national partners and other development agencies*
Working in partnership with national government and non-government organizations has been essential to achieve sustainable technology development.

*(vi). On-going development of participatory skills*
Training courses sensitize development workers to the 'tools' of PTD but the essential skills of communicating with farmers can only be gained with time and field experience. Partners in the FSP from all countries have regularly met to share skills, experiences and ideas.

PTD is a learning process for all involved. Locally-successful technologies are a result of this process and cannot be easily transferred to other areas without the new farmers also going through a process of evaluating and adapting them. The challenge now is to develop methods of expanding locally-successful forage technologies to wider areas but within a participatory framework.

**Impact:** The new participatory approach has been implemented at 18 sites in four Southeast Asian countries (Indonesia, Laos, Philippines and Vietnam). Since July 1998, 10 training courses have helped 170 national partners upgrade their skills in participatory technology development with forages using the training manual "Developing forage technologies with farmers" developed by the FSP.

Regional interest in the experiences of the FSP with PTD has resulted in a grant from ACIAR to produce three new books for publication in five languages:

- Developing forages with smallholder farmers – how to select the best varieties to offer farmers
- Developing forages with smallholder farmers – how to grow, manage and use forages
- Developing agricultural solutions with smallholder farmers – participatory approaches for getting it right the first time

These books are in preparation and will be published over the next 12 months.

**Contributors:** Werner Stür, Francisco Gabunada and Louie Orencia (CIAT, FSP Philippines); Peter Horne and Phonepaseuth Phengsavanh (CSIRO, FSP Laos); Viengsavanh Phimphachanhvongsod (NAFRI, Laos); Maimunah Tuhulele (DGLS, Indonesia); Ibrahim (Livestock Service, East Kalimantan, Indonesia); Tatang Ibrahim (BPTP, North Sumatra, Indonesia); Ed Magboo (PCARRD, Philippines); Willie Nacalaban (LGU, Malitbog, Philippines); Perla Asis, LGU, Cagayan de Oro, Philippines); Le Hoa Binh (NIAH, Vietnam), Le Van An (UAF, Hue, Vietnam), Bui Xuan An (UAF, Ho Chi Minh City, Vietnam), Bryan Hacker (CSIRO Tropical Agriculture, Brisbane, Australia), Peter Kerridge (CIAT, Cali, Colombia).

### 4.6.2 Training provided on use of economic model in Peru

**Highlights**

- The second multi-institution workshop provided feedback on model operation and its parameters.

**Purpose:** To facilitate more interaction amongst Pucallpa-region economists, agronomists and extensionists via a farming system model.

**Rationale:** Slash-and-burn farming practices are heterogeneous and complex land use systems. Farmers produce a mix of animals, agriculture crops, tree and forest products. Furthermore crops are annual, semi-perennial or perennial in monocultures or multiple crop associations. These many facets of farming systems provides a challenging environment in which to research the implications of agronomic and policy research.

**Outputs:** After the development of the initial agro-economic model two further steps are necessary, refining of the model with potential users, and training of its use among different local institutions. During a second workshop the model received comments about its potential use of the tool, the type of technologies that national institutions want to include and ideas on how to make it more user-friendly. Another workshop is being organized to test the addition of different agriculture technology alternatives developed by institutions and to refine parameters used the model parameter according to farmers and researcher experiences.

**Impact:** The next workshop will present a deeper explanation of the model and its underlying assumptions. It will also include instruction on how organize data before it can be incorporation into the model. A sensitivity analyses will include opportunities for participants to build real-world scenarios and to adjust key parameters based upon their own experiences.

The model has have received keen interest from within the Ministry of Agriculture and will be employed by extensionists who are in close contact with farmers. In this manner, the potential impact of agronomic advances can be discerned before they are incorporated in farmer fields.

***Contributors*** Douglas White, Ricardo Labarta, SN-1, INIA, MinAg-Ucayali, DEPAM, ICRAF

### 4.6.3 Farmer-experimentation mini-kits as a tool for promotion of legume technology

**Highlights**

- Mini-kits were distributed to farmers to enable learning experiences about alternative green manure and cover crops.

**Purpose:** To devise a means of efficiently adapting cover crop (CC) technology to the diverse circumstances of large numbers of farmers, and enabling farmer-to-farmer dissemination at low cost.

**Rationale:** Cover crop technology is difficult to promote because: benefits only appear over time; adjustments of cropping systems are generally needed; technical options are environment specific and identification of appropriate niches takes time; farmers have little understanding of the potential of cover crops in soil management; and the extension services generally lack the capacity to promote such technology.

**Methods:** For the 1999A season, 2000 kits were prepared in collaboration with the IDEA project for distribution to farmers in six districts of Uganda. Another 1000 kits were prepared for the second season of 1999 and distributed through various NGOs for use in eight districts. The kits contained seed of canavalia, mucuna and sometimes tephrosia and/or climbing beans. They also contained leaflets on canavalia, mucuna, tephrosia for mole rat control, a listing of best bet options for mid-altitude areas of Uganda, and a decision guide to the use of four legume species.

**Outcome:** The effectiveness of the approach has not yet been evaluated.

**Impact:** More capable farmers, with an inclination to innovation, will have successful learning experiences through these kits and will be able to integrate appropriate legumes into their systems. Eventually, we expect more farmers to learn from their neighbors.

**Collaborators:** Charles Wortmann and Mark Wood, IDEA (Investment for the Development of Export Agriculture)

## *Activity 4.7 Communicate results through networks, workshops and journals*

### 4.7.1 Communication activities of the Forage for Smallholders Project

**Outputs:**

*Newsletter.* SEAFRAD, the Southeast Asian Forages and Feed Resources Research and Development Network is a network of researchers and development workers who are working with forages. The secretariat of SEAFRAD and editorship of the SEAFRAD newsletter rotate between member countries on an annual basis. In 1998, it was based in the Directorate General of Livestock Services, Indonesia. In 1999, it moved to the National Institute of Animal Husbandry, Vietnam. Each year, two issues of the SEAFRAD newsletter are produced and distributed. SEAFRAD has been sponsored by the Forages for Smallholders Project from 1995-1999. This sponsorship will be continued by ADB from 2000-2003.

*Books:* In 1998/99, the Forages for Smallholders Project published an Indonesian and Vietnamese versions of the 'Field experiments with forages and crops: practical tips for getting it right the first time' manual by Cheng, Y. and Horne, P.

*Workshops:* The progress of forage technology development in the Philippines and Indonesia was reviewed at workshops held in January and April 1999. This workshop brought together researchers and development workers involved in participatory forage technology development, reviewing progress, sharing experiences and planning activities at FSP sites.

In Lao PDR, a Workshop "Developing forage technologies with farmers: putting plans into action in northern Lao PDR" was held in Luang Phabang on 15 and 16 July 1999, which communicated the results of the FSP to a wide audience. The Workshop was attended by 64 participants from the National Agriculture and Forestry Research Institute (NAFRI), Provincial Agriculture and Livestock Offices, District Agriculture Offices, Government-funded rural development programs, Lao Womens Union, Department of Livestock and Fisheries, and foreign-funded projects.

**Contributors:** Werner Stür (CIAT, FSP Philippines) and Peter Horne (CSIRO, FSP Laos).

### 4.7.2 Communication of results within the Asian Cassava Research Network

**Outputs:**

- During 1999 the papers presented at the International Symposium on Cassava, Starch and Starch Derivatives, held in Nanning, Guangxi, China, in Nov 1996, were edited and published as Workshop Proceedings. These will be widely distributed to libraries, researchers and the private sector involved in starch processing.

- A chapter entitled "Cassava Nutrition and Fertilization" was written as part of a book on cassava to be published by CABI.

- A desk study on "the Effect of Small-scale Cassava Production and Processing on the Environment" commissioned by IFAD in Rome, was coordinated by CIAT and written in collaboration with CIP, IITA, NRI and CIRAD. This will be published and presented at the Global Cassava Forum, to be held in late 1999 or early 2000.

**Contributor:** R. Howeler (CIAT)

### 4.7. 3 Tropileche - Dissemination of research results

**Highlights**

- The database developed on the web with research results on dual-purpose cattle offers researchers a new tool to access information
- The production of a videotape about a small producer who adopted new feeding strategies is a practical way to show producers and extension agents how small farmers can succeed in intensifying production

**Outputs:**

*Tropileche Newsletter*

The Consortium has published six newsletters and the seventh is in print. Publication dates are March and October. The objective of this newsletter is to inform about the activities of the Consortium, on-going research trials, research results being produced at the different benchmark sites, and any other news our partners consider useful to inform. These newsletters can be obtained free of charge through the Tropileche HomePage on the Internet (http:/www.ciat.cgiar.org/tropileche/start.htm).

**Contributors:** F. Holmann, CIAT-ILRI, Colombia, and national institutions in Peru, Costa Rica, Nicaragua, and Honduras

***Data base on research results from dual-purpose cattle***

In 1996 Tropileche developed a database of research results on dual-purpose cattle systems in tropical Latin America from the year 1960. Themes include nutrition and feeding, forages (grasses and legumes), genetic improvement and reproduction, animal health, economics, and extension, transfer, and adoption of technology. This is maintained.

At present there are more than 2,200 references and approximately 100 items are added each month. All references include basic descriptors and 70% of them also include an abstract. This database was developed in micro CD/ISIS and follows the normative of the information system AGRIS-CARIS from FAO. This database is available through the Tropileche HomePage on the Internet (http:/www.ciat.cgiar.org/tropileche/start.htm).The average number of users consulting the database during the last year was 4.3 per day.

**Contributors:** A. Medina and F. Holmann, CIAT-ILRI, Colombia

***Tropileche on Internet***

The Tropileche Consortium has developed its own HomePage on the Web, which contains the newsletters that have been produced as well as the data base containing research results generated in tropical Latin America. This HomePage can be accessed through the CIAT HomePage (http:/www.ciat.cgiar.org/tropileche/start.htm).

In addition, this HomePage has a list of researchers with affinities in research on dual purpose cattle in LAC, with contact addresses. Researchers can access the database from anywhere in the world, request information, and communicate and interact with other colleagues.

**Contributors:** F. Holmann and A. Medina, CIAT-ILRI, Colombia

**Videotape Production**

Tropileche in collaboration with the Department of Communications of the Ministry of Agriculture of Costa Rica developed and produced a 11-min videotape. This is a case study of evolution of the feeding system on a dual-purpose farm located in the dry tropics of the Central Pacific region of Costa Rica. This will be made available to extension workers and loaned to farmers and others on request.

Antonio Lopez is a small producer who has adopted many of the technologies that the Tropileche consortium has developed in association with the Ministry of Agriculture. Antonio is currently producing more milk on less area, has doubled his family income, and has released areas from the livestock enterprise to serve as protected areas for timber production and protection of water sources.

This videotape will be used to show other producers in Costa Rica and Latin America how one small farmer succeeded in intensifying production with new forage-based technologies that were developed by him with the technical assistance of MAG and Tropileche and a donation of seed for evaluation.

**Contributors:** F. Holmann, C.E. Lascano, P.J. Argel, and R. Goyenaga, CIAT, and MAG, Colombia, Costa Rica. Dean Holland, Sam Fujisaka, Peter Kerridge, Douglas White, Glenn Hyman, Scott Cechi, Carlos Bruzone, Carlos Ostertag, Mark Lundy, Ann Braun, Maria Fernandez

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See list in following section.

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## Videotapes

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