Final Technical Report

Sustainable Agriculture in Forest Margins (R6382)

NRSP Forest Agriculture Interface

Executive Summary

The project "Sustainable Agriculture in Forest Margins" started in April 1995, and finished in March 1999. Total budget was 0393,032. Management of the project was by NRI. The purpose of the project was *to develop and promote improved management strategies for the integration of crop, livestock and agroforestry systems* for resource-poor farmers living at the margins of tropical moist forests.

Declining soil fertility, increasing weed infestations and a lack of income-generating opportunities are serious constraints to the establishment of sustainable cropping systems and livelihoods in the forest margins of Bolivia. Assistance was provided to CIAT (Bolivia) to address these issues in a research programme which was jointly supported through the RNRRS CPP (Project R6008) and NRSP (this project). The project worked as a multidisciplinary team to develop and validate technologies to combat these constraints, and to develop and document participatory research methods.

The joint project was successful in identifying and validating systems which allow fanners to progress from unsustainable migratory slash and bum agriculture to more sustainable and stable farming systems. Sustainability was addressed through a number of principles including: (a) an increased cropping period for annual crops; (b) increased opportunities for perennial crops; (c) the development of sequences towards perennial systems; (d) improved weed control (and reduced labour for weeding); (e) integration of legume covers/green manures, and (f) economic sustainability through diversification. The research methodology was one of participatory on-farm research supplemented by researcher-managed, formal trials. Participatory research methods used and documented included on-farm trials, fanner-led technology evaluation workshops, field days, case studies and surveys.

Main outputs were: a) Validation of the viability and adaptation of fanning systems that include perennial species novel to smallholder farmers (citrus, pineapple, macadamia, bananas and palm hearts *(Bactris gasipaes));* b) Improved understanding of opportunities to combat the soil fertility and weed constraints of upland rice following bush fallow clearance; c) Identification of the potential contribution of different cover crop species to annual and perennial cropping systems: d) Preliminary confirmation of the potential for enrichment of bush fallow to achieve productive agroforestry systems, and successful testing of the concept of sequential and relay cropping towards stable agroforestry plantation from cleared land; e) field testing and adaptation of a range of participatory research methods, that were then analysed and carefully documented.

The project's target beneficiaries were resource-poor fanning families at the forest margin. The project worked with this group. through local research and development institutions. By this means poverty and natural resource sustainability were directly addressed; at the same time institutional capacity to conduct and disseminate relevant research was strengthened.

Background

Agricultural production which is dependent on the clearing of forested land is common to many countries of the humid tropics. Slash and burn agriculture, as practised by indigenous forest dwellers, can be ecologically sensitive, sophisticated and sustainable (Posey, 1985). In contrast, the slash and burn methods used by colonist farmers in Brazil and Bolivia are unsustainable and destructive and have resulted in the degradation of soil, forest and biodiversity resources over large areas. The process has serious long-term economic and environmental implications.

Smallholder colonist farmers in Santa Cruz, Bolivia, are recognised to be among the core poverty groups of the country. They often have relatively abundant land (30-50 ha) but extremely limited capital and labour, and an immediate requirement for food and cash. This leads to the adoption of extensive farming methods that are wasteful of natural resources, but require low inputs of labour and cash. The situation is complex and dynamic (Richards, 1997) and farming households may opt for different routes through the capitalisation/stabilisation process depending on factors such as soil, climate, road access, access to support services, ethnic origin. community cohesion, etc. (Wachholtz, 1996).

Inequitable land distribution and various directed and spontaneous colonisations have placed increasing pressure on the forest resources in the Sara-Ichilo provinces (Mariaca and Torres 1996) notably on the margins of the Amboro National Park (PNA). The PNA and surrounding 'buffer zone' have been cited as one of the leading megadiverse areas within Latin America (Pacheo 1998). A major DFID project (Amboro Development Project) is currently active in the PNA, and in particular the buffer zone, working in collaboration with CARE and local NGOs to develop sustainable livelihoods in the area.

The slash and bum system practised by these colonist farmers is not sustainable (Maxwell and Pozo, 1981). When farmers have exhausted all virgin forest on their land they begin to cultivate dryland rice in the bush-fallow (barbecho). Once they are cultivating in bush-fallow, increasing weed populations and declining yields result in an ever-shortening fallow period until a time is reached when it is no longer worthwhile for the farmer to continue. This is referred to as the `"bush-fallow crisis". At this point, the farmer is forced to acquire new land, or change the fanning system.

While weeds play a major part in land abandonment (Webb & Gonzales. 1989), in the longer term soil factors are also important (Barber & Diaz, 1994). The soils are inherently low in available phosphorus, and nitrogen is quickly lost through leaching and volatilisation. Nitrogen, sulphur and organic matter are lost through burning. and micro-nutrients can soon become limiting under acid conditions with poor organic matter buffering. On sloping lands, soil erosion is also a serious problem.

Rice is the principal food and cash crop of the colonist farmers, and a further factor limiting sustainability is the lack of locally validated agricultural income generating opportunities that justify investment in the land.

During the 1980s, escape from the bush-fallow crisis was a major focus of applied research by the DFID supported British Tropical Agricultural Mission (BTAM) (Wilkins, 1988). CIAT continued with the theme and their strategic plan for 1990-95, defined as a main priority "the development of sustainable agricultural production systems which permit the definitive establishment of farmers on their land" (CIAT, 1989).

The process of extension and research in Santa Cruz was transformed in 1991 under the World Bank supported Eastern Lowlands Project. CIAT (as the main provider of research) worked closely with local (government) development corporations who, alongside CIAT, were responsible for technology

transfer. PROD1SA, the development corporation for the provinces of Ichilo and Sara, was initiated in 1992 with financial and technical support from IP/GTZ.

PRODISA-lP/GTZ conducted an appraisal of agricultural problems in the area, on which they based a Regional Development Plan (Muzilli, 1992). This plan recommended a programme of participatory research to address the problems faced by small to medium-sized farms and focused on the development of sustainable systems. Various alternative crops and systems were suggested for testing and validation. In 1993, 40 on-farm technology validation plots were established and a methodology for plot establishment and data collection was outlined by Muzilli (1992). The selection and distribution of crops and systems took account of the Santa Cruz Development Corporation and IP-GTZ "Strategic Plan for the Use of Soils" (CORDECRUZ, 1994).

In 1994, a concept note was prepared by NRI to address weed problems and the development of sustainable cropping systems for slash and bum farmers in Bolivia. This was discussed with CIATBTAM and CORDECRUZ-PRODISA who modified the project to meet their priority objectives. The proposal was funded from February 1994 - April 1995 under the ODA's Renewable Natural Resources Department **(NRD)** Adaptive Research Initiative (ARI). The project was managed by NRI and supported jointly through the Applied Ecology Division. Weed Science Profile (R6008CB) and the Agronomy and Cropping Systems Programme (R6165CB). From September 1994, this CIAT-NRI project ("Sustainable Agriculture in Forest Margins: Ichilo-Sara Adaptive Research Project") took responsibility for the PRODISA validation plot programme, though PRODISA-lP/GTZ continued to provide financial support.

During 1994, the project held a planning workshop which was attended by CIAT, PRODISA, and many NGOs active in agricultural research and extension in the area. A result of this workshop was the establishment of the GO and NGO "Ichilo-Sara Adaptive Research Network". In addition, the number of on-farm technology validation plots was extended to include more alternatives for farmers and a wider range of zones and interest groups. On the insistence of CIAT, the basic methodology proscribed by Muzilli (1992), was retained. Funding for the work continued under the re-organised DFID Renewable Natural Resources Research Strategy (RNRRS) from April 1995 - March 1999.

The project addressed three main developmental problems: (i) the destruction of moist, tropical forest by expansion of the agricultural frontier (ii) the degradation of natural resources (principally soil and biodiversity) through unsuitable agricultural practices and (iii) the lack of locally verified, sustainable agricultural systems for smallholder farmers in the forest margins. The project was based in the Department of Santa Cruz in the provinces of Chile and Sara, a zone which includes the Chore Forest Reserve and the margins of the Amber National Park, both areas of exceptionally high biodiversity and under threat from migrant agriculture.

The central aim of the research was to generate and validate cropping systems which maintain or enhance soil fertility, suppress weeds and diversify farm incomes. There were three principal technical research objectives: (a) to evaluate the performance of novel crops and systems under local conditions according to these criteria (b) to monitor their adoption and to study how farmers manage and modify the systems according to their own conditions, needs and experiences and (c) to adopt and adapt farmer participatory research methodologies within the local research environment.

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Project Purpose

The project purpose was: *Improved management strategies for the integration of crop, livestock, agroforestry systems developed and promoted*

Declining soil fertility, increasing weed infestations and a lack of income generating opportunities are serious constraints to the establishment of sustainable cropping systems and livelihoods in the forest margins of Bolivia. In partnership with CIAT (Bolivia) and the Crop Protection Programme project R6008, the project developed and validated technologies that combat these constraints, and developed and documented participatory research methodologies.

The NRSP-CPP-CIAT project aimed to identify and validate systems which would allow farmers to progress from unsustainable migratory slash and bum agriculture to sustainable and stable farming systems. Sustainability was addressed through a number of principles including: (a) an increased cropping period for annual crops (b) increased opportunities for perennial crops (c) the development of sequences towards perennial systems (d) improved weed control (and reduced labour for weeding) (e) integration of legume covers/green manures and (f) economic sustainability through diversification. The research methodology was one of participatory on-farm research supplemented by researcher-managed, formal trials.

Research Activities

A detailed description of the project methods is contained in Annex One, which is the main technical report of the joint CIATINRSP/CPP project, and in a thorough analysis of participatory research methods used (Carreno *et al,* 1999).

The planning stage of the project included literature reviews, institutional diagnosis and planning workshops with farmers and research and development institutions. An "adaptive research network" resulted from the latter, which was instrumental in the implementation and evaluation of the on-farm trial programme. The project conducted over 200 participatory on-farm trials. testing over 30 novel cropping and agroforestry systems. These were complemented by a series of researcher-managed trials for problems that required controlled conditions, or for new technologies that were of unproven adaptation to local conditions.

Field days, cross-visits and farmer-led workshops were used in the joint researcher/NGO/farmer evaluation of the technologies and systems under test. Both quantitative and qualitative information was used to assess the

relevance, economic viability and performance of technologies and systems under farmer's conditions. Detailed case studies of farmer's opinions of the relevance of the project outputs to their livelihoods were carried out towards the end of the project. as was a large survey of 110 collaborating farmers. The latter collected information through semi-structured interviews on farmer management of the on-farm trials, and on adoption and adaptation of project technologies

Planned inputs of consultancies in fanning systems, agroforestry and socio-economics were fully used. In addition, the project was able to commission additional consultancies in biometrics and data management, and studies of adoption and economic viability. This was due to efficiencies derived from joint project implementation with the CPP, and the use of APOs and graduate/postgraduate students.

Outputs

A detailed account of the research activities of the project and their results is contained in Annex One. , which is the main technical report of the joint CIAT/NRSP/CPP project. Briefly, the results of the project against agreed outputs (as defined by the mid-term review in June 1996) were as follows:

Output 1: The NRSP-CPP-CIAT project validated the suitability of perennial species for the project area (including citrus, palm hearts *(Bactris gasipaes),* macadamia, bananas) and identified viable cropping systems and sequences. The association of perennials with annuals, semi-perennials and legume covers proved how it is possible for small-scale farmers, with very limited financial capital, to diversify into perennial systems. The annuals and semi-perennials offset establishment costs and provide a source of income in the short and medium term. The legume covers prevent weed build-up and reduce labour requirements for weeding, both during establishment (in association with annuals and semi-perennials) and in mature plantations. Suitable legume species and management were identified for both phases. The association of citrus with pineapple, annual crops and legume covers proved the most popular. In a survey of collaborating farmers at the end of the project, 54% of those testing citrus had already adopted and expanded these systems on their farms, and most were not (as previously) planting monocrops, but had adopted the principle of cropping systems.

A combination of on-farm and formal trials studied improved systems for the cultivation of upland rice. Research tested systems of intercropping and rotating rice with legume crops and covers. The aim was to identify suitable legume species and management practices with a view to reducing weed build-up and extending the cropping period (the main constraints in traditional systems). In *a rice-Calopogonium mucunoides* intercropping system, the optimum sowing date and density of the legume was identified. Over three years, the *Calopogonium* was very successful in reducing weed build-up in comparison with traditional systems, but did not have a marked influence on soil parameters. While the system greatly reduced weed build-up and hence the cost of weed control, it did not prevent a decline in yield over time. Adoption of this system is most likely to occur where there is little available quality land in bush fallow. Trials to investigate rice rotations with legumes (in winter) identified *Canavalia ensiformis, Crotalaria juncea, Cajanus cajan* and *Mueuna spp.* as the most efficient in suppressing weeds. By 1998, at least one farmer had successfully adopted a rice-mucuna rotation (in citrus alleys) which had extended the cropping period for rice and provided additional income from the sale of mucuna seed.

Output 2: Two novel agroforestry systems were tested with 20 farmers. Although there is a need to continue monitoring these trials, results after two years indicate that the agroforestry systems under test' arc appropriate to those farmers with a positive attitude towards trees, and an appreciation of the income-generating potential and other (environmental) benefits. They are appropriate for buffer zones of

One of the systems enriches existing bush fallow with native fruit and timber species. leading to a conversion (without burning) to a productive and income-generating system. The second system starts with cleared land and takes it through a sequence of annual. semi-perennial and perennial species to a permanent and productive tree-rich system.

National Parks and forest reserves, and other areas designated as mainly suitable for agroforestry. The native fruits grow well within the bush fallow, but are slow to produce fruit. There is a role for research to select provenances that are quick bearers, and methods such as grafting that might speed fruiting. One of the timber species tested grows fast, but mahogany is a slow grower. All are long-term crops, and it is important to include short and medium-term income sources in the farming system. The establishing trees have to be protected from cattle. Adoption is limited by an underlying attitude that trees are not a valuable resource. Markets are often inaccessible and small, and arc poorly understood by farmers. Seedlings are often unavailable, and technical assistance for agroforestry has been weak. CIAT should continue to monitor the performance of the agroforestry plots, in collaboration with fanners.

Output 3: Participatory methodologies were successfully used and developed by the NRSP-CPP-CIAT project. It is now an accepted methodology in OAT (who previously had little experience outside on-station, researcher managed trials) as well as other target institutes. Significant advances were made (and documented) in developing FPR methodologies, particularly in terms of data management, analysis and interpretation.

Capacity building was not an envisaged output of the project. However, the project has resulted in significant capacity building for CIAT staff, NGO staff, University students and farmers. In many ways achieving the project outputs depended on the training of project staff. Involving students and APOs in the project allowed the project to achieve more than it would have been able to otherwise. An indicator of the increased capacity of CIAT is the fact that CIAT staff are now contracted by projects such as the Amboro Rural Development Project and the Pilon Lajas Agroforestry Project to give training in sustainable agriculture, participatory research and technical alternatives to slash and burn. Capacity building in CIAT has, however, been eroded of late by down-sizing, and a disproportionate loss of personnel within the Ichilo-Sara provinces.

Results tables and graphs are presented in the technical Annex.

Contribution of Outputs

Contribution towards DFID developmental goals

By working as part of a multidisciplinary team, this project was successful in achieving its outputs. In the first year, an Adaptive Research Network was created and participatory research methodologies were, to a large extent. institutionalised into the main collaborating institutions. Results of research were promoted through workshops with farmers and intermediate users (GOs and NGOs), and through a series of extension bulletins. manuals and videos.

The research successfully developed and promoted crop and agroforestry systems and management practices that enhance stability and sustainability in forest margin agriculture in Bolivia. The impact of the project was greatly increased by operating as part of a larger research effort which addressed three technical issues (soil fertility, weed management and income-generation) simultaneously.

The slash-and-burn colonist farmers targeted by the project are recognised to be among the core poverty groups in Bolivia. In recognition of the lack of financial capital, most cropping systems tested by the project had a low requirement for external inputs. Higher-capital systems were made more accessible by using crop sequences that provide income in the short and medium term. The project also put considerable effort into improved rice systems, and the integration of rice into perennial systems, in recognition of its critical importance as a cash and subsistence crop for the poorest farming families.

Promotion pathways to target institutions and beneficiaries.

Target beneficiaries were resource-poor farming families living at the forest margin. Target institutions included the main project partner, CIAT Bolivia, and the NGOs comprising the Adaptive Research Network initiated by the project. Through working closely with these institutions, staff training and generating a large diversity of dissemination materials there has been good uptake of concepts, methods, systems and technologies by these collaborating institutions. In addition the project has also influenced other projects and programmes, such as the DFID-supported Amboro Development project and the Pilon Lajas Agroforestry project, the Belgian Aid Credit and Extension project and the GTZ-supported Masrena Sustainable Agriculture project.

Required follow-up

Discussions held in final (CPP-NRSP-CIAT) project workshops demonstrated the concern of farmers and secondary stakeholders with the need to continue the process initiated by the project in terms of (a) continued research into sustainable agriculture (b) dissemination of project results (c) follow-on studies of specific topics and (d) an improvement in the "enabling environment" to facilitate adoption, including the availability of seed, local processing, marketing and credit. A Belgian funded project soon to be initiated in the area will directly address some of these issues, in particular credit for smallholder farmers for perennial crops and the commercialisation of products. It is also likely to take-over from the project as co-ordinator of the Adaptive Research Network. Farmers, NGOs and the managers of the Belgian project emphasise the critical importance of a continued research input, but there is some concern that institutional difficulties within CIAT may weaken its participation in the process.

A 6-month study supported through the **NRSP** F/AI was planned for April 1999 to look at the poverty focus of outputs from the NRSP-CPP-CIAT project. The study has been delayed by DFID and there is concern that this may lead to a discontinuity in the research.

The NRSP-CPP -CIAT project has produced and distributed a wide range of dissemination materials, for local and wider use (see list below). Many of the experiences and results are of interest and application outside Bolivia but, given the complexity of the project and large amount of material generated, it has not been possible to adequately address the wider dissemination of outputs within the project time frame and budget. Additional publications need to be produced for this purpose, particularly in the form of journal articles and a "glossy" for a wide audience.

Barry Pound
Farming Systems specialist. NRI

Dissemination outputs produced by the project (as joint outputs with CIAT and CPP project R6008)

Videos

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