The use of vegetation for better land husbandry

Project ZF0019/R6292CB

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Photograph **Live barrier/cover crop trial site, Choluteca, Honduras**

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ACRONYMS

CATIE	*Centro Agronómico Tropical de Investigación y Enseñanza*
CIAT	*Centro Internacional de Agricultura Tropical*
CIDICCO	*Centro Internacional de Información Sobre Cultivos de Cobertura*
CIFAD	Cornell Institute for Food, Agriculture and Development
COHDEFOR	*Corporación Hondureña de Desarrollo Forestal*
CONSEFORH	*Proyecto de Conservación y Silvicultura de Especies Forestales de Honduras*
COSECHA	*Asociación de Consejeros para una Agricultura Sostenible, Ecológica y Humana*
COSUDE	*Cooperación Suiza al Desarollo*
EAP	*Escuela Agrícola Panamericana*
FAO	Food and Agriculture Organisation of the United Nations
GTZ	*Deutsche Gesellschaft für Technische Zusammenarbeit*
IFPRI	International Food Policy Research Institute
IICA	*Instituto Interamericano de Coorperación para la Agricultura*
LUPE	Land Use Enhancement and Productivity Project
LQI	Land Quality Indicator
MARGOAS	*Programa de Desarollo, Marcala y Goascorán*
NGO	Non-governmental organisation
NRI	Natural Resources Institute
PASOLAC	*Programa para la agricultura sostenible en laderas en America Central*
SQFK	Soil quality field kit
SQS	Soil quality scorecard
SRI	Silsoe Research Institute
SRN	*Secretaría de Recursos Naturales*
SWC	Soil and water conservation
USAID	United States Agency for International

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1. EXECUTIVE SUMMARY

1.1 Project Purpose

The purpose of the project was:

Knowledge of crop-tree interaction in below and above ground environment *<u>improved</u>* *and* *<u>incorporated</u>* *into management strategies*

Rural people ultimately decide how their land will be managed and recommendations for change must be perceived to be beneficial, often in the short-term, by the supposed beneficiaries. Improved knowledge of crop-tree interactions may not be incorporated into management strategies if this knowledge, and the way it is promoted, does not complement the socio-economic and bio-physical factors that determine farmers' management decisions.

1.2 Research activities

- Establishment of a live barrier/cover crop trial in southern Honduras.
- Quantitative and qualitative study of adoption and adaptation of live barriers.
- Quantitative and qualitative study of farmer innovation of soil and water conservation (SWC) technologies.
- Qualitative study of farmers' needs and perceptions of land degradation.

1.3 Outputs of the project

The project was directed at smallholder hillside farmers in Honduras who are growing maize, beans and some vegetables.

Research results

- After two rainy seasons, there were no significant differences, in soil erosion control, between live barrier treatments and control plots with no live barriers. In the short-term, live barriers of tree, shrub and grass species may not be effective in reducing soil loss.
- The trial site showed the importance of soil cover in reducing rainfall intensity (vertical component in the erosion process) and subsequent soil erosion.
- Farmers often select species for use in live barriers as much for the productive function of the barriers in terms of fruit and fodder production as for the barrier's ability to control soil erosion.
- In terms of tree planting, farmers tend to show a preference for fruit trees either in live barriers or more commonly planted close to the home. There is little demand for planting tree species traditionally favoured by foresters.
- SWC is not a priority for farmers in Honduras. Farmers stressed that many SWC programmes are irrelevant because they are not directed at their more immediate needs which include land security and lack ofeconomic resources.
- Farmer innovation is governed by a plethora of personal and institutional factors some of which, like self-esteem, can be influenced by development programmes.

Target institutions and the uptake of research results

The manual on the concept of land husbandry and the use of live barriers summarises many of the research results. It is co-authored with one of the target institutions, *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE), and will be distributed extensively to development organisations in Latin America.

The live barrier/cover crop trial, which is located at the experimental station run by the Honduran government- and DFID-funded *Proyecto de Conservación y Silvicultura de Especies Forestales de Honduras* (CONSEFORH), has high demonstration value. The use of catchpits to capture runoff enables visitors throughout the rainy season to see differences in soil loss under different treatments.

1.4 Contribution of the project to DFID's development goals

The goal of FRP's Forest/Agriculture Interface System is *productivity and productive potential of forest/agriculture interface increased through environmentally and economically sustainable management and exploitation of forest resources.* The project's goal is *contribution of trees to productivity of tree/crop based systems increased*.

The project has shed light on the contribution that live barriers of tree, shrub and grass species can make to reducing erosion and points to the fact that live barriers should be used in combination with technologies, such as cover crops and sparsely-located trees, to ensure that the soil surface is better protected.

The project has also demonstrated that in Honduras, farmers' problems and needs are not generally technical but rather socio-economic. Farmers are unlikely to adopt and adapt technologies such as live barriers, however suitable they are from a technical point of view, unless those technologies simultaneously address their social and economic needs.

2. BACKGROUND

2.1 Description of researchable constraints

The project sought to address researchable constraints in the following areas:

- Increase production from land area already in use.
- Reduce erosion-induced loss in soil-productivity brought about by unsuitable farming practices.
- Improve the adoption and adaptation of improved farming systems which incorporate soil-conserving technologies.

2.1.1 Agricultural activity and land degradation worldwide

Approximately, 800 million people do not have access to sufficient food (Pretty, in press). By the year 2020, the world will have approximately eight billion people and the majority of the developing world is faced with the need to increase production from land already in use. This requires maintenance of the productive potential of these resources, as a fundamental element in sustainable land use (Pieri *et al.*, 1995). One of the challenges in the tropics and subtropics is therefore to intensify the output from the land without destroying the soil resource upon which it all depends (Shaxson, 1993). Erosion reduces crop productivity by decreasing the amount of available nutrients necessary for plant growth. Erosion also increases the likelihood of crop failure due to drought by decreasing the amount of topsoil which reduces soil moisture storage. Erosion-induced loss in soil-productivity is now recognised as one of the principal threats to agricultural sustainability (Pretty, 1995).

2.1.2 Agricultural activity and land degradation in Central America

Steeplands with slopes greater than 20% occupy approximately 400 million ha. of land in tropical America and the Caribbean, constituting about 25% of the total land area (Purnell 1986; Cook 1988). Many steeplands in Latin America are cultivated primarily by small-scale farmers because of increased land and population pressures. Many of these smallholder farmers depend on steeplands for their subsistence and many Latin American countries rely on steeplands to meet the food security needs of the urban population.

Sheng (1990) calculated that cultivating slopes of more than 30% in the humid tropics without conservation methods, can cause annual soil losses of 100-200 t ha^{-1}. In Central America, a total of 46 million ha. of land has been affected by water erosion (Oldeman, 1992). Based on a bulk density of 1.15 g cm^3, steeplands with annual soil loss rates of 100-200 t ha^{-1} are loosing between 0.9 and 1.7 cm of top soil per annum.

The World Bank has identified a number of key land use issues for agro-ecological zones based on results from regional workshops (World Bank, 1995). One of the agro-ecological zones is steeplands in Latin America and the associated key land issues is the extent, severity and effects of soil erosion as a result of agricultural encroachment (see third bullet point below). Much of Central America falls into the category of steeplands. Leonard (1987) states that the hilly and highland zones in each of the five Central American Republics make up between 73% (Costa Rica) and 95% (El Salvador) of the total area. Central America’s mountains and heavy rainfall make much of the region particularly vulnerable to soil degradation (Lutz *et al*., 1994). In Honduras:

- Only 25% of the land area, approximately 2.8 m hectares is classified as agricultural land
- Almost 4.0 m hectares are farmed
- The difference of 1.2 m hectares is largely made up by the appropriation of hillsides (Humphries, 1994)
- 73% of annual crops in Honduras are produced on cleared hillsides (*Instituto Interamericano de Coorperación para la Agricultura* [IICA], 1995).
- Inappropriate usage of land is associated with the fact that 90% of the land designated as agricultural is in the hands of 10% of the producers (*Secretaría de Coordinación, Planifcación y Presupuesto* [SECPLAN - Honduras], 1989).
- Continuous cultivation of slopes with mono-cropped maize in Honduras and the rest of Central America is both depleting soil fertility and increasing splash erosion (Sheng, 1982).
- Central America's population is growing at 2.8% per annum and Honduras' at 3.2% per annum (Leonard, 1987).

2.1.3 Adoption and adaptation of soil and water conservation technologies worldwide

Soil and water conservation (SWC) can contribute to greater agricultural sustainability but results to date have been disappointing in terms of low adoption rates and sustainability (Hudson, 1991 & 1992), largely as a result of misinterpretation of the real needs of farmers, the imposition of top-down extension activities, and the fact that many of the SWC technologies promoted have not led to an increase of at least maintenance of production levels. As Shaxson (1996) has pointed out, farmers do not generally equate soil erosion as their prime concern, they are more concerned with stable and economic production and not with the conservation of soil and water *per se*.

In Honduras and the rest of Central America, there are many examples of failed soil and water conservation projects (see also section 2.2.2). The Food and Agriculture Organisation of the United Nations (FAO) reported that in the department of Lempira in Honduras almost all the SWC technologies promoted in the 1980s had been abandoned by 1994 because they did not complement bio-physical and socio-economic conditions in the area. (FAO, 1994).

2.2 Demand for research on researchable constraints

2.2.1 *Instituto Interamericano de Coorperación para la Agricultura* (IICA)

The need for a multi-disciplinary approach to conserving Central American hillsides has been voiced by IICA. The organisation has stated that serious erosion is affecting 170,000 hectares in hillsides per year in Honduras with a soil loss of 22-46 tonnes/hectare/year and that more attention needs to be directed at the development and transfer of appropriate agricultural and forestry technologies for hillside farmers in the country (IICA, 1995).

2.2.2 Government of Honduras - *Secretaría de Recursos Naturales* (SRN)

The need for incorporating more sustainable farming practices into farm management has also been recognised by SRN for some years and has been manifested in the SRN's SWC projects in the last fifteen years. The *Programa de Desarollo, Marcala y Goascorán* (MARGOAS) was funded by SRN and the Swiss aid agency *Cooperación Suiza al Desarollo* (COSUDE). The project was active in the 1980s and involved soil and water conservation work.

SRN and the United States Agency for International Development (USAID) promoted soil and water conservation in the 1980s as part of a project designed to protect the watershed of the river Choluteca. The project tended to emphasise mechanical structures and subsidies were used. As a result there was a low uptake of SWC technologies by farmers.

In 1989 SRN and USAID started the Land Use Productivity and Enhancement Project (LUPE). LUPE is a US$ multi-million project with the purpose of increasing hillside agricultural production and productivity on a sustainable basis in central and southern Honduras. LUPE provided technology transfer and training in sustainable hillside agriculture and natural resource management to beneficiary farm families. Poor adoption of SWC technologies in the 1980s persuaded SRN and USAID to emphasis biological as opposed to structural/mechanical technologies.

2.2.3 Government of Honduras - *Cooperación Hondureña de Desarollo Forestal* (COHDEFOR)

COHDEFOR is increasingly aware of the overlap between forestry and agriculture and the need to involve the forestry community in SWC work. In the early 1980s, COHDEFOR and FAO incorporated SWC technologies into a project designed to protect watersheds. More recently COHDEFOR has incorporated SWC work with farmers as a major component of the US$ multi-million *El Cajón* project which is designed to protect the watershed of Central America's largest electricity-generating projects in central Honduras. COHDEFOR through CONSEFORH has also supported FRP Project ZF0019/R6292CB by providing land for the live barrier/cover crop trial site at the Santa Rosa experimental station in Choluteca.

2.2.4 International Food Policy Research Institute (IFPRI)

IFPRI (Scherr and Yadav, 1996) has identified subhumid Central American hillsides as suffering from extreme land degradation. In its general policy recommendations to protect and improve agricultural lands IFPRI identifies a need for more research on:

- Soil fertility improvement, control of soil erosion and agroforestry systems
- Yield and financial impacts of degradation and the private and public returns to investment of various types in land improvement
- Socio-economic and policy conditions that are most conducive to investment in land management
- New lower-cost strategies in order to address the need for technology appropriate to the wide diversity of conditions found in hillsides

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The authors stress the need for greater integration between rural land use sectors (forestry and agriculture) and between disciplines (such as economics and soil science) in developing extension programs.

2.2.5 The Pressure-State-Response Framework, and the need for more research on the Change of State Land Quality Indicators (LQIs) especially soil erosion and its effects on productivity

The World Bank, FAO, United Nations Development Program, United Nations Environment Program and other international and national organisations are developing the concept and application of Land Quality Indicators (LQIs). The objective is to measure changes in the quality or condition of land, and so promote land management practices that ensure productive and sustainable use of natural resources (Pieri *et al.*, 1995)

The need for LQIs has led to the development of the Pressure-State-Response (PSR) framework. LQIs measure pressures upon land resources, effects of such pressures upon the state of land quality, and the response of society to these changes. Some of the more commonly-used change of state indicators are unsatisfactory (Pieri *et al.*, 1995). This is especially the case with the current rate of erosion in tonnes per hectare. Due to a lack of sufficient erosion research and soil surveys on tropical steeplands, annual soil loss tolerances have not been established for most of these soils. Research on steeplands, with slopes exceeding 20%, has been sketchy or neglected because cultivation of these sites has traditionally been considered inappropriate and unsustainable (Lal, 1988).

There are some fundamental gaps in our knowledge of erosion-induced loss in soil productivity (Lutz *et al.*, 1993 & 1994). These were summarised in the report of FAO's Second Erosion-Productivity Network in Brazil in March 1996 and cited by Tengberg *et. al*, (in press). One of the gaps identified was *How much erosion will cause what level of change in soil properties and consequent decline in yields*?

One of the reasons that the erosion LQI is unsatisfactory is that loss of topsoil with its higher content of soil organic matter and nutrients is more significant than bulk soil loss as such, except for off-site effects (Tengberg *et al.*, in press). Physical process models exist, and in soil science many such models have been developed for research purposes. There are, however, dangers in the uncritical application of models, a comparison with indicators derived from direct measurements is always desirable. To this extent Pieri *et al.*, (1995) and Tengberg *et al.*, (In press) have identified the need for better field measurements of soil erosion and effects upon production in order to estimate more effectively the rate of soil loss at which production is sustainable - for specific soil types -, and the threshold rate at which there is a danger of acceleration leading towards severe and irreversible damage.

Tengberg *et al.* (In press) add that professional institutions have an important mandate in quantifying the threat that erosion makes to soil productivity. Only if we can translate the dangers of erosion - and the benefits to conservation - into meaningful terms, do we have any possibility of assisting local people towards the goal of sustainability.

Lutz *et al.* (1993 & 1994), Ellis-Jones and Sims (1995) and Pagiola (1992) add that more empirical work on the link between soil loss and productivity would also improve some of the cost-benefit research that has been carried out on SWC technologies. In their studies extensive sensitivity analyses were incorporated into each case study. In some cases the results were affected significantly by changes in assumed rates of decline in yield. The premium to do additional research is evident and the payoff is likely to be high because the approach to soil conservation would be more targeted, with efforts concentrated where they are needed most (Lutz *et al.*, 1994).

2.2.6 Live barriers and cost-benefit analysis

Most research and analysis of SWC technologies, including agroforestry systems such as live barriers of tree species, have dealt with the physical and biological aspects of the systems. This analysis may not reflect the concerns of farmers and more work is needed on the impact of SWC technologies and erosion-productivity research on farm economies (Tengberg *et al.,* in press). The economic contributions of live barriers along with other agroforestry systems at the farm level have not been systematically assessed (Current *et al*., 1995).

There are also few data available on the contribution that live barrier products can make to a farm household, even though they make the live barrier technology more attractive to farmers (Ellis-Jones and Sims, 1995). The more profitable a technology, the better the adoption rates. One of the reasons for this is that if the investment is repaid quickly some of the constraints on farmer adoption of SWC technologies become less influential. One such constraint is insecurity of tenure. Current *et al.,* (1995) concluded that the payback period for live barriers of agroforestry species was only 1-3 years. This technology, in theory, therefore has great potential in SWC efforts.

However, even if the Net Present Value (NPV) estimate of a technology is positive, other factors might prevent a household from adopting a new system (Ellis-Jones and Sims, 1995; Lutz *et al.,* 1993). The cost-benefit calculations themselves often provide insight into whether particular constraints are likely to prove binding. The length of time it takes for an investment to be repaid can indicate whether tenure issues are likely to pose problems.

2.2.7 The Positivist paradigm and the need for a new approach to rural development: combining bio-physical and socio-economic research

Pretty (1995) has argued that agricultural development has tended to be dominated by a framework of positivist science, in which it is believed that single, correct truths exist, is itself only partial picture of the world's complexity. Positivism is just one of many ways of describing the world, and what is needed is pluralistic ways of thinking about the world and acting to change it (see also Chapter 7).

These pluralistic ways of thinking recognise that problems are always open to interpretation. All actors have different perspectives on what is a problem and what constitutes improvement. Thus it is essential to seek multiple perspectives on a problem situation by ensuring the wide involvement of different actors and groups. Participation and collaboration are essential components of any system of enquiry, as any change cannot be effected without the full involvement of all stakeholders, and the adequate representation of their views and perspectives.

The need to take into account different perspectives is well illustrated by SWC activities. One of the reasons that farmers may reject SWC technologies is that they do not fit in with the way that they themselves see land degradation problems (see Chapter 12). Shaxson (1993) has argued that in the past SWC efforts have been directed at controlling soil erosion whilst farmers themselves may not see soil erosion as a problem. Have technologies developed by researchers not been readily adopted by farmers because they address an agricultural problem that farmers either do not see as a problem? Or could it be that farmers have a preference for other ways of mitigating the problem other than adopting the externally-developed technology?

2.3 Significant research previously carried out

2.3.1 Soil erosion, soil fertility and productivity

Soil erosion research in Central America

In El Salvador, in an area with annual rainfall of 1900 mm., Sheng (1982) reported an annual soil loss of 127 t ha^{-1} on a field of bare soil with a 30% slope, planted with corn running up and down the slope. Annual soil loss measurements from Northwest El Salvador on clay loam to clay soils on 20 m long plots with 30% slopes under traditional corn/bean cultivation ranged from 13 to 137 t ha^{-1} (Wall, 1981). Annual soil loss rates on high intensity cultivated steeplands of the Acelhuate river basin in El Salvador ranged from 15 to 150 t ha^{-1} (Wiggins, 1981). Research by Rivas (1993) in Nicaragua documented annual soil losses of 78 t ha^{-1} from bare slopes of 15%. In Nicaragua, Mendoza (1996) monitored soil loss from maize plots with live barriers of *Gliricidia sepium* on slopes ranging from 16% - 40%. Annual soil losses ranged from 9 to 22 t ha^{-1}.

Smith (1997) measured runoff, soil, total nitrogen, and total phosphorous loss from three steepland field catchments over a three year period (1993-995). The 0.2 ha. field catchments with 60% slopes were monitored at Los Espabeles, Choluteca and Honduras. There were three treatments: mulch only; *Vetiveria zizanioides* (vetiver grass) live barriers with mulch; and the traditional practice of burning prior to planting. *V. zizanioides* live barriers with mulch significantly ($p<0.10$) reduced runoff compared to mulch only. Burning prior to planting significantly ($p<0.10$) increased runoff compared to mulch only.

In southern Honduras, Thompson (1992) estimated annual soil loss rates ranging from 19 t ha^{-1} at Orocuina to 188 t ha^{-1} at Texiguat by measuring differences in top soil depth between terraced and unterraced fields on which mulch from the previous crop was left.

As part of Silsoe Research Institute's RNRRS-funded research in Honduras experiments have been established to look at erosion rates and changes in soil fertility under different cover crop treatments (Arévalo-Méndez, 1994 & 1995). SRI also conducted some research in Honduras on soil loss in fields with live barriers of two grass species (*Vetiveria zizanioides* and *Pennisetum purpureum*. Erosion pins were used to monitor changes in soil levels and from these changes soil loss was calculated. The results are currently being analysed.

Food and Agriculture Organisation (FAO) study in Latin America

As part of a FAO-instituted co-operative research programme, experiments have been established in several South American countries to look at erosion-induced loss in soil productivity. Preliminary results have been reported by Tengberg *et al.,* (In press). The researchers are not looking at live barriers but rather at erosion rates for different soil covers.

Results at one of the site in Brazil showed sudden increase in erosion rate after approximately 2.5 years. Erosion led to a progressive deterioration in soil surface structure which had originally been protected on the stony cambisol and now generates substantially more runoff and sediment transport with a likely effect on soil productivity (Tengberg *et. al.,* in press). The other main result to date has been the logarithmic form of relationship between yield and soil loss, indicating that for some tropical soils there is an initial large decline in yields with the first five centimetres loss of topsoil. By contrast, further erosion has only a modest impact. Findings from Chapecó, Brazil in the FAO study also showed that maize is more sensitive to erosion than soyabeans (Tengberg *et al.,* in press).

Tengberg *et al.,* (in press) also point out that erosion-yield-time relationships are variable between sites and that some area have very high erosion rates but relatively low impact per tonne of soil loss. Lutz *et al.,* (1993 & 1994) have also pointed out that erosion rates, even where they are significant, may have little effect on productivity under certain conditions for example in deep soils that contain a high percentage of organic matter.

Soil changes with erosion indicate that no single soil variable explains fully the impact on soil productivity. Degradation, often led by decline in organic matter, results in a complex of soil physical and chemical changes including increasing acidity and declining plant-available water.

Cover crops in Latin America

There is increasing interest in Central/South America on the use of cover crops for soil conservation. There are several organisations in Central America carrying out research on cover crops in addition to SRI's work, these organisations include the *Centro Internacional de Información Sobre Cultivos de Cobertura* (CIDICCO) and Cornell International Institute for Food, Agriculture and Development (CIFAD). Much of the research was summarised in the proceedings of a workshop held at CATIE in 1994 edited by Thurston *et al.,* (1994). Additional research specific to Honduras has been documented by Triomphe (1994). More recently a DFID and GTZ-funded workshop on cover crops as part of integrated systems was held in Mérida, Mexico in February 1997 (see Chapter 13) and in April 1997 the Rockefeller funded an international workshop in Brazil. More recently the limitations of cover crops, especially with regards to water competition with agricultural crops, have become clearer (Roland Bunch pers. comm.) [Director of the Honduran-based NGO *Asociación de Consejeros para una Agricultura Sostenible, Ecológica y Humana* (COSECHA) and author of *Two ears of corn: a guide to people-centered agriculture* (1985)]

2.3.2 Soil loss, productivity decline and cost-benefit analysis

Soil loss and productivity decline

Many of the cost-benefit studies to date have relied on inaccurate information on the link between soil erosion loss and productivity. For example Vasquez (1986) using information from the US Soil Conservation Service, estimated the relationship between cumulative soil loss and yield n the Mexico situation. Vasquez had in turn predicted soil loss from the USLE. Based on his work Ellis-Jones and Sims (1995) used a loss of productivity of 15% for a loss of 2 inches (5.1 cm) of soil. And Wiggins (1981) in El Salvador used an estimate of 2% loss of productivity per cm of soil based on regressions from observed yield differences in maize fields in Mid-Western United States.

The research by Tengberg *et al.,* (in press) showed that in some soils there is logarithmic form of relationship between yield and soil loss, indicating that for some tropical soils there is an initial large decline in yields with the first five centimetres loss of topsoil. Pagiola (1992 & 1993) has also pointed out the danger in cost-benefit work of using a constant estimate of yield decline induced by soil degradation over the period of the analysis. If the logarithmic form of relationship between yield and soil loss is common then the immediate decline in yield will lead to an immediate jump in the returns of conservation since returns that occur later in the period of analysis are weighted less, due to discounting, than returns which occur earlier.

Benefits of SWC technologies from a farmer's points of view

Farmers decide how to use their land in light of their own objectives, production possibilities, and constraints, not on the basis of any theory of the social good (Lutz *et al.,* 1993; Carter, 1995; Ellis-Jones and Sims, 1995). In making their land use decisions, farm households need to consider both the agro-ecological and the economic characteristics of the environment in which they operate.

Soil conservation efforts to date have often been directed at tackling the agro-ecological aspects of the problem (principally soil erosion) with little emphasis on other land degradation issues nor on the profitability of the conservation efforts from the farmers' point of view. In the last five years more research has been directed at the costs and benefits of soil conservation from the farmer's point of view. In Central America in recent years there have been three principal studies.

A CATIE-World Bank Study carried out an economic and institutional analysis of soil conservation projects in Central America and the Caribbean (Lutz *et al.*, 1993 & 1994). A CATIE-IFPRI-World Bank Study looked at the costs, benefits and adoption of agroforestry by farmers including agroforestry for soil conservation (Current *et al.*, 1995); and Silsoe Research Institute, with funding by RNRRS, appraised a number of soil conservation technologies on hillside farms (Sims & Ellis-Jones, 1995 & Sims *et al.,* in press). Some analysis of live barriers was included in each of these threes but none of them took into account the value of the products of the barriers.

McIntire (1993) found that cultivation and cropping practices, including vegetative barriers, were superior to structural measures in terms of profitability. Current *et al.,* (1995) reported that losses in agricultural production were typically offset by the benefits received from the trees. SRI carried out cost-benefit analysis of four live barrier species but the barriers were only 15 month old and the study did not value the products of the live barrier species (Sims and Ellis-Jones, 1994; Ellis-Jones and Sims, 1995).

2.3.3 Adoption and adaptation of SWC technologies

Obstacles to adoption

Lutz *et al.* (1993 & 1994) concluded that in the case studies, adoption rates appeared to correlate well with the estimated profitability of conservation. The authors recognised that although profitability of conservation is a necessary, it is not always sufficient condition for their adoption. Most often institutional issues (such as land tenure and access to credit) and the conservation ethic of farmers must be considered together with the results of the cost-benefit analysis (Ellis-Jones and Sims, 1995). Current *et al.* (1995) found that requirements for and availability of land, labour and capital appeared to influence adoption of agroforestry as much as, or more than financial profitability. They further concluded that one of the constraints on adoption of alley-cropping was the labour demands for pruning (see also Carter, 1995) but that intensive agroforestry systems such as alley cropping are more attractive to farmers in areas of greater shortage of land.

Some research has shown that land tenure in Central America is not as big an obstacle to farmers' adopting SWC technologies as originally thought (Wachter, 1993) and that often, even without an official title, de facto property rights provide the farmer with enough security (Bonner, 1995). Current *et al.* (1995) reported that the risk associated with not being able to harvest trees because of restrictive permit procedures and government regulations was a major obstacle to initial adoption in many areas. Current *et.al.,* (1995) also found that farmers in the study area initially adopted agroforestry systems to meet household subsistence needs. Once these needs were satisfied, farmers became interested in market opportunities.

Farmers' attitudes to SWC

Less research has been carried out on Central American farmers' attitudes to SWC. Bunch and López (1994) and López *et al.* (1995) documented the degree to which farmers have adopted, rejected or adapted a number of SWC technologies (including live barriers) in several communities in Honduras and Guatemala, but the authors did not detail the reasons for these changes. Arellanes (1994) reported on factors influencing adoption of hillside agriculture in the Cantarranas area in Honduras and Bonner (1995) looked at the link between land tenure and adoption of SWC technologies on hillside farms in Honduras.

IFPRI is currently analysing the results of an extensive farmer survey in the central region of Honduras. The objective of the study is to understand under what conditions pressures for intensification lead communities in fragile lands to improve natural resource management and human welfare, and how policy instruments can facilitate this process (Scherr *et al.,* 1996 and Pender, 1996).

2.3.4 Farmers' choice of species - manipulative participation to self mobilisation

Pretty (In press) has identified seven forms of farmer participation that range from manipulative and passive participation, where people are told what is to happen and act out predetermined roles, to self mobilisation, where people take initiatives largely independent of external institutions. Pretty (in press) cited a study by Narayan (1983) of 121 rural water supply projects in 49 countries in the developing world which found that participation was the most significant factor contributing to project effectiveness and maintenance of water systems.

Research in Honduras by Bunch and López (1994) and López *et al.,* (1995) has shown that the lack of farmer involvement in designing SWC conservation technologies may be one of the reasons that live barriers have not proved to be more popular with farmers. Carter (1995) came to similar conclusions for alley-cropping in Sub-Saharan Africa.

In the case of Honduras, the emphasis on a few better-known species, selected by extension agents, for use in live barriers is evident in the initial work of the NGO World Neighbours in the Güinope region in Honduras and by the LUPE project in Central and southern Honduras. In the case of the former, the emphasis was on two grass species - *V. zizanioides* and *P. purpureum* which are particularly good for fodder, and in the case of the LUPE, the emphasis has been on *V. zizanioides*.

2.3.5 Guidelines/manuals on SWC including live barriers and cover crops

There are several manuals on soil conservation in Central America (Best, 1988; Crozier, 1986; Hesse-Rodríguez, 1994; Secretaría de Recursos Naturales, 1994a & 1994b; and Tracy and Perez-Mungia, 1986). Many of these manuals detail similar SWC technologies with an emphasis on methods of establishment. There is very little published material on the methodology for determining if particular SWC technologies are appropriate for an area and/or in the case of live barriers or cover crops, the most suitable species to promote from a bio-physical and socio-economic point of view.

3. PROJECT PURPOSE

The project purpose was:

Knowledge of crop-tree interaction in below and above ground environment improved and incorporated into management strategies

Rural people ultimately decide how their land will be managed and recommendations for change must be perceived to be beneficial, often in the short-term, by the supposed beneficiaries (Shaxson, 1992). Improved knowledge of crop-tree interactions may not be incorporated into management strategies if this knowledge, and the way it is promoted, does not complement the socio-economic and bio-physical factors that determine farmers' management decisions.

The emphasis of the research on live barriers was designed to complement ongoing SWC research into cover crops. Live barriers not only deal with the horizontal component of the erosion process but can also provide valuable products for consumption and/or sale. Live barriers, when promoted as part of an integrated management system, that includes cover crops *etc.*,. can contribute to more sustainable agricultural production

3.1 Researchable constraints

The identified constraints to development, as detailed in Chapter 2, were:

- Increase production from land area already in use
- Reduce erosion-induced loss in soil-productivity bought about by unsuitable farming practices
- Improve the adoption and adaptation of improved farming systems which incorporate soil-conserving technologies

3.2 Project purpose, outputs and identified constraints to development

The project sought to:

- Elucidate the impact of live barriers on soil conservation and agricultural productivity
- Identify socio-economic and bio-physical obstacles to farmers incorporating live barriers and other SWC technologies into farming systems.
- Identify the most cost-effective species for use in live barriers.
- Produce a manual on land husbandry and a methodology to determine when live barriers may be appropriate and which are the best species to use based on farmers' needs.

3.2.1 Live barrier/cover crop trial site

The live barrier/cover crop experimental site was designed to provide data on the impact of live barriers/cover crops on soil conservation. In particular the experimental work was directed

- the degree to which different species in live barriers and a cover crop (*mucuna* spp.) can control soil erosion
- the link between soil loss over time and changing maize yields
- the link between soil loss and changes in the physical and chemical characteristics of the soil remaining on the research plots

Results from the trial site are relevant to other parts of Central America because the soils are characteristic of large areas of Honduras and those on more recent material in parts of Central America and Mexico (D. Kass, pers. comm. [soil scientist, CATIE).

3.2.2 Qualitative and quantitative surveys of farmers; needs and attitudes to SWC

The studies were designed to shed light on farmers' decision-making processes with regards to land management. Information on farmers' attitudes to SWC and priority needs can help ensure that technologies encompassing crop-tree interactions, such as live barriers, are promoted in ways that address farmers' needs. The surveys also indicate what sort of future research is needed on crop/tree interactions.

3.2.3 Manual on live barriers and land husbandry

The manual, co-authored with CATIE, includes sections on the philosophy of land husbandry and extension methodology in addition to a methodology for determining if live barriers are appropriate and if so which species should be promoted. The manual is a tool that, if used correctly, may ensure that live barriers are more readily incorporated into farmers' management strategies.

4. SUMMARY OF RESEARCH ACTIVITIES

The original proposal was directed at live barriers and their ability to retain soil. During the fist field trip to Honduras (August-September), it became clear that soil erosion control is not a priority for farmers and that soil erosion *per se* needs to be addressed in ways that complement farmers' perspectives and needs. Research activities were therefore expanded (Figure 1). Research was carried out in two areas in Honduras: Güinope and Choluteca (see Map 1).

As documented in the proposal, research was carried out into:

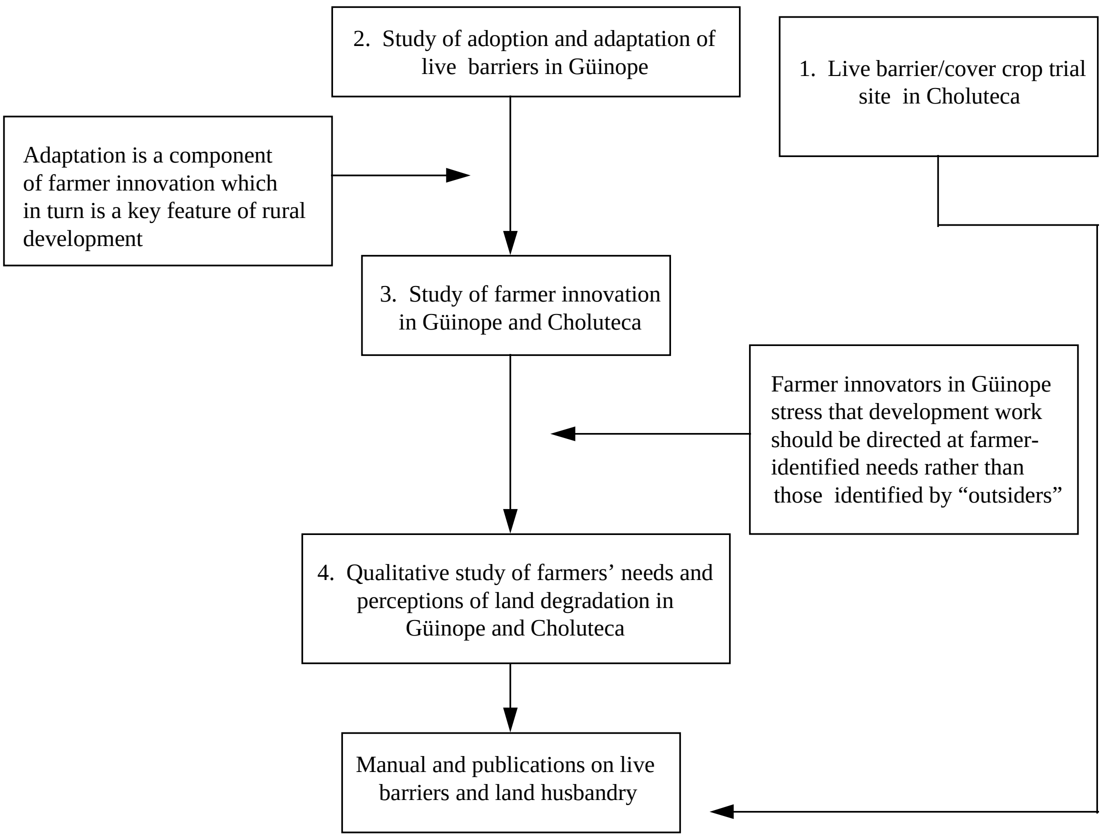
- What types of live barriers are most appropriate for farmers
- In what circumstances are live barriers an appropriate technology
- How can the live barrier technology contribute to better land husbandry

Research also shed light on:

- How farmers perceive soil erosion and soil and water conservation in general.
- Importance of farmer innovation as opposed to transfer of technology for rural development.
- What farmers' priorities are in terms of rural development.
- Farmers' views on extension methodology.

Map 1 Honduras and location of Güinope and Choluteca research sites

Figure 1 A conceptual framework of research activities



Research activities were divided into four categories (Figure 1) which are linked and follow a logical process of research.

1. Live barrier/cover crop trial site (Chapters 5 and 9) was predominantly designed to show different species' ability to control soil erosion.

2. Study of adoption and adaptation of live barriers in Güinope and Choluteca (Chapters 6 and 10) showed which species are favoured by farmers and the criteria used in the selection process. The study also revealed the importance of innovation in rural development.

3. The study of farmer innovation in Güinope (Chapters 7 and 11) demonstrated the complexity of farmer innovation and the difficulty of relating key variables to the adoption/adaptation process. The study also showed that soil and water conservation (SWC) is not central to a farmer's perception of his reality (see below).

4. Qualitative study of farmers' needs and perceptions of land degradation (Chapters 8 and 12) was designed to test further the hypothesis that neither soil erosion control nor SWC are

priorities for farmers and that one of the reasons that SWC programmes fail is that they do not tend to address farmers' priority needs.

In August/September 1995, research activities were prioritised and collaborative links were established with a number of organisations including:

- *Corporación Hondureña de Desarrollo Forestal* (COHDEFOR) through CONSEFORH [live barrier/cover crop trial site in southern Honduras].
- Honduran-based non-governmental organisation *Asociación de Consejeros para una Agricultura Sostenible, Ecológica y Humana* (COSECHA) [farmer adoption of SWC tecnologies].
- *Centro Agronómico Tropical de Investigación y Enseñanza* (CATIE) [co-authorship of the manual and periodic consultancy inputs].

At the beginning of 1996, collaborative links were established with the *Centro Internacional de Agricultura Tropical* (CIAT) through its Central American Hillsides Program.

5. LIVE BARRIER/COVER CROP TRIAL SITE AT THE SANTA ROSA EXPERIMENTAL STATION, CHOLUTECA, HONDURAS

5.1 Site location and description

5.1.1 Location

One of the activities detailed in the original project application was the establishment of a live barrier trial in Honduras. During the first field trip to Honduras (August-September 1995), Jon Hellin decided to establish the experiments at the Santa Rosa experimental site near Choluteca in the south of Honduras at 87^0 04' W and 13^0 17' N. This site is managed by CONSEFORH.

5.1.2 Description

The immediate area is characterised by hillsides with an elevation of approximately 100 m above sea level and lies in the foothills of Cerro Guanacaure (1007 m above sea level). Most of the hillsides are cultivated with fields ranging from 0.1 to 0.3 ha. The main crops grown are maize (*Zea mays*) and sorghoum (*Sorghum bicolor*). In higher elevations, towards the summit of Cerro Guanacaure, coffee (*Coffea arabica*) is grown as are beans (*Phaseolus* spp.).

In the lower elevations, shifting cultivation used to be common. However, increasing population pressure and enormous inequalities in land distribution have reduced fallow periods and many areas are under continuous cultivation. Traditionally fields are burnt prior to planting in May but recent extension activity has reduced the amount of burning. The land tenure situation is complex; some farmers have title to their land (*dominio pleno*), others have usufruct rights (*dominio útil*) and many rent from larger landowners or squat. The forest type in the area, albeit very degraded, is dry deciduous.

5.1.3 Climate

The climate at the Santa Rosa experimental station is rainy with an extremely dry winter. The dry season, under the influence of cold fronts of polar origin, lasts from November to April. The wet season, influenced by the Intertropical Convergence Zone, is essentially bimodal and lasts from May until October. These six months account for approximately 90% of the annual precipitation which exceeds 2,000 mm. September and October are often the wettest two months. During July and August there is a marked reduction in rainfall. This is known as the *canícula* and is caused by an anticyclone positioned over Bermuda.

The rainfall at Santa Rosa is higher than the rest of the lowland Pacific littoral as it is strongly influenced by the local orographic effects of the nearby mountains, principally Caleras, Calaire and Guanacuare (Bampton, 1994). There was higher than average rainfall in 1996 but in 1997 the effect of the *El Niño* has been very pronounced and rainfall until the end of September was 60% lower than at the same time last year (see Graph 1 in Chapter 9). Rainfall is also 80% lower than at the same period in 1993 and 1994 and these two years were considered very dry years. Average daily temperature at Santa Rosa is 27^o C with a maximum temperature of 35^o C and a minimum of 21^o C. Relative humidity varies between 60 % and 80 %. The low humidity readings coincide with the dry season when solar radiation is highest (250 hours/month) and cloudiness lowest.

Another local meteorological phenomenon which only affects this area is the system of marine breezes. These usually influence the region in late April and early May and cause heavy evening thunderstorms. The prevailing winds are the north-east trades (Zúniga, 1990).

5.1.4 Soils

The soils at the live barrier/cover crop research site have been classified as inceptisols and ustropepts (Kass, 1997). See Annex 1 for the full classification. The soil is characteristic of large areas of Honduras and soils formed on more recent material in parts of Central America and Mexico.

5.1.5 Land use history

Until 1982, the land had been used for cattle and had then been left in fallow. The resultant secondary vegetation was cleared, without burning, in March 1996 prior to the establishment of the research plots in April/May 1996.

5.2 Trial design and research objectives

5.2.1 Original design

Prior to establishing the research plots, biometric advice in the design of the trial was provided by Dr. Gaye Burpee (CIAT), Professor Martin Haigh (Oxford Brookes University) and Dr. Ian Hunter (formerly NRI). Trial design including plot size (24 x 5 m) was also based on suggestions from the abovementioned people and published literature, in particular Omoro and Nair (1993); Garrity and Mercado (1994); Jama and Nair (1995); Mureithi *et al.* (1995); and Hudson (1993 & 1995).

The trial is a split plot design (Figure 2 and Photographs 1 and 2). The main plot treatment is slope and there are two slopes (35-45% and 65-75%). The sub-plot treatment is the type of barrier used. There are four treatments i) control with no live barriers ii) barriers of *Vetiveria zizanioides* (Vetiver grass) iii) barriers of *Gliricidia sepium* (madreado) and iv) barriers of *V. zizanioides / G. sepium.* The treatments are replicated on the two slope angles as follows:

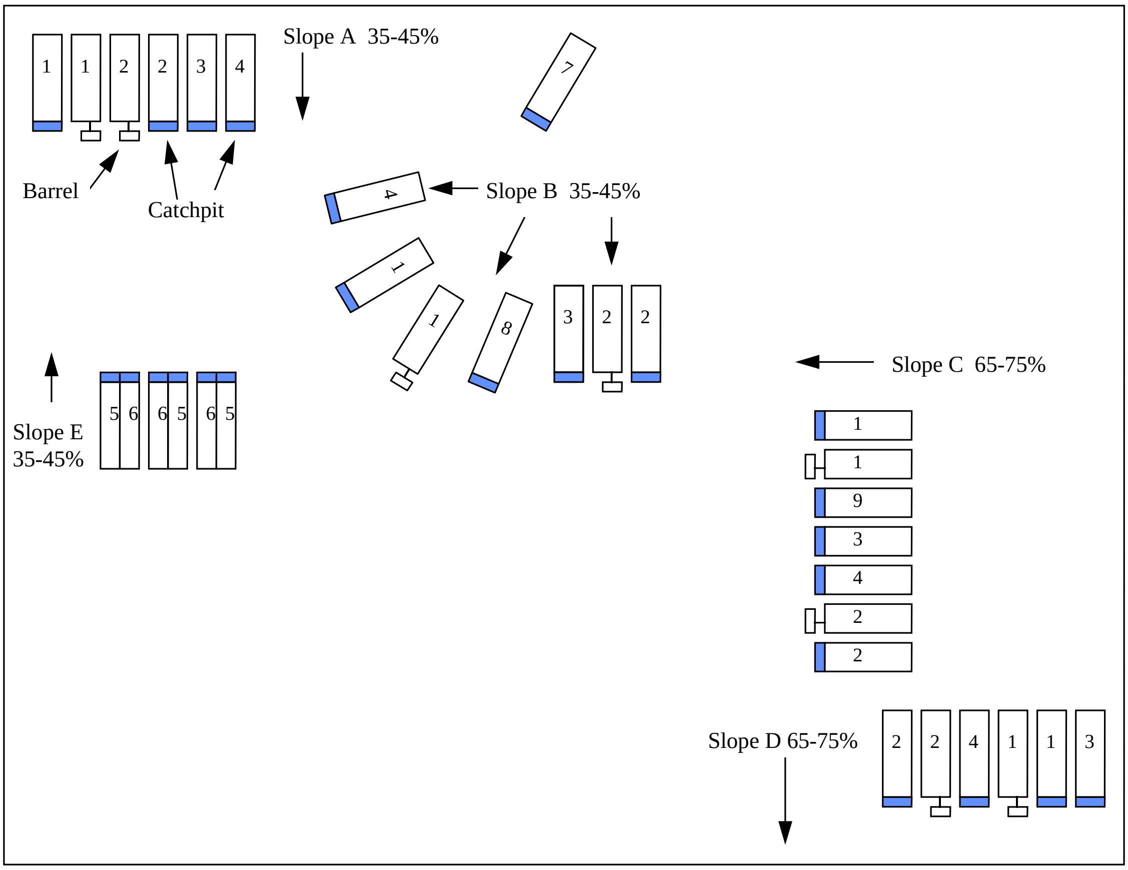
1. Four sub-plot treatments within the two slope angles, replicated twice, with the runoff collected in large catch-pits. Total 16 plots.

2. Two sub-plot treatments (control and *V. zizanioides / G. sepium* barriers) within the two slope angles, replicated twice, with the runoff collected in barrels. Total eight plots.

3. In addition during the rainy season in 1996 there were six plots which were not replicated and which were planted with a variety of tree, shrub and grass species in live barriers.

For an explanation of the use of barrels and catchpits see Sections 5.4.1 and 5.4.2 respectively.

Figure 2 Trial design of the live barrier/cover crop trial site at the Santa Rosa experimental station, Choluteca, Honduras



Plot size 24 x 5 m with the exception of treatments 5 and 6 where plot size is 24 x 2.5 m

Key

1 No live barriers
2 Live barriers of *Vetiveria zizanioides* (vetiver grass)
3 Live barriers of *V. zizanioides* (vetiver grass) & *Gliricidia sepium* (madreado)
4 Live barriers of *G. sepium* (madreado)
5 Live barriers of *Cymbopogon citratus* (lemon grass)
6 Live barriers of *C. citratus* (lemon grass) and a cover crop of *mucuna* spp.
7 Live barriers of *Cajanus cajan* (pigeon pea)
8 Live barriers of a mixture of nine tree, shrub and grass species
9 Live barriers of *Leucaena salvadorensis, L. leucocephala* and *L. collinsii*

Photograph A

Farmer sowing maize with
Slope C in the background.
September 1997.

Photograph B

Slope A and part of Slope
B with newly-germinating
maize. June 1996.

5.2.2 Modifications to trial design

At the beginning of 1997 and based on advice from a visiting consultant (Francis Shaxson [land husbandry specialist]) it was agreed that in order to reflect the title of the research project and to complement more fully the research work of organisations such as *Centro Internacional de Agricultura Tropical* (CIAT) *etc*., cover crops should be used in some of the research plots. The implications for the statistical analysis of any changes in trial design were discussed with John Sherington (Natural Resources Institute [NRI]), Andrew Pinney (CONSEFORH) and Gaye Burpee (CIAT). It was agreed that any change to the plots in the main experiments (see 1. and 2. in section 5.2.1) would in effect "sabotage" one or both experiments.

It was decided to convert three of the unreplicated plots on Slope C (see Figure 2). These plots had been planted with live barriers of *Cymbopogon citratus* (lemon grass) and native tree species. In April 1997 each of the plots was divided down the middle with metal sheeting and the catch pits at the bottom were divided into two by constructing a brick wall. The native tree species were removed.

Hence instead of three 24 x 5 m plots, there are now six 24 x 2.5 metre plots and in effect a third experiment with two treatments a) *C. citratus* barriers and b) *C. citratus* barriers together with cover crops. With three replications of each treatment. The cover crop is *mucuna* spp. which is known in the area as *Pica dulce* and which provides extensive cover.

5.2.3 Research objectives

The principal objectives of the trial were to:

i) Measure the soil and water runoff from slopes of different angles with live barriers of different species.
ii) Look at changes in the physical and chemical characteristics of the soil remaining under different live barrier (and cover crop) treatments.
iii) Document changing maize yields from the research plots.
iv) Serve as demonstration plots to visiting professionals and farmers

5.3 Establishment and management

5.3.1 Establishment of research plots and live barriers

In February 1996, the hillsides were manually cleared of secondary vegetation. In March, the contours were marked out on the cleared hillsides with an A frame and a series of 24 x 5 m plots were superimposed on the hillsides. The plots were established by April 1996. Three sides of the plot are demarcated by 30 cm wide metal sheeting (approximately 18 cms. are buried and 12 cms. are above the ground). The pieces of metal sheets overlap by about 10 cms. and are joined by rivets and then covered with a oil-based sealant that is reapplied when necessary. There are also 0.5 m deep drainage channels above the plots to prevent the dangers of runoff entering the plots from above. The sides of the plots and drainage channels are inspected on a regular basis to ensure that there are no holes in the case of former nor a build up of soil and vegetation in the case of the latter. The vegetation immediately surrounding the plots is cut frequently to reduce the risks of any interference with the plot itself.

In July 1996 the live barriers were established. There are three barriers per plot i.e. the barriers are at 6.0 m intervals. This is approximately the minimum distance that is accepted by farmers in Honduras. All the plots are planted with maize twice a year.

5.3.2 Management regime

The *C. citratus* and *V. zizanioides* barriers were pruned three times during the rainy season in 1996 and twice in 1997 to a height of eight inches. The prunings were laid just above the barrier so as to form a dead barrier (this follows the practice of local farmers). In 1996 the tree/shrub species were not pollarded because they had not grown sufficiently. In 1997 the tree/shrub species were pollarded at the end of September. The woody material was piled up behind the live barrier to form a dead barrier and the leaves were spread over the plot so as to form a mulch..

5.4 Field methods for calculating soil loss

Three methods for calculating soil loss were selected: barrels, catchpits and erosion pins. These methods were chosen in order to complement research by Dr. Gaye Burpee (CIAT) on monitoring soil loss under different cover crops in research plots in Güinope, Honduras. A dipping-bucket rainfall intensity gauge was installed at the end of May 1996. There is also a simple rain gauge next to the dipping-bucket rainfall intensity gauge. The former is read on a daily basis at 0600.

5.4.1 Barrels

The most important parameter in soil erosion experiments is often the amount of soil removed from a specific area. The conventional research method has been to construct runoff plots and to collect the runoff in a collecting recipient such as a barrel or tank. After each runoff event (or several events) the amount of soil and water that has been collected in the recipient(s) is then calculated. Although this method is often time-consuming and expensive, the use of barrels and tanks to collect runoff has been extensively used in soil erosion experiments worldwide and documented by Hudson, (1993 & 1995); Arévalo-Méndez, (1994); Mendoza (1996); and Rivas (1993).

At the trial site soil and water runoff was collected in barrels in the case of eight plots. Barrels were used on plots with the control (no live barriers) and those planted with live barriers of *V. zizanioides*/*G. sepium* (two plots of each treatment on each of the slope angles) (See Figure 2).

Collecting boxes

At the bottom of each plot with barrels there is a triangular metal box. The box is 5 m wide at the bottom of the plot and narrows downslope where the water drops down PVC tubing into the barrels (see Figure 3 and Photographs C & D). The metal boxes are covered with plastic to prevent rain entering. The metal box is made of three pieces of zinc lamina which are joined with rivets and subsequently welded along all the joints. At the junction between the metal box and the end of the plot, an eight-inch deep trench was dug. A “lip” was moulded to the box at approximately 90 degrees to the plane surface of the collecting box and this “lip” was buried. The soil level at the bottom of the plot is flush with the surface of the metal box. There is a 0.75 inch metal mesh between the plot and metal box (buried alongside and to the same depth as the lip of the box). This is designed to prevent vegetation entering the box and blocking the PVC tube in heavy run off events. The same mesh is used at the bottom of all plots.

Photograph C

Collecting box that
channels runoff into
barrels. September 1997.

Photograph D

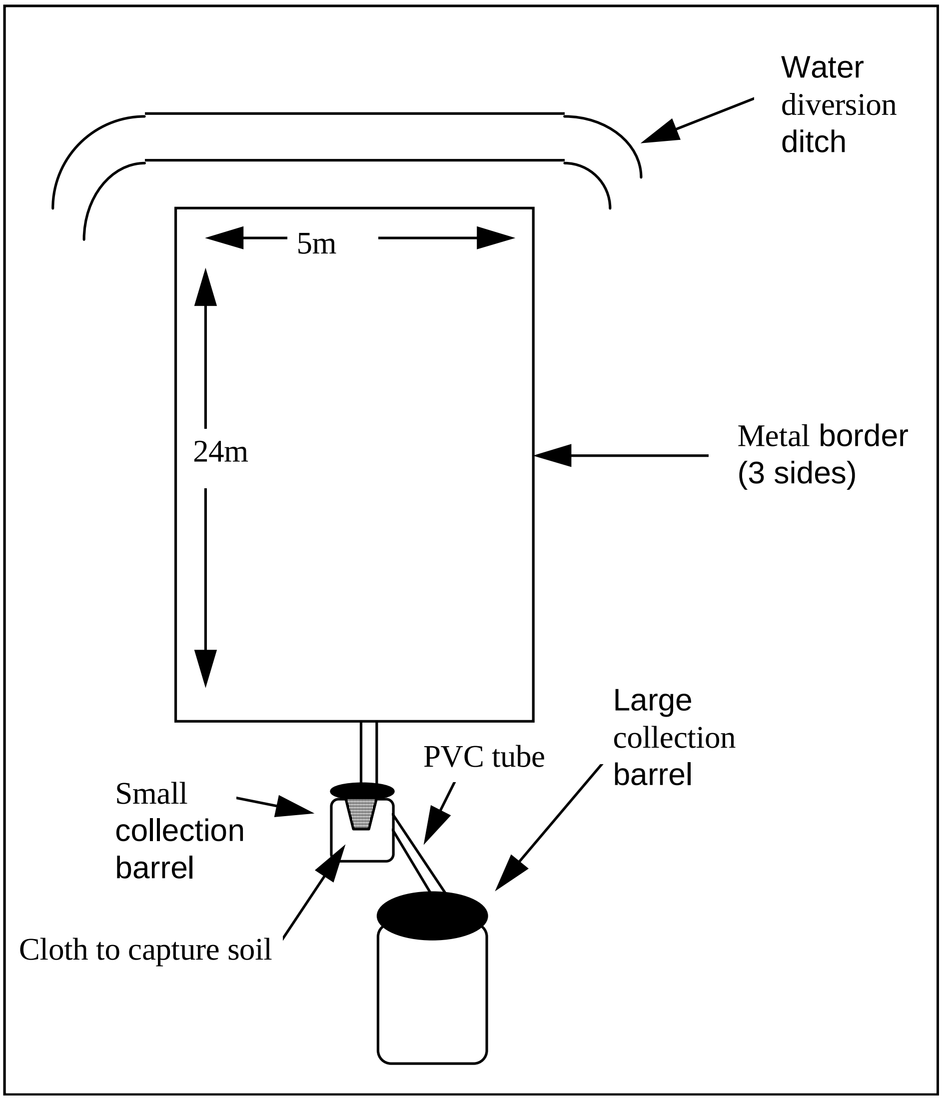
Base of collecting box
showing PVC tube
that leads runoff
into barrels.

In the case of the barrel plots, some soil does accumulate behind this mesh and after each runoff event is run a sharp stick along the bottom of the mesh from inside the plot in order to “push” this eroded soil into the box. Some soil is deposited along the metal surface of the box and this, together with the soil that has been pushed through the metal mesh, is brushed down to the PVC tube. Water from the barrel is used to clean the box and wash away the accumulated soil into the barrel.

Calculation of soil and water in the barrels

The water from the collecting box passes into a 200 litre barrel. There are three overflow holes one of which leads into a 800 litre barrel in the case of exceptional runoff events Figure 3). The majority of the sediment load is collected in a permeable cloth that is placed inside the 200 litre barrel. This is removed and weighed after each runoff event (Photograph E). A sample is weighed, dried at 105 ^{o}C for 24 hours, and weighed again. The total dry weight of the sediment load is then calculated.

Figure 3 Research plot and collecting barrels



The total volume of water and soil that passes through the cloth is measured by emptying the contents of the barrels from a tap. In the case of 50% of the runoff events, a 1.0 litre sample is taken. This is filtered through Whatman Filter papers number 1 in order to calculate the amount of soil in 1 litre of water (some clay particles are not captured by the filter papers). The total amount of soil that passed through the cloth in the barrel is subsequently calculated as is the volume of water that accumulated in the barrel.

5.4.2 Catchpits

The use of catchpits is an alternative and much simpler method for measuring soil loss. Catchpits are increasingly be used in agronomic research. Simple catchpits at the bottom of research plots can be used to demonstrate differences in soil loss under different agronomic treatments (Hudson, 1993 & 1995). Plastic-lined catchpits have been the most widely used. Small holes are made in the catchpits so that the water slowly dissipates and the sediment load is retained.

Previous use of catchpits
Catchpits have been used in soil erosion experiments around the world. In Thailand, Sombatpanit *et al.,* (1992) used plastic-lined catchpits immediately below two 5 x 71 m plots on a 40% slope. One plot was grown with upland rice without any conservation measures and the other was planted with 2 m wide strips of setaria grass at a spacing of 8 m. Upland rice, corn/red kidney bean and soyabean/red kidney bean were planted in cropped strips. In Colombia, Howeler (1987) used plastic-lined catchpits in a series of on-farm trials co-ordinated by the International Centre for Tropical Agriculture (CIAT) to compare soil loss under different *Manihot esculenta* (cassava) cropping systems. Plots sizes ranged from 20 x 10 m, to 15 x 10 m, to 10 x 10 m and slopes varied from 15 to 45%.

Chan *et al.* (1994) used plastic-lined catchpits in Malaysia to compare soil losses from various tillage practices and cassava-crop combinations. The plots were established on a uniform slope of 6-11% and each plot measured 10 x 10 m. More recently, and in collaboration with the CIAT Cassava Program, a number of national research institutes in Thailand, Indonesia, Vietnam and China have used plastic-lined catchpits to compare soil loss from research plots with different cassava cropping systems (Howeler, 1994; Howeler *et al.* 1996; Howeler, in press) .

Size of catchpits and frequency of soil measurements
Plastic-lined catchpits cited in the literature vary from 0.40 x 0.40 x 15 m (Howeler, in press) to 5 x 8 x 0.75 m (Sombatpanit *et. al.,* 1992). Howeler suggests weighing the wet soil that has accumulated in the catchpits once a month and taking a sample in order to calculate soil moisture. However if the catchpits contain considerable amounts of runoff, they may only be able to be cleaned once or twice a season. Sombatpanit *et. al.,* 1992, cleaned out the catchpits once at the end of the rains.

Advantages of catchpits
One of the main advantages of plastic-lined catchpits, as recognised by Howeler *et al.* (1996) and Sombatpanit *et. al.,* (1992) , is that the soil accumulation is a convincing visual demonstration of soil loss from plots with different treatments. The catchpits are easy to establish and operate and hence labour costs are considerably less than is the case with cleaning out collecting barrels *etc.* after each runoff event. The cost of establishing the catchpits is also not high.

Disadvantages of catchpits
One of the biggest disadvantages is that the amount of soil lost is only known when the catchpits are cleaned out. Hence no data are available on soil loss from individual storm events. In addition there is no record of total runoff. Chan *et. al.,* (1994) and Sombatpanit *et. al.,* (1992) also reported that solar radiation caused the plastic sheets to disintegrate. However there are alternatives to the use of plastic and Howeler (pers. comm. [soil scientist, CIAT]) has used catchpits that have been lined with bamboo sheets or bricks.

Catchpits at the trial site
Bearing in mind the quantity and intensity of the rain in Choluteca and the soil type (sandy loam) it was decided to construct catch pits measuring 2 m x 2 m x 1.5 m. The pit is entirely covered with plastic, the sheets are ovelapped by 0.5 metre and secured with tape. Nails with square inch aluminium washers are in turn hammered in along the length of the tape to prevent it peeling away. At the bottom of the plot a small trench is dug and the plastic is buried six inches deep. Around the catch pit a wall (over four inches high) is constructed from soil and stones. This is covered with plastic which is turn is buried into the soil and the catchpits are surrounded by drainage channels to prevent runoff entering (Photograph F).

In 1996, the catchpits were never dry and contained considerable amounts of water for almost the entire season. The logistics of trying to calculate the soil accumulation in 22 catch pits between rain storms dictated that the total amount of sediment that had accumulated in the plastic-lined catchpit was calculated at the end of the rainy season. In 1997 the effect of *El Niño* severely reduced rainfall at the trial site and as a result it was possible to calculate the sediment that had accumulated in the catchpits in August.

Simulated catchpit experiment

There is a dearth of literature on the accuracy plastic-lined catchpits i.e. what proportion of soil that enters the catch-pit is captured. Adjacent to the plots with a barrel there is a catchpit plot with the same treatment (see Figure 2). The original idea was to determine, in the case of the treatments 1 and 3, the differences in the measurements of the sediment collected in the barrels to that which accumulated in the plastic-lined ditches as a means of calibrating the catchpits. The first year's results (see Chapter 9) revealed the amount of on-site variation on the site. It became clear that it would not be possible to calibrate the plastic-lined catchpits by comparing the sediment load with that from an adjacent barrel plot with the same treatment.

In February 1997 a small experiment was established to test the accuracy of the plastic-lined catchpits. Five holes similar in depth to the catch-pits but not as wide were lined with plastic and secured with tape and nails (one of these smaller catchpits can be seen in the cover photograph). In February a known volume of water (750 litres) and a known weight of soil (45 kg wet weight with three samples taken to calculate the moisture content of the soil) were mixed and poured into the catch pits to simulate runoff during/following a heavy storm. This was done several time over a period of 2 days. By April 1997 the soil that had been captured by the pits was dry and it was collected and weighed. Samples were dried in the laboratory in Tegucigalpa and the dry weight of the soil that had accumulated in the catch-pit was calculated (see Chapter 9). A similar experiment is being carried out throughout the rainy season and the results will be sent to FRP in December.

Photograph E

Cloth from the barrels showing soil that has been eroded after one runoff event.
September 1997.

Photograph F

Farmers preparing a plastic-lined catchpit prior to the rains.
May 1997.

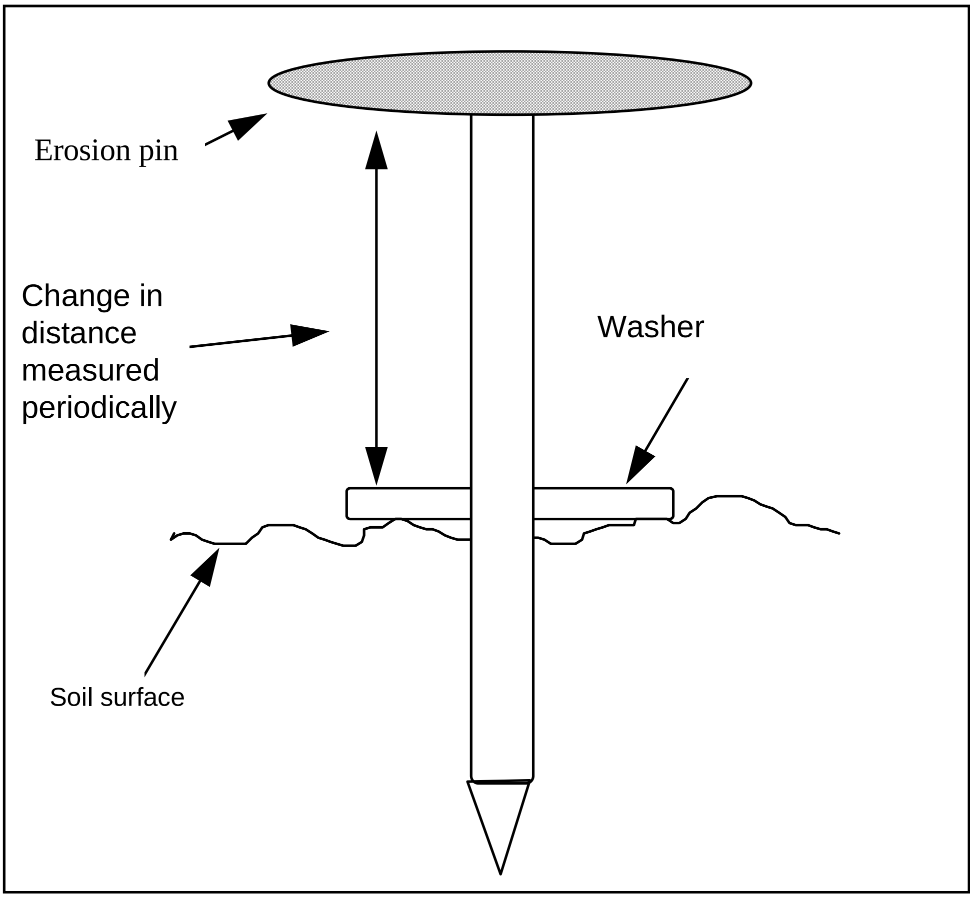
5.4.3 Erosion pins

An alternative method of measuring erosion involves inserting metal rods, wooden stakes, or nails and washers into the soil. The change in distance between the nail head and a washer resting on the soil surface, or the change in distance from the top of the rod to the soil surface is then periodically measured (Figure 4). According to Haigh (1977) pins can be arranged in different placement patterns at different spacings within a plot and measured at different time intervals depending on specific constraints and objectives.

Advantages and disadvantages of erosion pins

As with the catchpit method, erosion pins are inexpensive and easy to install. However they do not provide as dramatic a visual impact of soil loss as catchpits. Haigh (1977) has also pointed out that the change in distance between the head of the nail and the surface of the soil is not necessarily the result of erosion or sedimentation but may be caused by wetting-drying cycles, expansion and contraction of clay soils and/or movement of pins by animals or humans. Practitioners have also identified two measurement problems; the washer of each pin is often buried where soil accumulates, and when there is erosion the washer is sometimes supported on a protected pedestal of soil.

Figure 4 The use of erosion pins for measuring changes in the surface of the soil



Use of erosion pins at the trial site
Ten erosion pins were placed 30 cm above and below each of the live barriers and in the same positions on each of the control plots (60 erosion pins per plot). These were measured (two measurements per pin) at the beginning and end of the rainy season in 1996 and in May 1997. The principle is to document the amount of soil deposition and erosion above and below each barrier, document the formation of terrace rises, and test the accuracy of the erosion pins in measuring soil loss (comparing the figures given by the erosion pins to those from the barrels and catchpits).

Data from the pins on changes in surface level are averaged to one data point per line or plot depending on what is being measured i.e. total soil loss or the formation of terrace rises. The average change in distance can be converted to t ha $^{-1}$ soil lost, using mean bulk density of soil in the surface 8 cm of each slope in the formula *cm change in soil level on nails x plot area in cm3 x bulk density in g/cm3 = g of soil lost per plot*. This can then be converted to tons of soil lost per hectare and in addition relative comparisons of soil loss can be made from plot to plot.

5.4.4 Soil quality field kit and farmer-friendly methods for monitoring soil erosion

The work of agronomists, extension agents and scientists has contributed to basic knowledge about soils. With a knowledge of what affects soil quality comes the ability to avoid degradation and to foster amelioration. It is therefore important for research and development professionals to find ways to share basic scientific knowledge, tools and techniques with farmers and farming communities who are managing natural resources in tropical watersheds. The ability of local communities to conduct ongoing assessments of the condition of basic local resources is vital to their ability to sustain those resources. For example by recognising early warning of adverse effects of a particular land management system.

Dr. Gaye Burpee from the CIAT hillsides programme has modified and tested in several hillsides regions of Honduras and Nicaragua a soil quality field kit (SQFK) of simple quantitative tools (Doran and Parkin, 1994) and a soil quality scorecard (SCS) of qualitative tools (Romig *et al*., 1995; Wisconsin Soil Health Scorecard, 1995) that farmers can use to assess soil health. The SCS covers such soil characteristics as colour, depth, compaction, earthworm activity and vegetative cover. The SQFK includes tests for infiltration, texture, erosion/sedimentation, soil macrofauna.

Jon Hellin worked with Gaye Burpee since February 1996 in developing and testing parts of the SQFK and SCS. One key element of the SQFK is monitoring of erosion. The emphasis of the collaborative work with CIAT has been on testing two simple methods of measuring erosion - a plastic-lined catch pit at the base of research plots and the use of nails and washers inserted in the soil (see section 5.4.2 and 5.4.3). These two methods are being compared to the standard measure of collecting runoff in barrels (Burpee and Hellin, in preparation). The farmer-friendly methods complement the fact that farmers are often more interested in relative as opposed to absolute differences in soil erosion under different management regimes.

Other components of the SQFK were also tested at the live barriers experimental site as part of the process of modifying the SQFK to Central American conditions (Photograph G) Preliminary results of the qualitative study on how farmers distinguish between fertile and poor land (Chapter 12) have also contributed to the formulation of the SCS by Burpee.

5.5 Soil physical and chemical characteristics at the trial site

5.5.1 Soil sampling and analysis

Soil samples were taken in June 1996. Three samples from 0-10 cm were taken from each plot; one from the top, middle and bottom sections. Each sample was a composite sample from 10 collection points along the contour. Samples from each of the plots on the five different slopes were in turn bulked so that a total of 15 samples were analysed at the Pan-American Agricultural School, El Zamorano, Honduras. Soil samples will be taken in a similar way when the research finishes to see if there have been changes in soil fertility.

5.5.2 Soil taxonomy and chemical analysis - soil horizons

Don Kass (CATIE) and Jon Hellin worked at the trial site in December 1996 in order to classify the soil. Five soil pits were dug on each of the five slopes. The soil profile was divided into horizons and each of these was identified using Munsell Soil Color Charts. A description of each horizon was given according to Olson (1981). A sample from each horizon was tested for texture and chemical properties according to guidelines by the Soil Science Society of America and American Society of Agronomy. In particular Gee and Bauder (1986), Nelson and Sommers (1996), Thomas (1996), Helmke and Sparks (1996), Sumner and Miller (1996), and Suarez (1996). Another sample from each horizon was tested for bulk density according to Blake and Hartge (1986). Additional samples were taken from each horizon and tested for soil moisture according to Klute (1986). See Annex 1 for full results.

5.5.3 Tests on physical structure of the soil

Tests were used that reflect the changing physical characteristics of the soil: texture, infiltration, and bulk density. These tests are also simple to use by extension organisations and individual farmers and are part of the SQFK being developed by CIAT (section 5.4.4).

Texture - Soil analysis carried out by the soil laboratory at El Zamorano included a textural analysis. This test will be repeated when the research at the trial site finishes.

Infiltration - infiltration tests were carried out at the trial site in October with Guillermo Mendoza, a doctoral student from Cornell University who is carrying out research into sub-surface water movements. The single ring method was used (Anderson and Ingram, 1993). A metal cylinder 10 cm in diameter was vertically driven into the soil to a constant depth of 10 cm. Markings were made on the inside of the cylinder at 2 cm spacing. The cylinder was filled upto the first mark and recordings were made of the time that it took the water level to drop from one mark to another. This was repeated until a constant flow was achieved and the figures were converted into a basic infiltration rate in m/hr (see Chapter 9).

This test was initially carried out in three locations in each of the plots with barrels (Photograph H). The infiltration rates were so variable (reflecting the variation in the soil) that it was decided to do one infiltration test in the same location in each of the 30 plots (approximately 11 m from the top of the plot). A long steel pin was located 20 cm to the side of the infiltration spot to enable the location to be identified. An infiltration test in the same position will be carried out at the end of research to see there have beeen any changes in infiltration rates.

Photograph G

Gaye Burpee (CIAT) testing
Soil Quality Field Kit with
Samuel Carranza (farmer
in charge of trial site).
April 1997.

Photograph H

Single-ring infiltration
tests being carried out
with Guillermo Mendoza
(Cornell University).
October 1996.

Bulk density - in the case of the eight plots with barrels, twelve bulk density samples were taken from locations at 5.0 m and 19.0 m from the top of the plot in addition to three samples from around the selected infiltration spot (see infiltration above). The method for non-stony soils as described by Anderson and Ingram (1993) was followed and bulk density samples were taken at depths of 0-8 and 8-16 cm. The process will be repeated at the end of the experiment. In the case of the remaining 22 plots, bulk density samples were taken from three areas close to the infiltration spot (see infiltration above).

5.6 Calculation of maize yields

In September 1996, January 1997 and September 1997, maize in the research plots was harvested row by row. The number of maize stalks were counted in each row, as were the number of cobs harvested from the row and the weight of those cobs. Five samples of 200 randomly-selected maize cobs were weighed and the grain was removed. The weight of edible corn was recorded and five 1 kg samples were dried at 60 ^{o} C for 72 hours. The dry weight of the corn yield from each row in each plot was then calculated. All maize used at the site is same type and is sown at the same density.

In September 1996. some problems arose with theft of maize cobs and damage from animals. Where farmers reported theft and/or animal damage, the number of husks were counted per row as well as the number of cobs harvested. The difference represented the corn stole/eaten.

5.7 On-site versus on-farm research trials

There were several advantages to establishing an on-site as opposed to an on-farm trial both in terms of logistics and also the impact of the research results.

- It would have been very difficult to have ensured that farmers' activities in the area between live barriers were the same in terms of weeding regimes and land preparation.
- The majority of farmers in Choluteca do not own their land nor have usufruct rights. It would have been irresponsible to have established trials on land where there was no guarantee of continued access in the future.
- Honduras is the third poorest country in Latin America and the Caribbean (after Nicaragua and Haiti), and Choluteca is one of the poorest regions in Honduras. Establishing research plots is an expensive process not least in this case the cost of the plastic sheeting used in the catch-pits and the holes dug for the barrels, the metal sheeting used to demarcate the plots, and the barrels themselves. there is a danger that some of the plastic sheeting , metal sheeting and barrels would have been stolen had the plots been established on-farm.
- Farmers in the region farm plots dotted all around the hillsides. It would have been practically impossible to have established on-farm trials which could have been visited on a daily basis for collecting the runoff in the barrels. Although local farmers themselves could have done this work as opposed to the farmer in charge of the trial site, this would have introduced potential inaccuracies with farmers forgetting to clear the barrels out or just recording incorrectly and differently to one another.
- In the case of on-farm trials, it would have been very difficult to have found sufficient land for an entire replication.

- The plots are planted with maize by local farmers and the agricultural practices on the field station are exactly the same as farmers practice in the area. Hence some of the disadvantages associated with on-site trials i.e. that they are not representative of normal farming practices are avoided.

- With all the plots in one location, farmers are better able to see the differences in soil retention by different species (both through terrace accumulation above a barrier and the amount of soil accumulation in the catch-pits) than would be the case with isolated on-farm plots.
- The trial site is by a busy footpath that leads to several communities in the hills. It is one of the main access routes and therefore numerous farmers walk past the trial site on a daily basis.
- The trial site is at CONSEFORH's experimental station and is visited by visitors to the CONSEFORH trials.

5.8 Calendar of activities at the trial site 01.01.96 - 30.09.97

The rainy season lasts from May - November. During the rains, water and soil in the barrels are measured after every runoff event. In 1996 there were 75 runoff events and up to the end of September 1997 there were 30 runoff events. Measuring runoff, site maintenance, along with pruning of the live barriers and calculation of weed cover in the 2 x 2 m quadrats are on-going activities do not appear in the calendar of events below.

1996

January	Location of research site identified
February	Secondary vegetation cleared from slopes
March	Contour lines marked out
	24 x 5 m plots located on hillsides
April	Research plots established
	Catchpits excavated
May	Barrels and collecting boxes installed
	Catchpits lined with plastic
	Erosion pins located
June	Soil samples collected
July	First maize crop sown (*primera*)
	Live barriers established
	2 x2 m quadrats in research plots established to monitor changes in cover (maize and weeds)
	Research plots weeded
	First measurement of erosion pins
September	Maize harvested
	Research plots weeded
October	Second maize crop sown (*postrera*)
	Infiltration tests carried out
	Bulk density tests carried out
	Research plots weeded
November	Second measurement of erosion pins
December	Calculation of soil that had accumulated in catchpits
	Soil analysis with Don Kass (CATIE)

1997

January	Harvest of second maize crop (*postrera*)
February	Simulated catch-pit experiment established
April	Preparation of the trial site for the second rains
	new plastic placed in catch-pits, drainage ditches cleaned etc.
	Soil collected in June 1996 sent to EAP for testing
	Results of simulated catch-pit experiment calculated
May	First maize sown (*primera*)
	Third measurement of erosion pins
	Soil quality field kit tests on selected plots
June	Cover crop sown
September	First maize crop harvested (*primera*)
	Research plots weeded
	Second maize crop sown (*postrera*)
	Cover crop resown
	Trees and shrubs pollarded

6. FARMER ADAPTATION AND ADAPTATION OF LIVE BARRIERS IN GÜINOPE AND CHOLUTECA, HONDURAS

6.1 Rapid Rural Appraisals

In October and November 1995, Jon Hellin carried out Rapid Rural Appraisals (RRAs) in the central pine (Güinope) and the seasonally dry south (Choluteca) agro-ecological zones at the end of 1995 with. In Güinope all field visits were made with Mario Zavala, an extension farmer trained by World Neighbors and on several occasions with personnel from COSECHA.

Jon Hellin was also joined by Adrian Barrance (Technical Cooperation Officer with CONSEFORH 1990-1993). In Choluteca, Jon Hellin was accompanied on all visits by Mario Pinto an extension agent working with LUPE. The RRAs were designed to document the species being used in the live barriers; to identify some of the criteria used by farmers for selecting these species; and to draw up a list of some of the obstacles to the adoption of SWC technologies such as live barriers.

6.2 The Güinope region and World Neighbor's programme

6.2.1 The region

The Güinope region in southern Honduras lies between 500 and 1800 metres above sea level and has an area of 204 km^2. The population is approximately 5,500 of which 80% is engaged in agriculture. Annual rainfall is 1100-1300 mm, and farming takes place on slopes which are often 15-30%. An impenetrable subsoil underlies the 15-50 cm deep top soil.

6.2.2 World Neighbor's programme

Between 1981 and 1989, the non-governmental organisation World Neighbors promoted a number of SWC technologies in Güinope including live barriers of *Pennisetum purpureum* (Napier grass) and *Pennisetum purpureum* x *Pennisetum typhoides* (King grass). Prior to 1981, farmers in the Güinope region practised almost no SWC technologies and live barriers were unknown. The focus of the World Neighbors programme was, however, less on the transfer of technology and more on fostering self-esteem of the participating farmers (see Chapters 11 & 12).

The programme's objective was to foster human development and SWC technologies were designed to be the tools to achieve this (see also Chapter 11). The philosophy of the programme is outlined in Roland Bunch's *Two Ears of Corn* (1985).

6.2.3 Previous documentation of farmers' adaptations of live barriers

Studies by Bunch and López (1994) and López *et al*. (1995) have documented that five years after World Neighbor's programme finished in Güinope, farmers continue to use live barriers and other SWC technologies. The authors also noted that in several communities farmers are adapting the live barriers so as to include different species to those originally promoted. Neither study detailed the reasons for the adoption and adaptation of the live barrier technology.

6.3 Quantitative study of farmers' adaptations of live barriers in Güinope

6.3.1 Background to the study

The RRA (section 6.1.) showed that, since the World Neighbors programme finished in 1989, there has been extensive adaptations of live barriers; farmers have substituted species that they themselves have selected in place of the species promoted by World Neighbors.

In January 1996 Jon Hellin started work on a detailed study to document, in more detail than was possible during the RRA, the motivations and criteria used by those farmers who had adopted and adapted SWC technologies and in particular live barriers. He collaborated with Sergio Larrea a 4th year student at the Pan-American Agricultural School (EAP).

6.3.2 Methodology

The study focused on 15 communities in the region: Manzaragüa, Frijolares, Santa Rosa, Liquidambar, Pacayas, Lizapa, Galeras, Casitas, Güinope, Lavenderos, Silisgüalagüa, Loma Verde, Diquidambar, Arrayanes and Ocotales. In addition to the results of the RRA, Sergio Larrea consulted secondary data on the region and carried out more detailed interviews with a selection of farmers who had been trained by World Neighbors. The key objective of the interviews was to gain a better understanding of agricultural and socio-economic conditions in order to decide what to include in the structured and semi-structured interviews. A workshop was subsequently held for 10 farmers from the region who had received extension training from World Neighbors and who are still involved in SWC extension work (see also Chapter 7).

The focus of the quantitative study in the Güinope region was a structured interview (Annex 2) designed to show the reasons why some farmers have adopted and adapted SWC technologies and in particular live barriers). The interview was designed with the assistance of Karen Dvorak, a socio-economist with CIAT's Central American Hillside Program.

The first step was to determine the number of farmers in the 15 communities who had adopted SWC technologies such as live barriers in the past irrespective of whether they had rejected, continue to use or had adapted the live barriers. Three farmers were interviewed in each community in order to obtain a list of those who had adopted the live barriers. The limitation of this approach was that the farmers tended to remember those who continue with the live barriers rather than those who had abandoned the technology. In the absence of a list of "adopters" during the World Neighbors programme, there was little option but to use the information from the farmers. A total of 299 farmers were identified in the 15 communities. The sample of farmers to be interviewed in each community was based on a maximum error of 30% and a probability of 0.2. The formula used was:

$$n = (t^2 * p * q)/E^2$$ (Cochran, 1976)

Where:
- n = the size of the sample
- t = the value with a probability of 0.20 found in the Student Tables
- E = the maximum error permitted (30%)
- p = the proportion of adopters and adapters of live barriers in Güinope
- q = the proportion of those who had rejected of live barriers in Güinope

N.B. $p + q = 1$

In the above formula p*q is at a maximum when p = q = 0.5 and this also gives the maximum sample. Although it is far from certain that p = q = 0.5 in each community i.e. that the proportion of adopters/adapters of live barriers is the same as those who had rejected the technology, it was decided to use these figures because they gave the maximum sample size per community. Sixty-eight farmers in the 15 communities were interviewed.

Sergio Larrea subsequently carried out a semi-structured interview with 10 farmers from the Güinope region who had adapted live barriers (Chapter 7). The semi-structured interviews were partly designed partly to shed more light on some of the more important issues highlighted by the structured interview with regards to the motivation of farmers using live barriers and the criteria that they used/use when selecting species for the barrier.

7. POSITIVISM, TRANSFER OF TECHNOLOGY AND FARMER INNOVATION

7.1 Introduction to collaborative work with Sergio Larrea

Collaborative work with Sergio Larrea directed at farmers' adaptations of live barriers (Chapters 6 and 10) identified the importance of farmer innovation in agricultural and rural development in the Güinope region as opposed to transfer of technology *per se*. Sergio Larrea, with FRP funds and as part of his undergraduate thesis at EAP, decided to carry out a detailed study of the link between agricultural change in Güinope and farmer innovators. Funding from FRP enabled Larrea to carry out a much more in-depth study (18 months) than would have been the case had he stuck to the timetable normally allocated to students at EAP (three months).

Building on the ideas of Paulo Freire (1990 & 1994) Larrea decided to explore the idea that in the past homogenous technologies have largely been imposed on farmers irrespective of cultural differences. As a result this type of transfer of technology does not permit farmers' participation and therefore largely excludes farmer experimentation, the generation of new ideas, and farmers assuming responsibility for their actions. Larrea's research has been based on the idea that agriculture is not just a technical activity but also a social one and as such agricultural practices are a reflection of a farmer's perceptions and values *etc*. as well as bio-physical constraints and opportunities.

7.2 Positivism and agricultural development

Since the early seventeenth century, scientific investigation has come to be dominated by the Cartesian paradigm, commonly called positivism or rationalism (Pretty, 1995). The process of reductionsim involves breaking down components of a complex world into discrete parts, analysing them and then making predictions about the world based on interpretations of these parts. Knowledge about the world is then summarised in the form of universal and context-free generalisations or laws. It is this positivist approach that has led to the generation of technologies for farmers that have been applied widely and irrespective of context (Pretty, 1995). However, farmers have a different perspective on what is a problem and what constitutes improvement in an agricultural system.

Positivism has led to a simplification of the natural and social mechanisms of small-scale agriculture. Agricultural/development problems have been analysed and packets of technologies developed. Many agricultural development efforts are still based on this misguided model of technology transfer. Technology is the means employed to achieve a practical purpose. Often it refers to specific technical practices, such as conservation or pest management measures, that can be employed to improve farming. According to the philosophy of technology transfer, development projects aspire to identify improved practices, introduce them to rural communities, and make them stick.

Modern agriculture can generally be characterised by three types of agriculture: industrial, green revolution and many traditional agricultural systems that are carried out by farmers with few resources. The principal objective of the first two types is largely profit whilst that of the third type is food security. The first two types are more homogenous in terms of bio-physical and cultural conditions, and productivity techniques etc. whilst the third system is complex and diverse.

Many traditional agricultural systems rely on complex balances between people and ecologies and may be vulnerable to subtle changes. Systems also depend on relationships between the people themselves and these in turn are influenced by local social and cultural conditions. Change tends to be most appropriate when it is generated from within farms and communities, when it emerges from the local biophysical, cultural, social, and economic context.

The technology transfer approach has various flaws:

- It assumes that agriculture is static, when it actually comprises ever-changing and intricate balances between many biological, physical, and social interactions. Technological fixes are at best temporary.
- Given the complexity within and between communities, it is difficult, costly and unrealistic to expect that experts could identify appropriate technologies.
- Even when appropriate alternatives exist, farmers do not commonly have access to information sources or the information is packaged in inappropriate language or media.
- There is a tendency to treat farmers as passive recipients of externally-imposed solutions. Extension work has often ended up prescribing technologies that undervalue farmers' knowledge and culture.

Agricultural development demands a more independent and local technology generation process. It also needs to address social issues. Sustainable agriculture is more than just the use of effective ideas and practices, it requires a particular approach to learning about the world (Pretty, 1995). Sustainable agriculture needs local innovation. If some degree of agricultural sustainability is the aim of agricultural/development project, then the objective of agricultural extension ought to be the growing ability of an individual to learn, experiment and improve his/her life, rather than the transference of technologies *per se* (see Chapter 11 on farmers' comments on the fundamental role of the World Neighbor's programme in Güinope whereby farmers' self-esteem and subsequent wish/ability to innovate grew out of the realisation that they themselves have the capacity to improve land and increase agricultural production through simple technologies such as the application of chicken manure and the use of cover crops and live barriers).

There is still a need for scientific agricultural/forestry investigations *etc.* but technologies should be developed in conjunction with farmers and should be dynamic so that they can subsequently be adapted by farmers to changing social, economic and ecological conditions. If farmers do not participate in generating technologies, their ability to learn and experiment is reduced (Freire 1965 & 1990). Rural/agricultural development is more a process of learning and action by farmers than the transference of technologies *per se*.

7.3 Farmer innovation and rural development

Innovation is uniquely human - In our daily lives we are endlessly observing, testing ideas, and reaching conclusions that we store in our memory. Our learning is a cyclical process of trial and error that relies on strengths of observation, analysis, and decision. We can draw on the sum of our experience to construct creative solutions to situations we have never encountered before. Nevertheless, human livelihood depends not only on our ability to respond to problems, but rather our ability to respond wisely.

Past and future agriculture has depended on innovation - Human innovative capacity has been an historic driving force behind agriculture. Through experience, early farmers domesticated plants and animals and developed complex means of using soil, water, and light for human purposes. Farmers have adapted to meet the demands of changing social, cultural, and economic environments. Agriculture has been the result of millennia of creativity to manipulate and manage natural ecologies and social structures in order to meet human needs and interests.

Innovation is a learning and action process - Innovation of agriculture is not merely the passive adoption of new practices (often through a process of transfer of technology). While adoption involves the incorporation of new ideas and practices on the farm, usually through the advice of another farmer or an extension agent, innovation goes one step further. It involves the vision to imagine how things could be improved and the ability to assess options, plan, and act. Innovation is therefore more than just the adoption of other people's recommendations. It is the purposeful adaptation of ideas or practices and the invention of novel approaches to resolving a problem. Innovation is a creative learning and action process directed an improving some aspect of our lives such as agriculture.

Innovation as part of the rural development agenda - There is growing recognition of the importance of farmer knowledge, innovation and experimentation in rural development (Bunch, 1985; Chambers *et al*., 1993; Scoones and Thompson, 1994. Technologies and agriculture are tools that contribute to human development and programmes that facilitate innovation at the farm level as well as personal level are likely to make far greater contributions to rural development than ones that focus on the transfer of technologies *per se*.

Development projects are increasingly looking for ways to inspire and enable genuine innovation among farmers through capacity- building, and the enhancement of a time-honored and independent creative learning process: farmer experimentation. It is now more accepted that the generation of a technology and its subsequent diffusion is a cultural process that is best developed under local conditions with full farmer participation as opposed to an externally-imposed transfer of technology.

The concept of human development and farmer innovation has been synthesised in Honduras by Elías Sánchez (Smith, 1994) and Roland Bunch (1985). The former has expressed the concept of human development through the principles of the human farm. The human farm has three components: the head that generates knowledge, the heart that provides enthusiasm and motivation, and the hands that enable us to act. Although many agricultural/development projects in Mexico and Central America continue to emphasise transfer of technology, there are also examples of agricultural development programmes that have focused on farmer innovation: Campesino to Campesino in Nicaragua (Holt-Gimenez, 1995), World Neighbors in Honduras and Guatemala (Bunch and López, 1994) and the Chilmalapas ecological reserve in Mexico (Russel1, 1996).

Innovation does not exist without innovators - A farmer innovator is not someone who has new technologies or higher incomes but rather someone who is able to adapt to changing ecological, economic and social conditions. What makes a farmer an innovator? A farmer, for example, with little self-esteem often lacks the confidence to experiment with new technologies and to adapt farming practices. One of the main aims of rural development projects should therefore be to foster those human characteristics that lend themselves to innovation (Chapter 11).

7.4 Study of farmer innovation in Güinope, Honduras

7.4.1 Objectives

The objective of the study was to identify how to create more favorable conditions for farmer innovation. Research was carried out in the Güinope region with farmer leaders (see Chapter 6 for details on the Güinope region). The study focused on the following:

- Who are outstanding innovators and what makes them so special?
- Why do these farmers innovate?
- What are the farmers' opinions of present and past development projects, what are their on-going concerns and what would be their recommendations to future programmes in terms of the creation of more favourable conditions for rural development?
- What are the links between grades of innovation in soil and water conservation activities (specifically adaptations of live barriers) and farmer and farm characteristics.

The study, therefore, attempted to identify a number of external factors (institutional factors) that foster or hinder farmer innovation, for example extension methodology of a development project or lack of rural credit. In addition the study sought to identify how a development project may be able to enhance a few of the internal characteristics identified by the farmers themselves as disposing them to be innovators (for example high self-esteem).

7.4.2 Methodology

Larrea used a variety of investigative techniques including observations, exploratory interviews, semi-structured interviews, formal surveys, workshops, construction of mind-maps and secondary sources to shed light on farmer innovation

Exploratory interviews - Larrea initially interviewed ten farmers with experience of soil conservation in order to select the variables for inclusion in the formal survey and semi-structured interviews. These were not the same farmers who participated in the workshops (see below).

Workshops - Two workshops were held for innovative farmers and subsequently a meeting was held with a group of local NGOs to discuss the results of the workshops. The farmers who attended the workshops fulfilled the following criteria:

- They are points of contact between the community and development organisations
- They have adopted and adapted soil and water conservation technologies
- The are recognised community leaders
- They have been involved in farmer to farmer extension activities

The objectives of the first workshop were:

- to share and discuss farmers' motivations for conserving soil
- to elaborate criteria for evaluating the work of development organisations and subsequently to discuss the impact of those organisations that have worked in Güinope

The tools used in both workshops followed suggestions by Pretty *et al.* (1995) and included:

- Sketches of the communities - these enabled farmers to visualise their communities and note the communities' principal characteristics.
- Matrices of the evolving condition of natural resources in each community.
- Open discussion with score cards about the motivations to conserve soil

- Open discussion about the criteria to evaluate the impact of development organisations
- Matrix to evaluate the performance of different development organisations in Güinope..

Analysis of the workshop was distributed to all participants in a post-workshop document. The second workshop was attended by the same group of farmers as the first meeting. The second focused on three questions

i) what are the key personal characteristics of innovative farmers?
ii) how are farmers themselves able to foster these characteristics?
iii) how can development organisations help foster these characteristics?

As in the first workshop, a number of participatory tools were used and a post-workshop document was distributed to all participants.

Semi-structured interviews - semi-structured interviews were carried out with the farmers who attended both workshops (see above). The interviews were designed to shed more light on some of the more important issues highlighted by the workshops. The farmers were visited several times over a four-month period and all interviews were recorded.

Larrea sought more information on farmers' personal histories as a means of documenting the evolution of their perceptions and actions. The interviews clarified further the personal characteristics (internal motivations) and events (external motivations) that may explain why the farmer is an innovator both in his personal life and agricultural practices (conservation of soil).

Formal survey - the survey (Annex 2) was designed to identify those variables, at the personal and farm levels, that influence adaptation of soil and water conservation technologies. The same survey was used in the study of farmer adaptations of live barriers and details of the population size and sampling intensity *etc.* are found in Chapter 6. The variables used in the survey are shown in Table 1. Indices were used in order to summarise the variables. The indices are presented in Annex 2.

Table 1 Variables used in the formal survey of farmer innovation in Güinope

Characteristics of the Farmer	Characteristics of the Farmer
Level of education	Land tenure
Age	Access to irrigation
Size of family	Use of animals in land preparation
Years of experience as a farmer	Access to off-farm labour
Recipient of formal extension advice	Agricultural crops grown
Contribution of farm to livelihood	Area of farm cultivated
Reasons for being a farmer	Quality of land (farmer's perception)
Length of time in the community	Slope

8. QUALITATIVE STUDY OF FARMERS' DEVELOPMENT PRIORITIES AND PERCEPTIONS OF LAND DEGRADATION

8.1 Background

Francis Shaxson (land husbandry specialist) visited Honduras on a consultancy for R6292 at end of January 1997 and pointed out that one of the reasons why farmers adopt, adapt or reject SWC technologies is whether they see the recommendations made by extension/development organisations as relevant to their needs.

Based on Francis Shaxson's suggestions, building on preliminary results from the study of farmer innovations in Güinope (Chapter 11), and following a meeting at EAP with representatives from the *Centro Internacional de Información Sobre Cultivos de Cobertura* (CIDICCO) and the Cornell Institute for Food, Agriculture and Development (CIFAD), Jon Hellin decided to revise activity 3.1 in the original project proposal (*Survey to determine farmers' perceptions of soil erosion problems and research activities. Documentation of indigenous vegetative techniques of soil conservation from literature searches and field work*) and to carry out a qualitative study of farmers' needs and how they perceive land degradation. The study can be seen as the third stage in research conducted at farmer decision-making (see Figure 1).

8.2 Objectives

The main objective of the study was to identify what farmers' main problems are, their perceptions of soil/land, and to document where SWC issues lie in the farmers' decision-making processes. If live barriers and other SWC technologies are to contribute to more sustainable agriculture and rural development, they have to be popular with farmers and fit into the farming systems. A first step is to find out more about farmers' concepts of soil/land. Are they the same as ours? Do we speak the same language as farmers? What are the issues that farmers are concerned with? Is the poor uptake of soil and water conservation technologies because farmers just do not see the recommendations as appropriate to their problems/needs?

8.3 Methodology - semi-structured interviews and focus groups

Jon Hellin discussed the methodology of the qualitative study with the following: Tim Blackman and Abbey Halchi (Oxford Brookes University), Bernardo Pena Ahumada (EAP) and Gaye Burpee (*Centro Internacional de Agriculture Tropical* [CIAT]). It was decided to carry out the qualitative study in Choluteca and Güinope through a series of semi-structured interviews and focus group meetings based on Miles and Huberman (1994), Pretty *et al.* (1995) and Stewart and Shamdasani (1990).

Three communities were selected in each region (six communities in total) and two farmers were selected for semi-structured interviews in each community. One of the farmers had adopted/adapted SWC technologies and the other had not. Two visits were made to each farmer and the interviews on each occasion lasted between 30 minutes and 1.5 hours. All interviews were tapped and subsequently transcribed.

One of the dangers of this type of work with farmers, as identified by Marmillod (1987) in Costa Rica, is that farmers' responses may be unreliable when the interviewers are not previously known to the farmers. Jon Hellin and Sergio Larrea had worked in Güinope since the end of 1995 and had already met some of the farmers interviewed. In addition the invitations to the focus group meetings were made by Mario Zavala and Samuel Carranza in Güinope in Choluteca respectively and they participated in all the focus group meetings. Mario Zavala and Samuel Carranza are farmers who have worked with Jon Hellin and Sergio Larrea for over 18 months and who are themselves well-known in their respective areas. They were also involved in at least the first of the two semi-structured interviews with each of the 12 farmers.

In each community a focus group meeting was organised. In the case of the Güinope region a list of farmers in each community was available. Ten farmers were selected at random from the list and Mario Zavala visited each community a few days before the planned focus group meeting in order to invite the farmers to a meeting. A formal invitation was given to each of the farmer which explained the reason for the focus group meetings. In addition the two farmers who participated in the semi-structured interviews were also invited to the focus group meeting. If a farmer was unable to attend another one on the list was invited.

In the case of Choluteca, Samuel Carranza who is the farmer in charge of the live barriers/cover crops trial site visited the three communities and invited the same number of farmers as was the case in Güinope. In the case of Choluteca, there was not a list available of farmers in each community and the selection of the focus group participants was based on a stratified sample. In almost every case, all the invited farmers attended the focus group meetings. All focus group meetings were tapped and subsequently transcribed.

8.4 Early steps in analysis

Based on Miles and Huberman (1994) a contact summary sheet was drawn up after every interview and focus group meeting. A preliminary lists of codes, designed to reflect the *conceptual framework, list of research questions, hypotheses, problem areas, and/or key variable that the researcher brings to the study* (Miles and Huberman ,1994), were drawn up and all the transcribed notes were coded.

9. RESULTS FROM THE LIVE BARRIER/COVER CROP TRIAL SITE

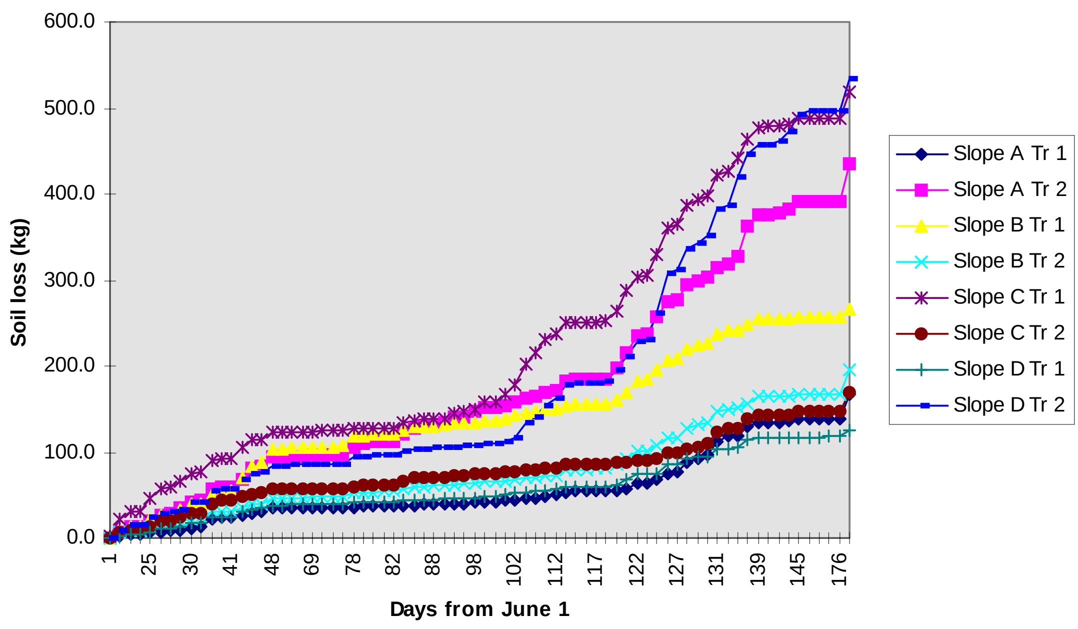
The results are presented for 1996 and until the end of September 1997. The rains in Honduras normally last until the end of October/beginning of November and therefore more soil and water loss is anticipated beyond the period of FRP funding. In December 1997, FRP will be sent full results for 1997.

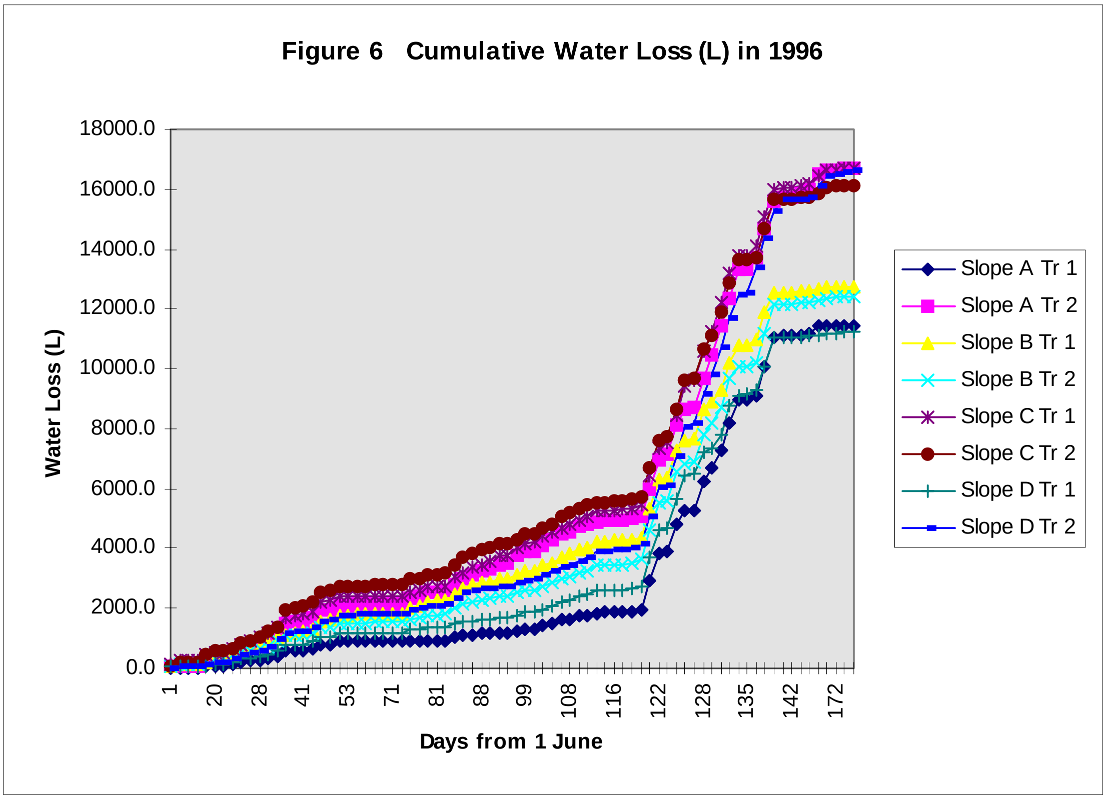
9.1 1996 Results

9.1.1 Water and soil loss from the plots with barrels in 1996

Figures 5 and 6 shows the cumulative soil loss (kg) and water loss (litres) from the eight plots where runoff is collected in barrels after each runoff event. The data are from 1996. Treatment 1 is the control without live barriers and treatment 2 is the *V. zizanioides*/*G. sepium* live barrier. There was considerable variation across the site with total soil loss varying from 125.2 kg (10.4 t ha^{-1}) in the case of Treatment 1 on Slope D (65-75%) to 533 kg (44.4 t ha^{-1}) in the case of Treatment 2 on Slope D (65-75%). Water loss varied from 11,200 litres to 16,700 litres in the case of the Treatment 1 plots on Slopes D and C respectively (see Figure 2 for a map of the trial site).

Figure 5 Cumulative Soil Loss (kg) in 1996





9.1.2 Justification of use of covariates in analysis of results from 1997

In consultation with Andrew Pinney (CONSEFORH) is was agreed that the variation in soil and water loss demonstrated by Figures 5 and 6 could be accounted for by using the end of season results as covariates in the analysis of results from 1997 (see section 9.2).

There were several justifications for this.

i) The results of an analysis of variance of total soil and water loss at the end of 1996 (Figures 7 and 8 respectively) demonstrate that neither slope nor treatment are significant. In both case the F probability values are very high. Figures 7 and 8 also demonstrate that although there was more soil and water loss from the 65-75% slopes compared to the 35-45% slopes, there was greater soil and water loss on those plots with live barriers in comparison with the control plots. These results, although not significant, are operating against the hypothesis that there is less soil lost on plots with live barriers than those without. Figures 5, 6, 7 and 8 suggest that there is potential for using the results from 1996 as a covariate in the analysis of the results from 1997.

ii) The differences between plots in terms of soil loss and runoff remain constant during the season. The only exception is the soil loss from Slope D Treatment 2.

iii) The live barriers were established at the end of July 1996 and had not developed fully by the end of the season. There are strong grounds for arguing that the results of the 1996 season show the inherent variation of the site as opposed to any effect of the barriers themselves. Hence the end of season results for soil and water loss demonstrate the effect of the site as opposed to any effect of treatment.

9.1.3 Analysis of variance of results from catchpits and barrels

The results of the experiment to determine the amount of soil retained by catchpits (Chapter 5) showed that over 95% of soil is retained. Similarly work by Gaye Burpee (pers. comm.[soil scientist, CIAT) in Güinope in Honduras has shown the catch-pit methodology to be an accurate way of calculating soil loss.

In terms of treatments 1 and 2 (control and grass/tree live barrier) and as shown in Figure 9, an analysis of variance was therefore carried out on soil loss from 16 plots (eight barrel and eight catchpit plots). The results of the analysis of variance (see below Figure 9) are similar to the analysis of variance of the data from the eight barrel plots (Figure 7). There are no significant differences between slope or treatment despite increasing the degrees of freedom.

In addition an analysis of variance was carried out on the soil loss from all 24 replicated plots with the following treatments - no live barrier; *V. zizanioides*/*G. sepium* live barrier; *V. zizanioides* live barrier; and *G. sepium* live barrier. Figure 10 and the accompanying analysis of variance table again show that neither slope nor treatment are significant.

Analysis of variance for soil loss for Figure 7

Variate: Soil loss

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Main plot stratum					
Slope	1	9.865E+09	9.865E+09	3.79	0.191
Residual	2	5.205E+09	2.603E+09	0.03	
Main plot.*Sub-plots* stratum					
Barrier	1	8.214E+09	8.214E+09	0.10	0.786
Slope.Barrier	1	2.366E+09	2.366E+09	0.03	0.883
Residual	2	1.716E+11	8.581E+10		
Total	7	1.973E+11			

Slope at the main plot stratum (F probability 19.1%) and barrier effect at the sub-plots stratum (F probability 78.6%) are not significant, nor is the interaction between the two.

Figure 7 Mean soil loss (g) in 1996 for two treatments (no live barrier and a *V. zizanioides* / *G. sepium* live barrier) on two different slope angles (35-45% and 65-75%). Data from eight plots. Soil collected in barrels after each runoff event. Vertical error bar = 1 standard error of the difference for means.

Y axis = Soil loss (g) X axis = Treatment

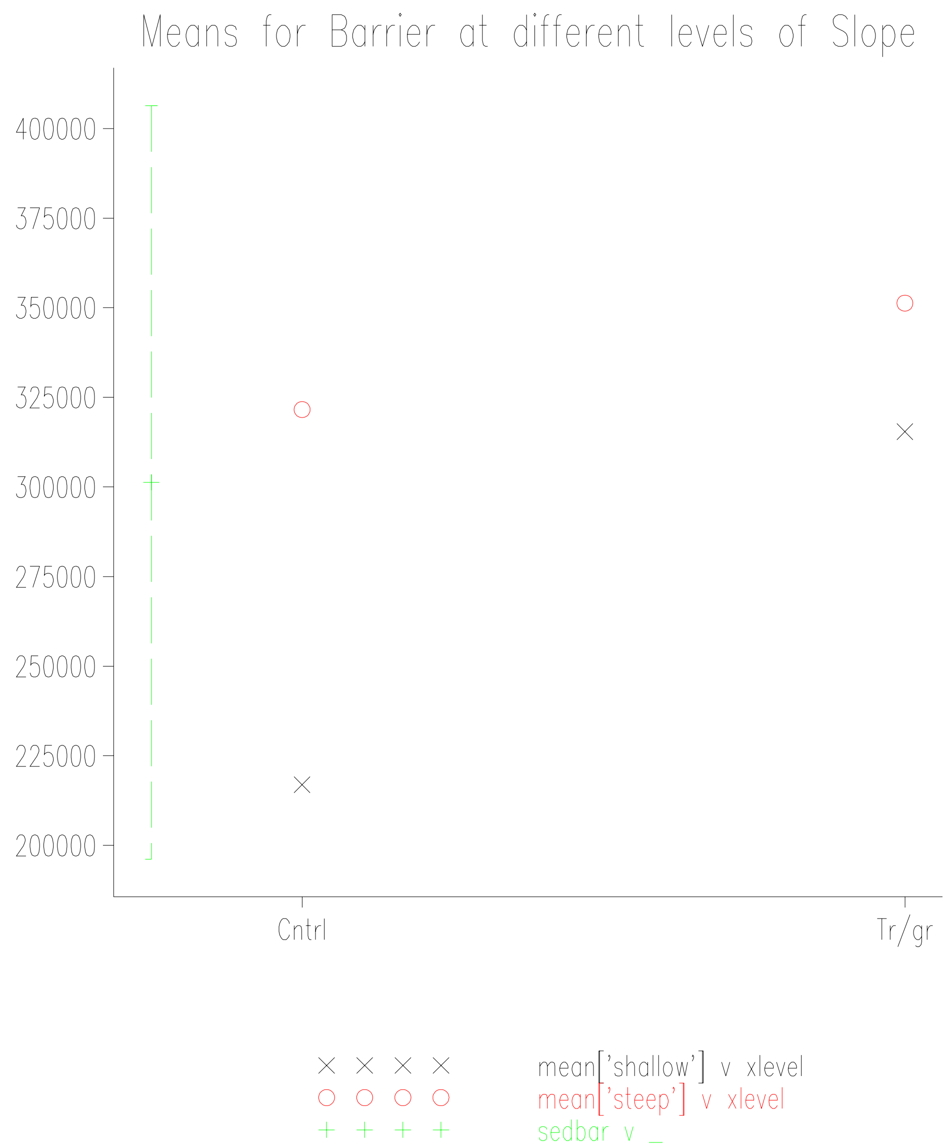


Figure 8 Mean water loss (L) in 1996 for two treatments (no live barrier and a *V. zizanioides* / *G. sepium* live barrier) on two different slope angles (35-45% and 65-75%). Data from eight plots. Water collected in barrels after each runoff event. Vertical error bar = 1 standard error of the difference for means.

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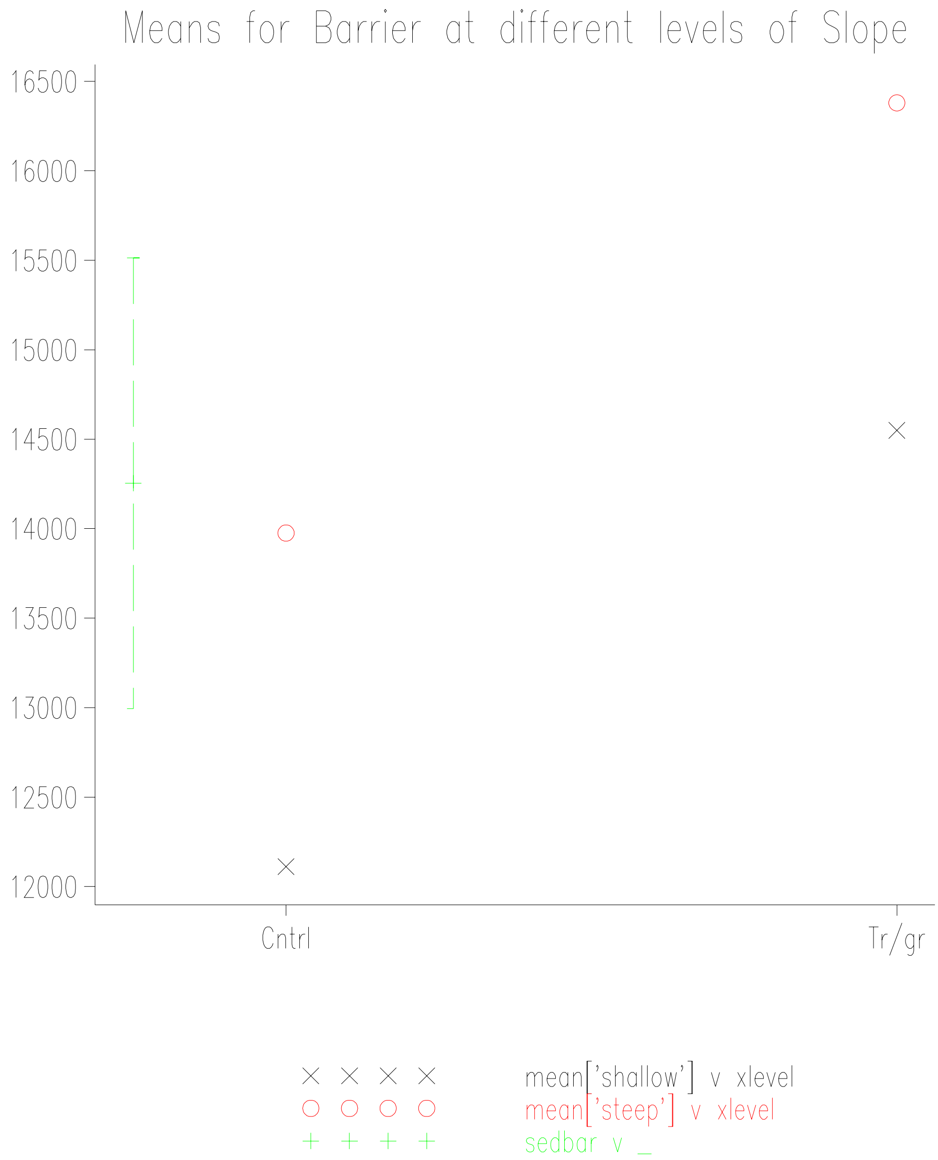
Y axis = water loss (L) X axis = Treatment



Analysis of variance for water loss for Figure 8

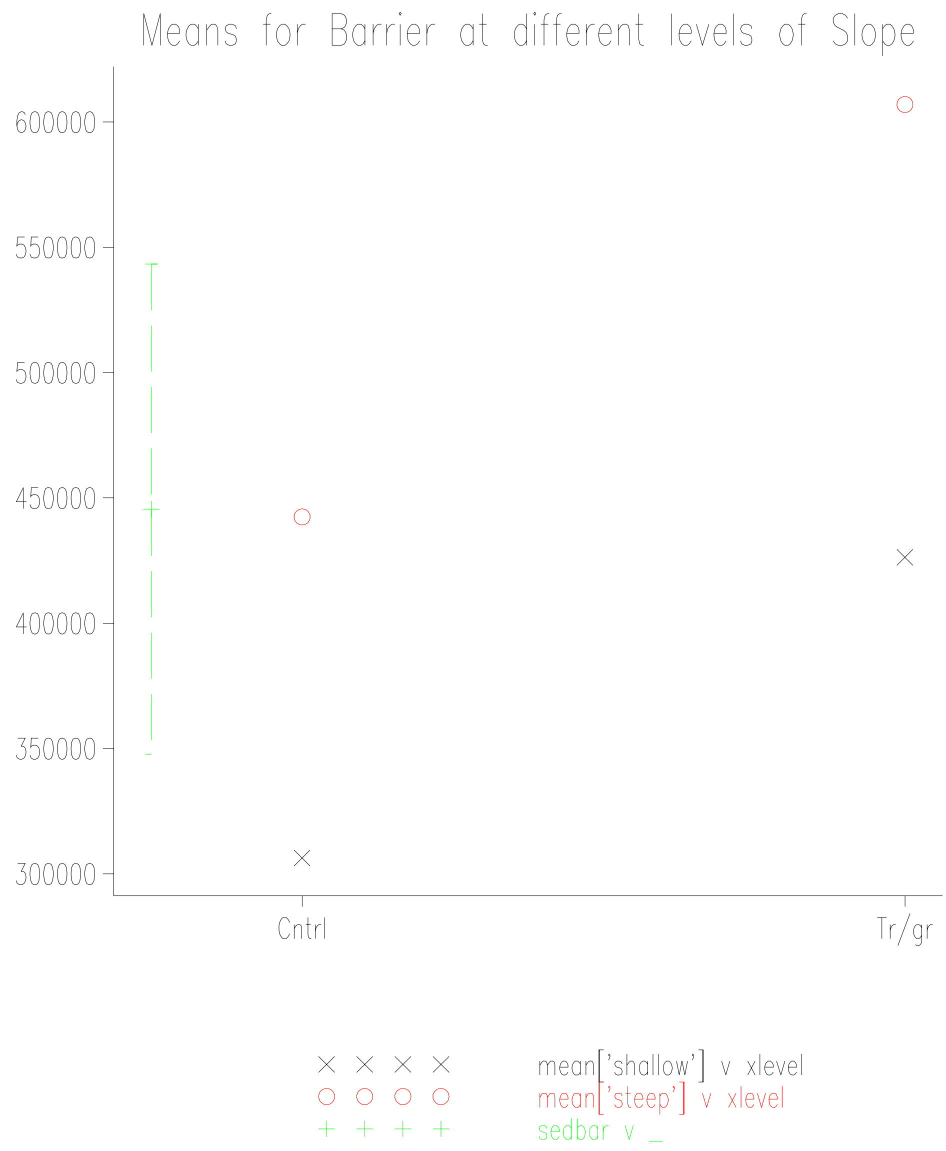
Variate: Water loss

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Main plot stratum					
Slope	1	6824480.	6824480.	1.60	0.334
Residual	2	8556885.	4278442.	0.51	
Main plot.*Sub-plots* stratum					
Barrier	1	11729020.	11729020.	1.40	0.359
Barrier.Slope	1	563.	563.	0.00	0.994
Residual	2	16804852.	8402426.		
Total	7	43915800.			

Slope at the main plot stratum (F probability 33.4%) and barrier effect at the sub-plots stratum (F probability 35.9%) are not significant, nor is the interaction between the two.

Figure 9 Mean soil loss (g) in 1996 for two treatments (no live barrier and a *V. zizanioides* / *G. sepium* live barrier) on two different slope angles (35-45% and 65-75%). Data from 16 plots. Soil collected in barrels after each runoff event in eight plots, and soil collected in plastic-lined catchpits in eight plots. Vertical error bar = 1 standard error of the difference for means.

Y axis = Soil loss (g) X axis = Treatment



Analysis of variance for soil loss for Figure 9

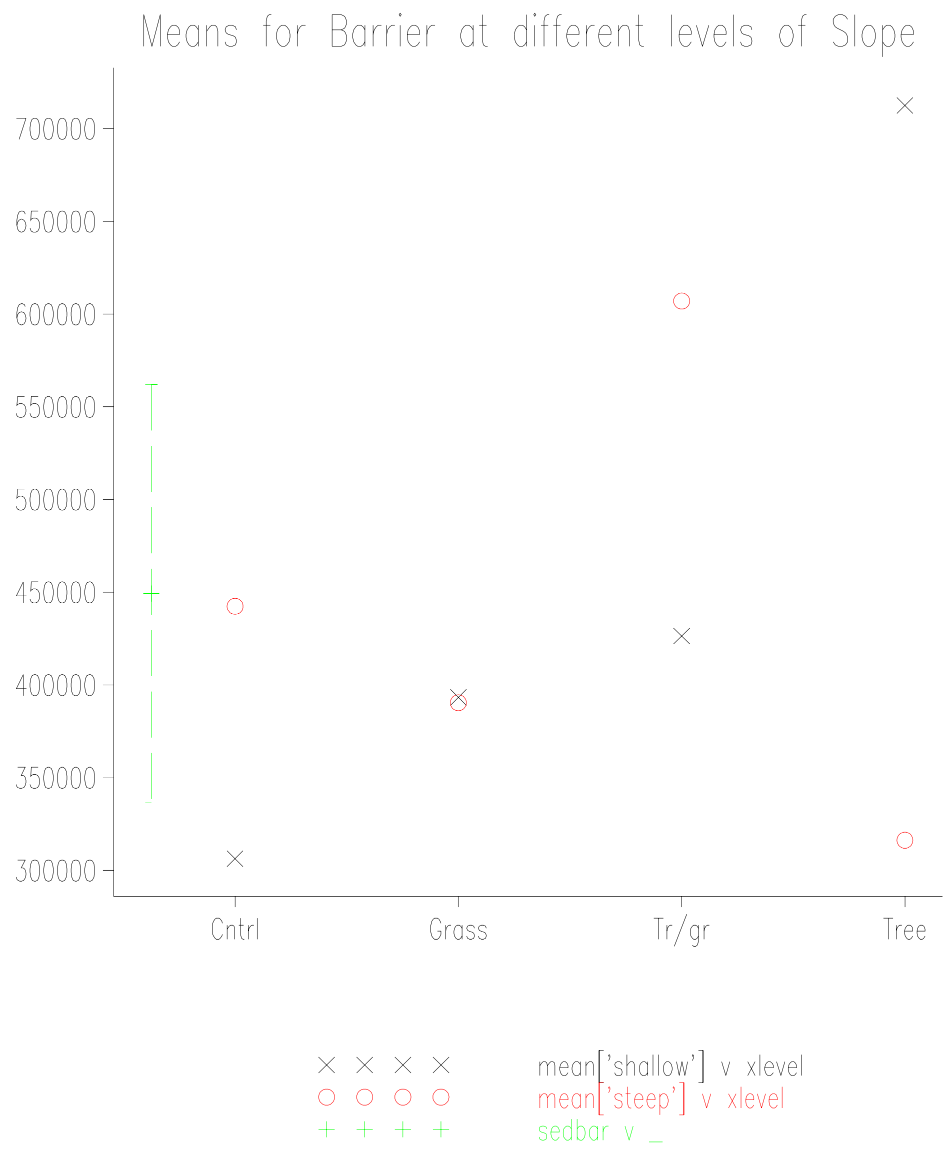
Variate: Soil loss

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Main plot stratum					
Slope	1	1.004E+11	1.004E+11	1.26	0.378
Residual	2	1.593E+11	7.963E+10	1.08	
Main plot.*Sub-plots* stratum					
Barrier	1	8.103E+10	8.103E+10	1.10	0.318
Barrier.Slope	1	1.984E+09	1.984E+09	0.03	0.873
Residual	10	7.348E+11	7.348E+10		
Total	15	1.077E+12			

Slope at the main plot stratum (F probability 37.8%) and barrier effect at the sub-plots stratum (F probability 31.8%) are not significant, nor is the interaction between the two.

Figure 10 Mean soil loss (g) in 1996 against four barrier types (no live barrier; *V. zizanioides / G. sepium* live barrier; *V.* zizanioides live barrier; and *G.* sepium live barrier) on two different slope angles (35-45% and 65-75%). Data from 24 plots. Soil collected in barrels after each runoff event in eight plots, and soil collected in plastic-lined catch pits in 16 plots. Vertical error bar = 1 standard error of the difference for means.

Y axis = Soil loss (g) X axis = Treatment



Analysis of variance for soil loss for Figure 10

Variate: Soil loss

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Main plot stratum					
Slope	1	9.155E+09	9.155E+09	0.10	0.783
Residual	2	1.851E+11	9.254E+10	1.52	
Main plot.*Sub-plots * stratum					
Barrier	3	1.114E+11	3.712E+10	0.61	0.620
Barrier.Slope	3	2.502E+11	8.341E+10	1.37	0.292
Residual	14	8.519E+11	6.085E+10		
Total	23	1.408E+12			

Slope at the main plot stratum (F probability 78.3%) and barrier effect at the sub-plots stratum (F probability 62.0%) are not significant, nor is the interaction between the two.

9.1.4 Regression analysis - rainfall intensity and total rainfall

The Universal Soil Loss Equation (USLE) and Revised Universal Soil Loss Equation (RUSLE) treat soil loss as a function of five parameters: rainfall erosivity; soil erodibility; slope-length and slope-gradient; crop cover and management; and the erosion control practices. The relationship between soil loss and rainfall erosivity/total rainfall was tested.

Rainfall erosivity - the EI index

In terms of rainfall erosivity, the best estimator of soil loss is a compound parameter, the product of the kinetic energy of the storm and the 30-minute intensity (Hudson, 1995). The latter is the greatest average intensity in any 30-minute period during a storm. This amount is doubled to give the same dimensions as intensity i.e. rainfall in mm per hour (Lal and Elliot, 1994). Research in 1991 in Nicaragua in plots 22.1 x 4.0 m gave R^2 value of 0.88 when EI_{30} values were correlated to soil losses from bare soil treatments (Rivas, 1993).

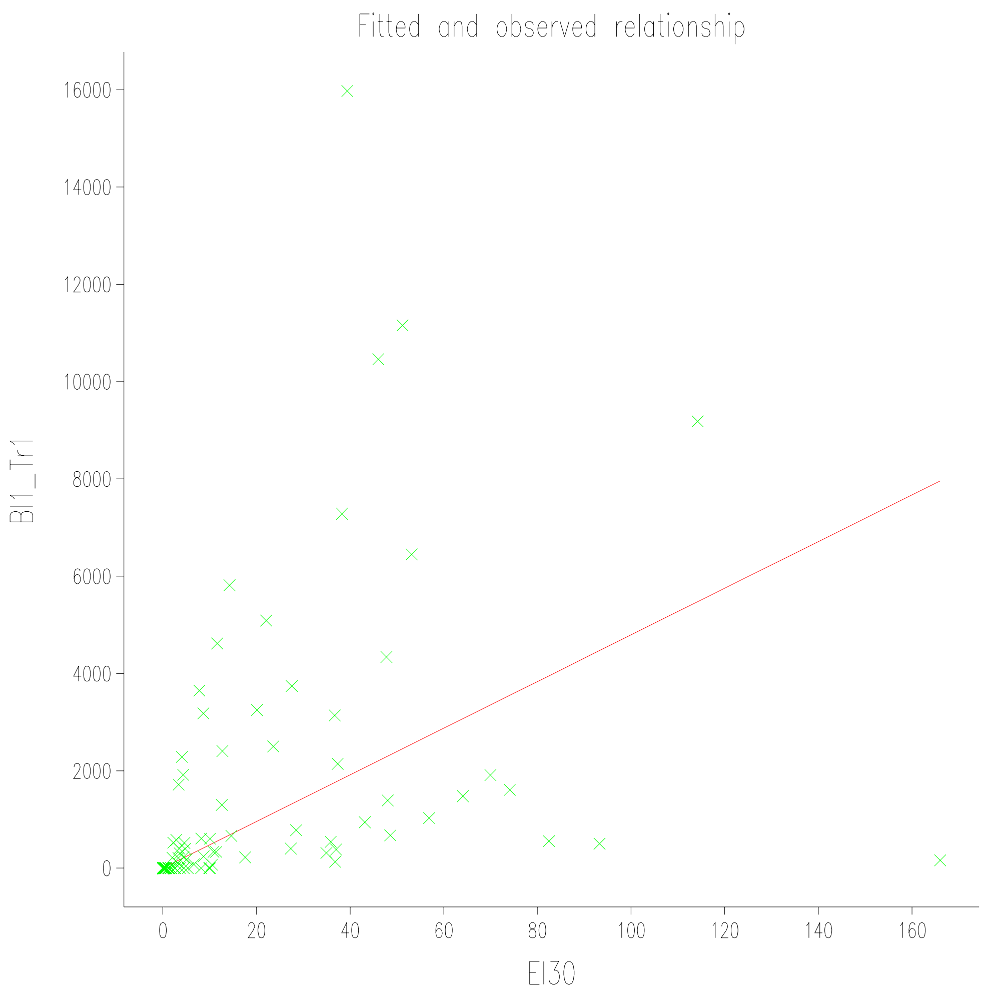
Rainfall erosivity - the KE>25 index

Hudson (1995) also states the intensity of 25 mm per hour can be taken as a practical threshold separating erosive and non-erosive rain. An erosivity index, KE>25, consisting of the total kinetic energy of all the rain falling at more than 25 mm per hour has often given an excellent correlation with soil loss. (Hudson, 1995).

Calculations

The EI index, KE>25 index and total rainfall were calculated for each rainfall event using data from the rainfall intensity gauge. A linear regression analysis, with the constant at 0, was carried out on the relationship between the EI index, KE>25 index and total rainfall, and total soil loss (Kg) for each of the eight barrel plots. See Figure 11 for the regression line for Treatment 1 on Slope A (35-45%) with the erosivity index.

Figure 11 Plot of soil loss in grams (y axis) for Treatment 1 (control without live barriers) on Slope A (35-45 %) and the erosivity index EI_{30} in erosivity units (x axis) during 1996. The regression line is fitted, *soil loss = 47.94 * EI_{30}* which accounted for only 28.2 % of the variation



9.1.5 Results of the linear regressions - the importance of soil cover

Results of the regression analyses for the other seven plots are similar to those shown in Figure 11 in terms of low R^2 values. The low R^2 values are almost certainly due to the effects of cover and antecedent soil moisture. For example in Figure 11, the outlying point showing a soil loss of 16,000 grams with a corresponding storm with an EI Index of 39.39 erosivity units occurred on 9 October 1996. This rainfall event followed several days of moderately intense rain and the soil was saturated. In addition the first maize crop had been harvested at the end of September and the plots had been weeded prior to sowing the second maize crop in the first few days of October.

Farmers had also removed the old maize stalks from the research plots after the maize harvest because the rotting matter adversely affects the growth of the subsequent maize crop. There was very little cover, the soil was saturated and consequently a moderately-intense storm on 9 October 1996 caused considerable soil loss. Several of the points that lie above the best-fit line and that likewise show considerable soil loss with moderate rainfall intensity, also come from the period immediately after 29 September 1996.

Conversely the graphs show a soil loss of 161.5 grams with an intense storm with an EI index of 166.04 erosivity. The storm occurred on 18 November 1996. It had not rained for over three weeks, the ground was therefore very dry and infiltration rates were high. In addition the maize crop had developed and was providing much cover and the farmers had not weeded for several weeks. There was extensive ground cover and hence the intense storm did not cause heavy soil loss

The regression analyses demonstrate the importance of including other parameters when explaining soil loss, especially ground cover. The importance of ground cover provides a valuable link between live barriers and cover crops, a link that is being demonstrated at the trial site; cover protects the soil against rainfall - the vertical component of the erosion process - and live barriers protect the soil against runoff - the horizontal component of the erosion process. The latter also have important socio-economic functions because they can make considerable contributions to farm income through the provision of fruits and fodder *etc.* (see section 3.1).

9.1.6 Erosion pins

Two common measurment problems were encountered. The washer was often buried where soil had accumulated, although this problem was resolved by slipping a washer onto the nail when measuring it. Where erosion had taken place, the washer was sometimes suspended on a pedestal of protected soil. This was rectified by breaking down the pedestal so that the washer was at the same level as the surrounding soil.

Data from 1996 showed that erosions pins were not very accurate at recording soil loss. A comparison of soil loss as indicated by the erosion pins, with that recorded by the barrels or catchpits for the same plot, showed some extreme differences especially in the case of those plots with live barriers. In some cases erosion pin data indicated a soil gain and not a soil loss.

There are several possible explantions for this:

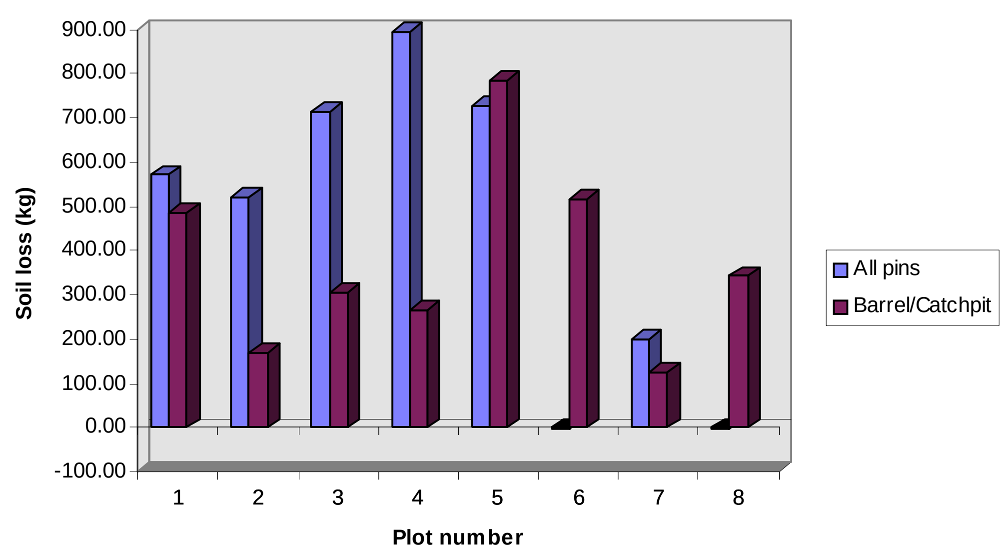
- With the pins located immediately above and below the barrier, there is a bias towards measuring accumulation (above the barrier) while soil loss is only being measured from immediately below the barrier and not in the 4 metre strip between one line of erosion pins just below a live barrier and the line just above the lower live barrier. Results may have been more accurate had the pins been placed in the areas between live barriers.

- Although farmers are aware where the nails are and of the need to avoid knocking them, it is clear that especially on the steep slopes some of the nails have been knocked. However, nails that had clearly been dislodged were not included in the soil loss calculations.

- The soil is very erodible and as farmers work on the plots some soil is dislodged. periodically this covers some of the nails hence increasing the inaccuracy of the readings.

Plots without live barriers were not affected by the first of the above problems (Figure 12). In these cases erosion pins on the shallow slopes (35-45%) (Plots 1, 2, 3 and 4 in Figure 12) tended to exaggerate soil loss whilst those on the steep slopes (65-75%) (Plots 5, 6 , 7, 8 in Figure 12) tended to record lower soil losses than was the case.

Figure 12 Soil loss (kg) control plots



Analysis of variance for differences in soil loss recorded by erosion pins and barrels/catchpits

Variate: Soil

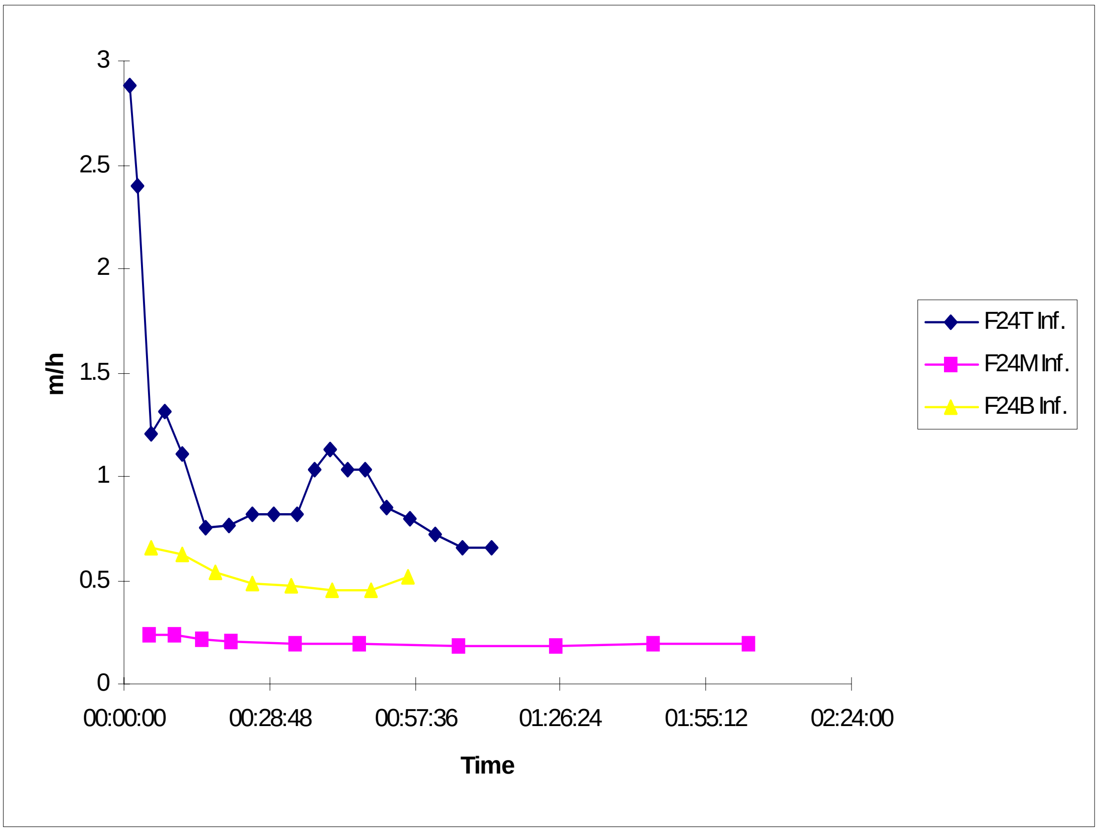
Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Slope	1	673094.	673094.	10.93	0.016
Residual	6	369414.	61569.		
Total	7	1042507.			

The tendency of erosion pins to exaggerate soil loss on shallow slopes (35-45%) and to under-record soil loss on steep slopes (65-75%) is significant (F probability 1.6 %) and concurs with CIAT's results with cover crops in Güinope (Gaye Burpee, pers. comm.[soil scientist, CIAT]).

9.1.7 Infiltration tests

Collaborative research with Guillermo Mendoza (Cornell University) showed that infiltration rates were vary varied on the site (Figure 13). The variation was so extreme both within plots that the results could not be used to explain the variation in runoff between plots (section 9.1.1).

Figure 13 Infiltration rates in m/hr for Treatment 1 on Slope D (65-75%). F24 is the code of the plot. T, M, and B refer to infiltration positions in top, middle and bottom sections of the plot respectively (see also Photograph H)



Mendoza's research both at the trial site in Choluteca and in Güinope, showed that lateral subsurface flow was likely to be an important component of hillside hydrology generating runoff. In Güinope, subsurface lateral flow occurred within 20 cm of the soil profile on an unsaturated soil layer of higher bulk density and clay content. Mendoza concluded that physical characteristics of the subsoil may be more important than soil surface characteristics in the generation of runoff. This conclusion is supported by John Quinton (Silsoe College, Cranfield University) who has pointed out (pers. comm.) that especially on the steep slopes the dominant erosion mechanism is likely to be hydraulic erosion and not splash erosion.

9.1.8 Maize yields

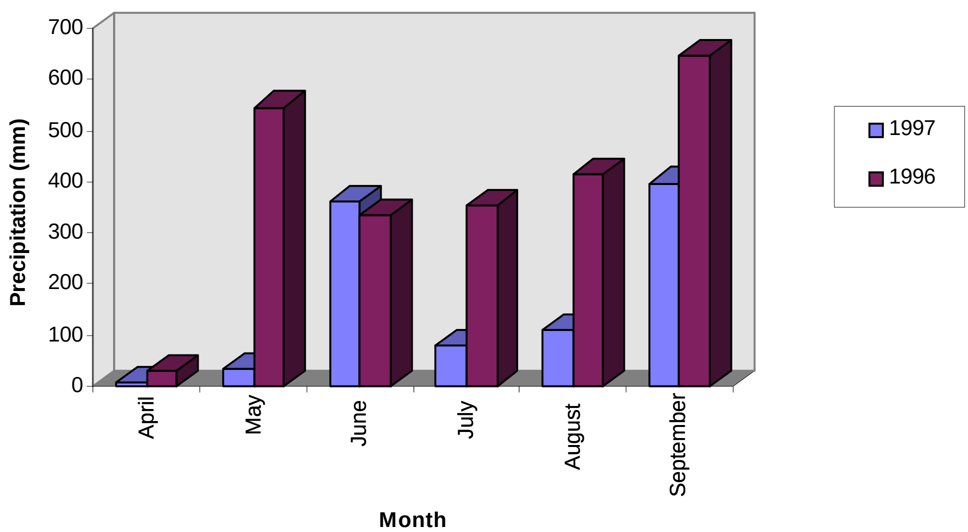
Maize yields in September 1996 (the *primera*) and January 1997 (the *postrera*) varied from 1000-3000 kg/ha and 800-2000 kg/ha. Local farmers said that these yields were high and could be accounted for by the good rains. It was decided to use the means of these two harvests as a covariate in the analysis of the *primera* in 1997.

9.2 1997 Results

9.2.1 Rainfall

Southern Honduras and especially the department of Choluteca was badly affected by *El Niño* in 1997. As can be seen in Figure 14, total precipitation from May-September 1997 was 985 mm as compared to 2294 mm in the same period in 1996. Although there was more rainfall in June 1997 than in the same month in 1996 (361 mm and 333 mm respectively) almost 40% of this fell in early June as a continuous light drizzle over a three-day period and there was no soil loss. The failure of the rains seriously affected data collection at the trial site both in terms of erosion data and maize yield data.

Figure 14 Precipitation (mm) in 1996 & 1997



9.2.2 Water and soil loss from the plots with barrels in 1996

As can be seen in Figures 15 and 16, cumulative soil and water loss from the plots was minimal. Soil loss varied from 2.5 kg (0.21 t ha^{-1}) in the case of Treatment 2 on Slope C to 9.2 kg (0.77 t ha^{-1}) with Treatment 1 on slope D. Water loss varied from 190 L with Treatment 2 on slope D to 528 L with Treatment 2 on slope B.

In comparison, by the end of September 1996, cumulative soil and water losses had ranged from 74.4 - 303.2 kg (6.2 - 25.3 t ha^{-1}) and 3,900 - 7,600 litres respectively. Several single rainfall events in 1996 generated more soil and water loss than the cumulative losses for the entire 1997 rainy season until the end of September.

Patterns seem to be emerging, for example, in the case of water loss (Figure 16), plots on slopes A, B, C and D are loosing similar amounts of water irrespective of treatment. However an analysis of variance of total soil and water loss until the end of September, with and without covariates did not show any significant differences either with slope at the main plot stratum or barrier effect at the sub-plot stratum. See Figure 17 for the analyses of variance of soil loss from the eight plots with barrels with and without the use of covariates.

With such small amount of erosion and water loss per storm (at times 10-20 grams) it is perhaps not surprising that significant differences between treatments have not occurred.

Figure 15 Cumulative Soil Loss (kg) in 1997

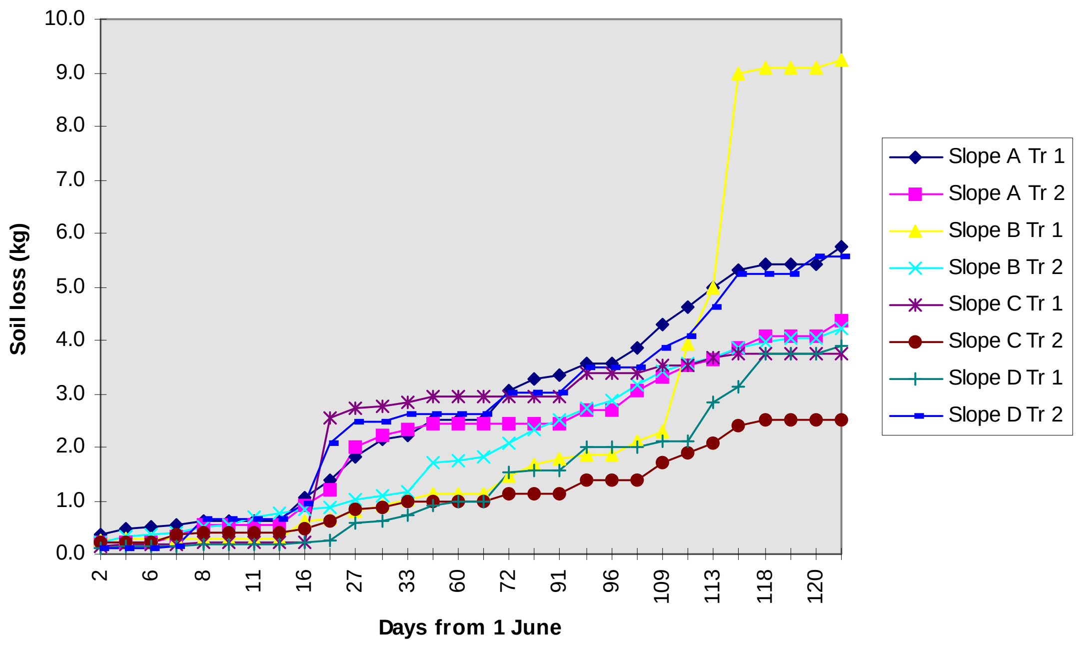
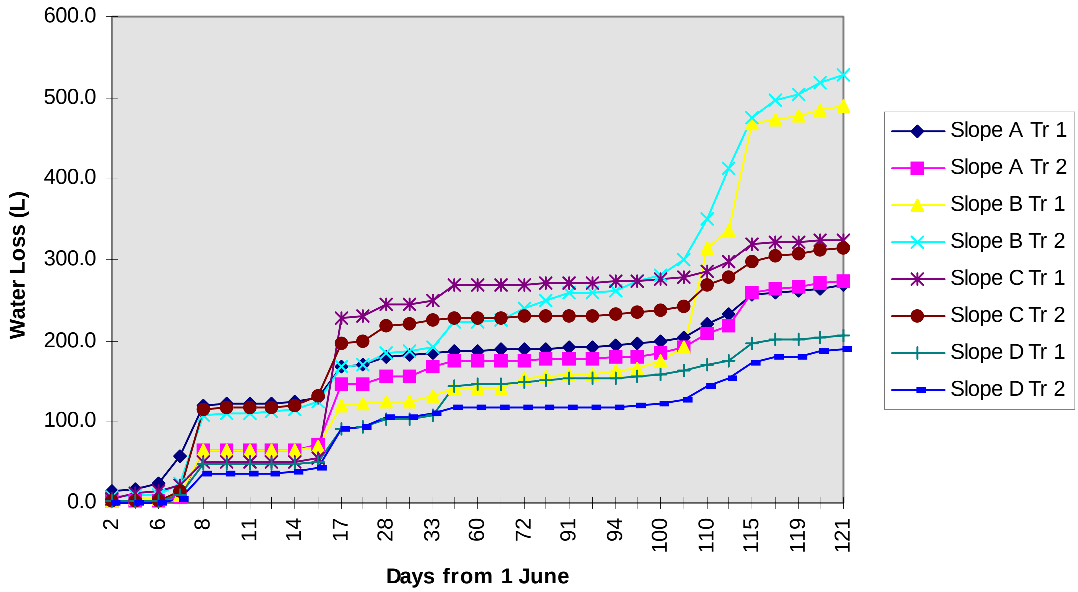


Figure 16 Cumulative Water Loss (L) in 1997



Analysis of variance for soil loss for Figure 17

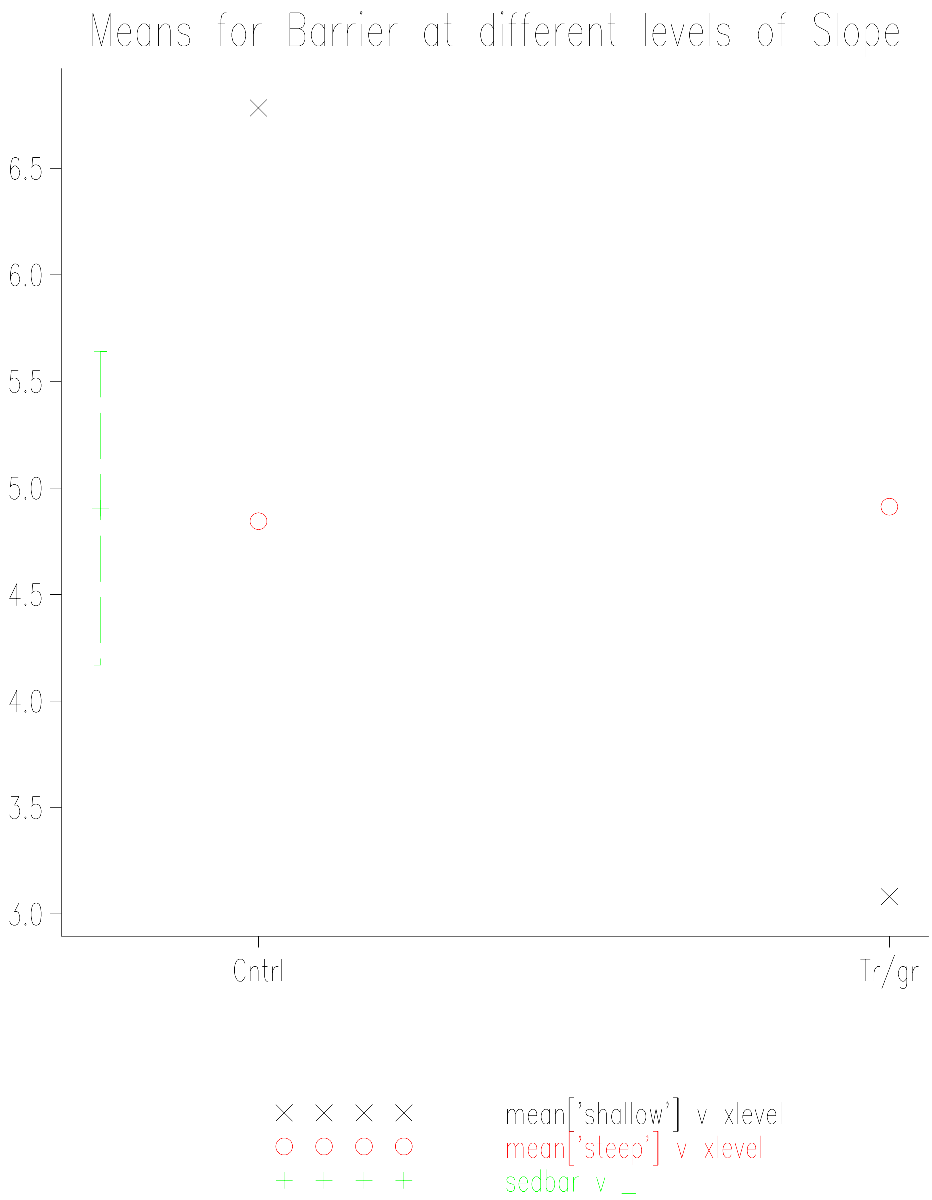
Variate: Soil loss

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Main plot stratum					
Slope	1	7.738	7.738	2.90	0.230
Residual	2	5.329	2.664	0.98	
Main plot.*Sub-plots* stratum					
Barrier	1	4.484	4.484	1.65	0.328
Slope.Barrier	1	5.873	5.873	2.16	0.280
Residual	2	5.444	2.722		
Total	7	28.868			

Slope at the main plot stratum (F probability 23.0 %) and barrier effect at the sub-plots stratum (F probability 32.8 %) are not significant, nor is the interaction between the two. The use of covariates did not reduce the F probability values.

Figure 17 Mean soil loss (kg) in 1997 for two treatments (no live barrier and a *V. zizanioides* / *G. sepium* live barrier) on two different slope angles (35-45% and 65-75%). Data from eight plots. Soil collected in barrels after each runoff event. Vertical error bar = 1 standard error of the difference for means. Covariates used.

Y axis = Soil loss (g) X axis = Treatment



9.2.3 Maize yields (*primera*)

The failure of the rains in 1997 severely affected the maize harvest. In July, farmers were predicting an almost complete failure of the maize crop. Their predictions did not come true but harvests were much less than either of the two harvests in 1996. One of the objectives of the trial site was to investigate whether maize yield reductions were greatest in plots which suffered from most erosion, and whether maize production was influenced by treatment . The lack of rain prevented a meaningful analysis being carried out. Maize yields in September 1997 varied from plot to plot and there was no relationship with soil loss or treatment. The second maize harvest - the *postrera* - may show some differences.

9.2.4 Cover crop

The lack of rain also affected the development of the *mucuna* spp. used as a cover crop. In an analysis of soil loss from the plots with live barriers of *C. citratus* and those with live barriers of *C. citratus* and *mucuna* spp., there were again no differences in soil loss.

9.2.4 Activities until December 1997

There may be more rain in October and there is still a possibility that the trial site may start to show significant differences between treatments. Jon Hellin has decided to continue working in Honduras until early 1998 and in December, FRP will be sent full results from 1997. The follow-up report will include information on soil loss after 30 September and if funding is not secured for a third season (see Chapter 14), information on changes in soil chemical and physical characteristics.

9.3 Conclusions from the trial site

The results from 1996 and 1997 did not show significant differences in soil retention between treatments. The four principal treatments; no live barrier; grass barrier; tree barrier; and a grass/tree barrier capture the variety of live barriers used by farmers in Central America. It may be the case that by the end of the rains there are still no significant differences between the live barrier treatments, or that the amount of soil retained by different treatments is largely insignificant compared to the total amount lost.

This would still have implications for the nature of extension work carried out *i.e.* live barriers should only be promoted with other technologies such as cover crops, or if there is a soil erosion problem, it would really not make that much difference if a grass species were used or if a farmer used an “anarchic” combination of 8-10 tree, shrub and grass species in live barriers. It would also bring into question the virtue of millions of dollars being spent to promote for example live barriers of *V. zizanioides* (vetiver grass) if this species is not significantly better at retaining soil than other species, and in turn does not seem to be very popular with farmers (see Chapter 10).

On the other hand if there are significant differences between the treatments, then again extension work could be modified. An extension agent, for example, could identify if the obstacles to adopting SWC technologies exist, if they do not it may be worthwhile working in the region. In a hypothetical case, farmer *x* suffers some degree of soil erosion and wishes to do something about it. The results from the trial site indicate that on 35-45 % slope a tree live barrier is *y* percent less effective at retaining soil than a grass barrier.

The extension agent and farmer can discuss the advantages/disadvantages of using a grass in terms of improved soil retention as opposed to the advantages/disadvantages of using a tree barrier that will retain less soil but perhaps make far greater contributions to the farming system in terms of the provision of fruits. The tree barrier may prove to be less effective than a grass barrier in retaining soil but more profitable from a farmer's point of view. The methodology for deciding if a live barrier is a suitable technology and if so which species to use, is included in the manual (see Chapter 13).

The trial site will also give some indication as to the time period before significant differences are seen between treatments. Bearing in mind farmers' time-horizons it may not be sensible to promote live barriers if the advantages in terms of soil retention are not seen for more than 2-3 years. This may be to long for many farmers to wait unless (once again) the species in the barriers provide products for consumption/sale in the first two years..

10. FARMERS' ADOPTION AND ADAPTATION OF LIVE BARRIERS - RESULTS

10.1 Species used in live barriers by farmers in Güinope

The sixty-eight farmers interviewed as part of a formal survey (Chapter 6) are using a total of 12 species in live barriers even though during the RRA 19 species have been documented (see Table 2). Adoption was defined as the use of the live barriers promoted by World Neighbors i.e. *P. purpureum* (Napier Grass) and *P. purpureum* x *P. typhoides* (King grass) and adaptation as the use of species other than the two grass species. Farmers who had adapted were not separated into first-time users of other species and those who started with live barriers of *P. purpureum* (Napier Grass) and *P. purpureum* x *P. typhoides* (King grass) and whom subsequently selected other species.

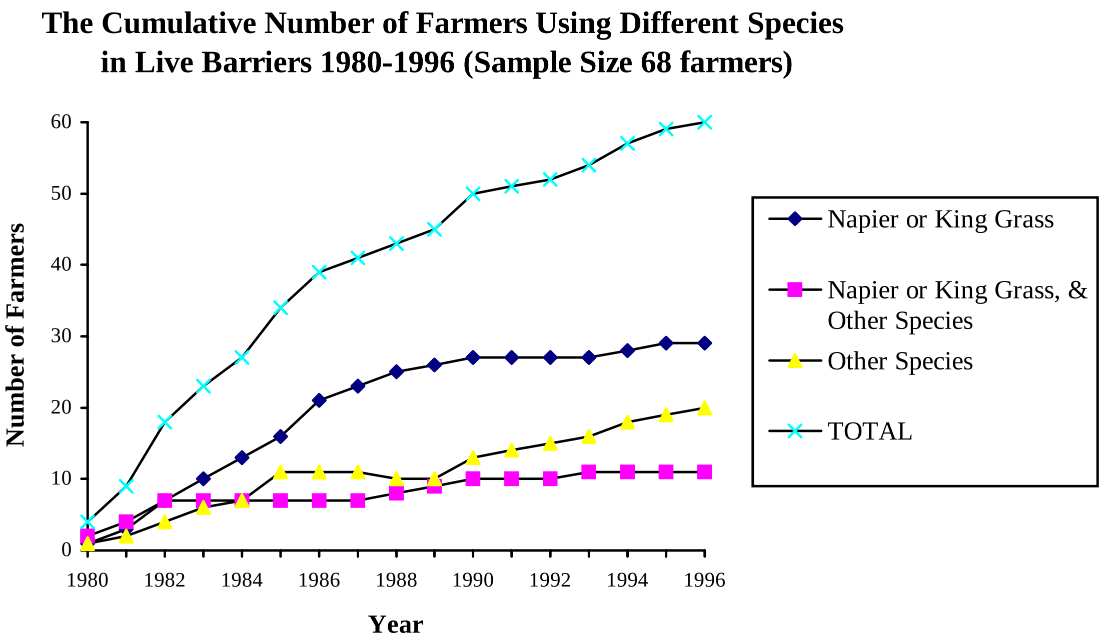
Table 2. Species being used in live barriers in the Güinope region **

Scientific name	Common name
Grass species	
Vetiveria zizanioides	**Vetiver grass**
Cymbopogon citratus	Lemon grass
Pennisetum purpureum	**Napier grass**
Pennisetum purpureum x Pennisetum typhoides	**King grass**
Setaria geniculata	**Rice grass**
Panicum maximum	**Guinea grass**
Saccharum officinarum	**Sugar cane**
Brachiaria mutica	Pasto pará
Paspalum notatum	**Pasto bahía**
Trees, shrubs and other plants	
Cajanus cajan	Pigeon Pea
Manihot esculenta	**Cassava**
Coffea arabica	Coffee
Citrus limetta	Lime tree
Citrus sinensis	Orange tree
Prunus persica	**Peach tree**
Gliricidia sepium	Madreado
Colocasia esculenta	**Quíscamo**
Musa acuminata	**Plantain**
Ananas comosus	**Pineapple**

** Species used by the farmers who were interviewed in the Güinope municipality as part of the quantitative study are in bold. Many of the farmers are using a mixture of several species in the same live barrier. Some of the species are used by farmers in other regions of Honduras such as Choluteca.

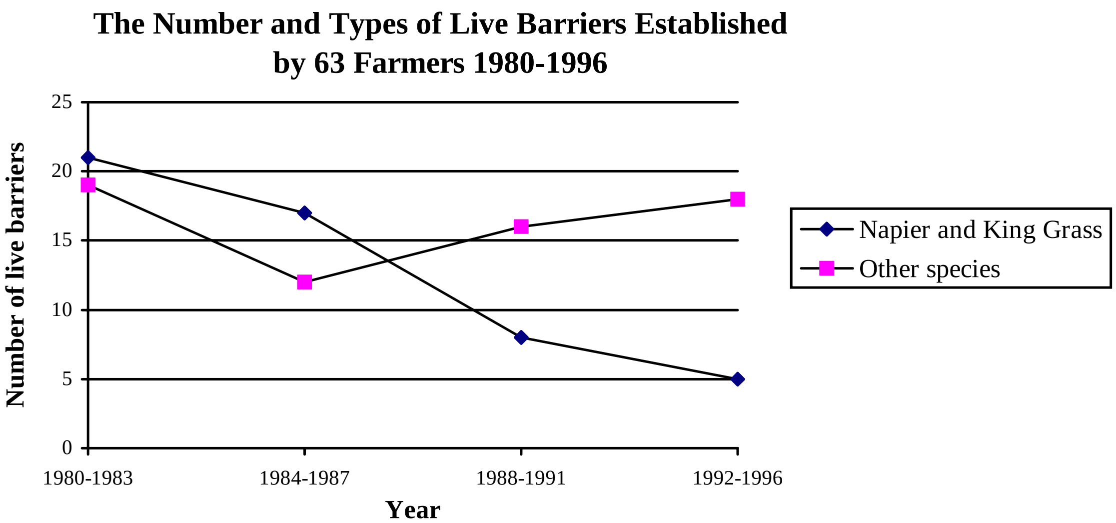
Of the 68 farmers in the municipality of Güinope who were interviewed, 63 had established live barriers between 1980 and 1996 and only three had subsequently rejected them. In 1996, there were 29 farmers who had established live barriers of *P. purpureum* (Napier Grass) or *P. purpureum* x *P. typhoides* (King grass), 20 farmers had adapted the technology and had established live barriers of other species.11 farmers had live barriers of the two grass species and other species (Figure 18).

Figure 18



From 1980-1996, the majority of farmers established live barriers of *P. purpureum* (Napier Grass) or *P. purpureum* x *P. typhoides* (King grass). However by 1988, farmers were establishing more live barriers of other species (Figure 19). This trend has continued to the extent that in the period 1992-1996, farmers established five live barriers of *P. purpureum* (Napier Grass) or *P. purpureum* x *P. typhoides* (King grass) compared to 18 live barriers of other species.

Figure 19



10.2 Criteria used by farmers for selecting different species for live barriers

Farmers in Güinope recognise that live barriers of *P. purpureum* (Napier grass) and *P. purpureum* x *P. typhoides* (King grass) retain soil and that over a period of 5-10 years natural terraces are formed. Farmers, however, have also pointed out that there are several disadvantages with using these two grass species in live barriers. These disadvantages can be divided into three categories.

- The most cited disadvantage is that both species are invasive if not regularly managed (Photograph I). This is especially the case with *P. purpureum* (Napier grass) and precludes the use of both species as a green manure.

- The two grass species provide excellent fodder and therefore the maintenance of the live barriers need not be a problem from the farmers' point of view if the farmers are regularly cutting the live barriers to feed to their cattle. However, few farmers in Güinope have cattle and therefore there is little demand for the amount of fodder produced.

- The two grass species have an extensive root system and therefore compete with agricultural crops. There are several examples in the Güinope region where the maize plants on either side of *P. purpureum* (Napier grass) and *P. purpureum* x *P. typhoides* (King grass) live barriers are stunted compared to the maize between the live barriers. This deleterious effect can be seen up to 2 metres on either side of the live barrier (Photograph J).

The problems of *P. purpureum* being invasive and competetive have also been reported from the Philippines (Fujisaka, 1991 & 1993).

10.3 Farmers' preferences - a rational choice

The species being selected by farmers in the Güinope region for use in live barriers are those that are not invasive and, more importantly, those that contribute to the farm household in terms of domestic consumption and/or the sale of the products of the live barriers. Farmers are increasingly using *S. officinarum* (sugar cane) in live barriers and a number of fruit trees including lemon, orange and pear trees (Table 2 and Photographs K and L).

Farmers are aware that many of the species being used in live barriers are not as effective as *P. purpureum* (Napier grass) and *P. purpureum* x *P. typhoides* (King grass) in controlling soil erosion but they make far greater contributions to the farming system than the two grass species. Farmers referred to their preference for a species that gave a *doble propósito* and often the soil retention function was secondary to the productive function of the live barrier itself. This concurrs with work in Sri Lanka where farmers are using live barriers of cinamon (Fergus Sinclair [University of Wales, Bangor] pers. comm), but contrasts with parts of the Philippines where species selected by farmers for use in live barriers appear to be equally effective in the control of soil erosion (Fujisaka, 1993).

In Güinope, farmers with live barriers of tall species, such as sugar cane of fruit trees, tend to be those growing maize and beans. The shade effect of the live barrier species and the subsequewnt reduced production of maize in one or two lines above and below the barrier, is more than compensated by the productivity of the barrier itself. Where higher-value vegetables are grown in Güinope, the reduction in crop yield is not compensated for by the value of products of the live barriers and farmers prefer shorter species such as *S. geniculata* (rice grass).

Photograph I Live barrier of *P. purpureum* that has spread into a farmer's field. Farmers are replacing *P. purpureum* with other species that are less invasive and which contribute to the household in terms of production of fruit. August 1996.

Photograph J Live barrier of *P. purpureum* showing competition between the barrier and the farmer's maize crop. August 1996.

farmer s maize crop. August 1996.

Photograph K

Farmer in Güinope with live barrier of plantain, peach trees, and pigeon peas. Dead maize stalks are placed above the barrier in order to increase the soil retention function of the live barrier.September 1996.

Photograph L

Farmer in Güinope with live barrier of plantain and coffee.August 1996.

10.4 Conclusions on farmer adaptation of live barriers

The results of the study point to the fact that species selection for use in live barriers in the Güinope region is based on socio-economic and ecological criteria. Farmers are clearly interested in the ability of the live barriers to retain soil and contribute to soil fertility, otherwise they would not be using the species in live barriers, but they show a preference for species that confer other benefits. This conclusion fits into the philosophy of the *Land Husbandry* approach to soil conservation which recognises that farmers are primarily concerned with stable and economic production and not with the conservation of soil and water *per se* (Shaxson, 1996).

There is also evidence of farmers removing the *V. zizanioides* barriers promoted by USAID-funded LUPE project and replacing them with some of the species in Table 2. *V. zizanioides* has few uses in Honduran other than for soil retention; the grass does have medicinal properties but the market in Honduras is very small.

11. FARMER INNOVATORS IN GÜINOPE - RESULTS

11.1 Quantitative survey of farmer innovators

The results below are preliminary ones. Further analysis, including multivariate analysis, will be included in Larrea's thesis, a copy of which will be sent to FRP in December.

11.1.1 Descriptive characteristics of the farmers interviewed

- Average age of the interviewed farmers was 47 years' old and 71% of those interviewed were between 33 and 61 years' old.
- Majority of the farmers had been managing their farms for 5-31 years. Average was 18 years.
- Majority of the farmers had lived in the communities for most of their lives although several had lived for several years in different parts of Honduras.
- Eighteen percent of those interviewed had no formal education.
- Average level of education was the third grade although the mode is located in the sixth grade.
- Farm family size ranged from 2 to 14 with an average of 6.
- Eighty percent of the farmers had adopted in some form of local organisations such as recreation activities, religious groups o local co-operatives.
- More than 50% said that community participation had been a positive experience and 77% said that they were interested in participating in future community activities.
- 75 % the farmers are dedicated full-time to agriculture and the rest are involved in off-farm activities such as building, tapping resin and making bricks.
- 62 % of the adopters had used credit and 52 % of farmers who had used credit said that it had been a bad or regular experience. The problems they cited were paying back the credit in years with poor harvest, high interest rates and the bureaucratic hurdles involved in obtaining credit.
- Over 50% of the farmers interviewed said that they wanted and needed credit for their farms.
- 91 % of the farmers had been involved in commercial activities such as sale of vegetables.

11.1.2 Descriptive characteristics of the farms

- Total area cultivated by the farmers interviewed was 150 ha. of which 31% was dedicated to the cultivation of basic grains (maize and beans), 47% to vegetables in combination with fruit trees and basic grains, and 15% to coffee and perennial shade trees.
- Average farm size was 2.5 ha., although the most common farm size is 1.2 ha.
- 75 % of farmers felt that their harvests had improved in between 1981 and 1996. The two reasons most mentioned were the use of soil and water conservation technologies (including the use of chicken manure) and the use of chemical fertilisers.
- 23 % of farmers reported that harvests had remained the same since using SWC technologies, 2 % said that harvests had declined.
- Farmers owned 82 % of the 150 ha. cultivated, whilst 1.5 % were rented and 16.5 % belonged to other family members.
- Majority of farm plots are found within 20 minutes' walk of the farm
- Majority of farmers' plots are on sloping land (10-40%)
- 58 % of the plots do not have irrigation
- Soil quality, as perceived by farmers, is normal in the case of 56% of the plots, good in the case of 39% and poor in the remaining 5 % of plots.
- 78 % of the plots are farmed with hired labour animal traction is used in 70 % of the plots.

11.1.3 Adoption and adaptation of soil and water conservation technologies

- Almost all the adopters of SWC technologies had been the recipients of extension programmes.
- Only two farmers said that they had never received any external advice.
- The most cited organisation in terms of promoting SWC technologies was World Neighbors.
- 68% of farmers said that they had shared their knowledge of SWC with another farmer.
- Chicken manure had been used by 85 % of farmers but at the time of the interviews, 30 % of the adopters of this technology had abandoned it. Farmers who had abandoned the technology were aware of its benefits but cited lack of financial resources and the high labour costs in applying the manure as reasons for abandoning its use.
- With regards to the degrees of adaptation (see Annex 2), 41% of farmers have not adapted any of the SWC technologies after the adoption phase, but 59 % have made changes.

11.1.4 Bivariate analysis

- Pearson correlations were established between continuous variables in the survey. The analysis only took into account linear relationships and also ignored partial links that existed around the variables. As is common in social sciences, a degree of significance of $\alpha \leq 0.25$ was chosen. The majority of the correlations are around 0.30 (Correlations 1 and 2 on pages 73 and 74).

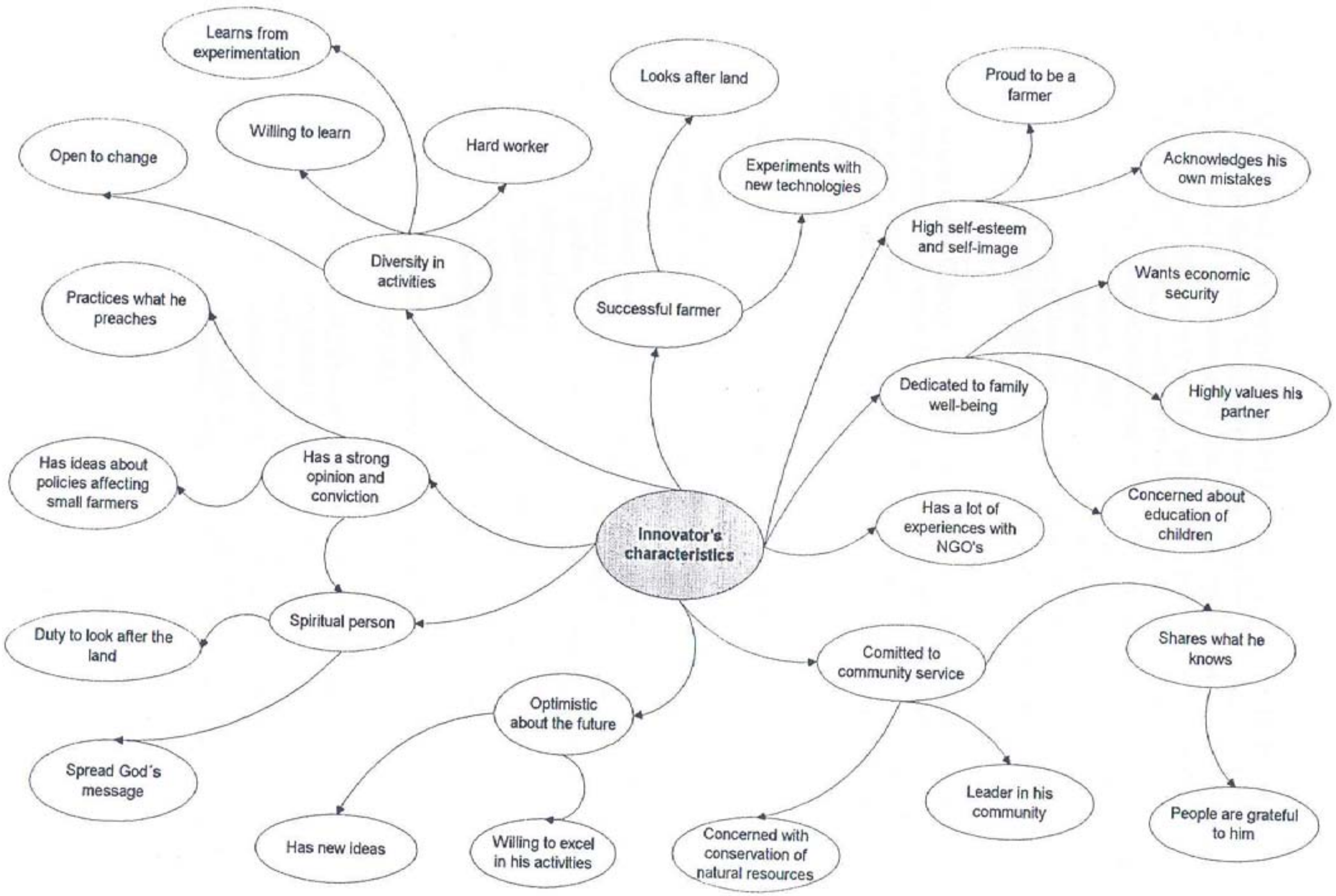
- The concept of degrees of innovation, of adoption, and of amenability to change is based only on aspects linked to the conservation of soil with an emphasis on live barriers. As can be seen in the correlations, significant correlations exist between these variables and those dealing with institutional contacts (either institutions which the farmers have worked with or received extension advice from). This result may just demonstrate the limit of the indices used to determine the degrees of innovation, adoption, and amenability to change. These indices excluded personal characteristics of the farmers (see Annex 2). The result may also, however, confirm the importance of extension activities in accelerating adoption, innovation and technological change.

- There exists a correlation, although a low one ($r = 0.161$, $\alpha = 0.207$) between the degree of adoption and the number of years that a farmer has lived in a community. However, there was no correlation between the latter and the degrees of innovation or amenability to change. It may be that a farmer who has lived for several years in a community has greater security and is more receptive to new ideas *etc*.

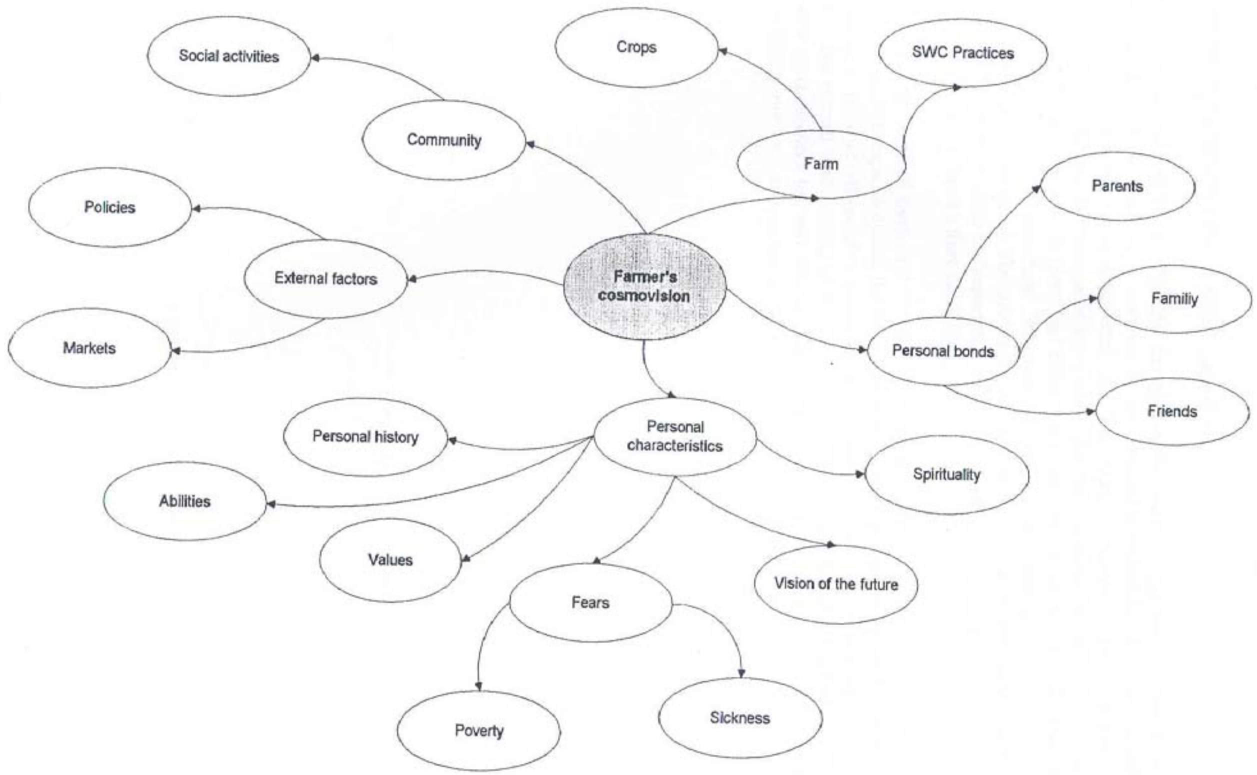
- The farm index is correlated with farmers' personal characteristics such as education, age of the farmer and the number of years that the farmer has lived in the community (Correlation 1). The farm index does not appear to affect the degrees of innovation, of adoption, and of amenability to change.

- All personal characteristics of the farmer, with the exception of the size of family and educational level - are negatively correlated with the number of institutions that have advised the adopter and/or for which the adopter has worked as an extension agent.

Concept Map 1: Farmer innovators' characteristics based on field work in Güinope, Honduras



Concept Map 2: Farmers' perception of his reality, based on field work in Güinope, Honduras



11.1.5 Conclusions on the quantitative study

The survey revealed that the process of adaptation/innovation is very complex and is difficult to quantify. There were some problems, however, with the quantitative study:

- The variables tended to be "Yes" or "No" answers and this limited the use of statistical tools.
- The construction of the degrees of innovation and adoption are subject to bias
- The validity of the analysis is restricted because several of the continuous variables did not have a normal distribution.
- The degrees of innovation and adoption measured innovations with an emphasis in live barriers. Hence the indices did not evaluate comprehensively other adaptations that may have taken place with other soil and water conservation technologies.

Although Larrea will be carrying out further analysis, including multivariate analysis, preliminary results demonstrate that there is a link between human development soil conservation in agriculture. Prior to multivariate analysis though, it appears that in order to have captured this complexity a more sophisticated quantitative study would have been needed with a larger sample

11.2 Qualitative research on farmer innovation

Ten innovators (Chapter 7) shed light on farmer innovation by addressing the following questions:

1. Who are outstanding innovators and what makes them so special?
2. Why do these farmers innovate?
3. What are the farmers' opinions of present and past development projects, what are their on-going concerns and what would be their recommendations to future programmes in terms of the creation of more favourable conditions for rural development?

11.2.1 What are some of the characteristics of a farmer innovator?

Characteristics are summarised in Table 3 and detailed through farmer quotations below.

Table 3 Personal characteristics of farmer innovators in Güinope

1.	A spiritual person
2.	Proud to be farmer
3.	High appreciation and commitment to protect natural resources
4.	Optimistic about the future
5.	Concerned about education of children
6.	Committed to community service
7.	High self-esteem and self-image
8.	Highly values his or her partner
9.	Willing to experiment, test new ideas and learn
10.	Dedicated to the unification of the family
11.	Shares what is known
12.	Practices what is preached
13.	Diversify activities
14.	Community leaders

1. A spiritual person

Someone who doesn't love God is also not going to love the things that exist because everything is the creation of God (Hermenegildo Valladares, Arrayanes).

All the good experiences that I have had, all the good changes that I have made in my life, and my ability to get to know myself, all this I owe to the celebration of the Word (Tomás Barahona, Lavanderos).

2. Proud to be farmer

The truth is that I didn't want my family to continue live in Tegucigalpa [the capital of Honduras] *the area where we lived was dangerous. I have my own house in Tegucigalpa but I don't like living there. I much prefer to be farming. Since the day I started farming, I have seen the beauty of working the land*. (Mario Zavala, Casitas)

Since I was a small child I have always enjoyed farming. Agriculture has been my inheritance (Alucio Nuñez, Lavenderos).

3. High appreciation and commitment to protect natural resources

Now I can see that if we continue to overuse chemicals as part of our farming activities, there is going to be more environmental contamination. This is bad for the health. We have to teach other farmers to try and conserve the natural resources (Hermenegildo Valladares, Arrayanes).

I want to ensure that the small group interested in conserving natural resources works more closely with the rest of the community but you have to work very hard to see positive results (Mario Zavala, Casitas)

4. Optimistic about the future

I feel optimistic and am prepared to struggle and to work hard. All I ask is that God grants me continued good health and that we don't ever have to live in misery again (Tomás Barahona, Lavenderos).

5. Concerned about education of children

I want to be able to give my son a chance, to help him so that he can develop socially, intellectually and spiritually because that is the fundamental basis of life. I want to be able to teach him about the relations that exist between one thing and another (Antonio Oseguera, Galeras).

My most important experiences are lived ones. I don't necessary think that I am going to bequeath a farm or a car to my children. I want to leave them the idea that they themselves can improve their lives and prepare themselves for life's challenges. The best inheritance is education (Mario Zavala, Casitas).

6. Committed to community service

At the moment we are building a church here. One has an obligation to work hard and try and bring the community close to God (Antonio Oseguera, Galeras).

7. High self-esteem and self-image

The community does respect me and they believe what I say. I am a member of all the community organisations and the community always elects me even though. I tell them that there are others that are capable. (Hermenegildo Valladares, Arrayanes).

8. Highly values his or her partner

My wife is studying at the moment. We don't want children now because if she was pregnant she wouldn't be able to continue studying. I believe that you know about these distance learning programmes. Each Sunday, she and others have to go to classes for six hours. She is going to get her school-leaving certificate (Jorge Durón).

9. Willing to experiment, test new ideas and learn

The rest I have learnt by studying alone. I read books and attend different courses. I have always liked investigating. When I enjoy something, I never just stay with what I have been taught, I always try to investigate more, to try out new things (Hermenegildo Valladares, Arrayanes).

Training opens other doors. Once you start receiving training, you find that other doors open. All training is important, some doors that were half closed suddenly open. I have this belief that all training is very important (Alfré Flores, Lizapa).

10.Dedicated to the unification of the family

I live with my parents. My father was good to us. In the first place he taught us to work and to be honest. Therefore, as I said, development in life begins in the home. I don't leave home very often. I am dedicated to my family and the work on my farm (Alfré Flores, Lizapa).

11.Shares what is known

What I like is to share some of those important moments with other people. To sit down and chat and share a few ideas, these are important moments for me. I consider the sharing a part of my life (Tomás Barahona, Lavenderos).

One of the most important aspects of life is that you get to know lots of people who have improved a few aspects of their lives because you taught them the means. I have seen agricultural changes in the farms of many people who I gave advice to (Alfré Flores, Lizapa).

12.Practices what is preached

Another important part is not to neglect the farm. There are several people who talk of technologies but then do nothing. I have not made that mistake and all the time, I have food (Alfré Flores, Lizapa).

I believe that it is much more important what you do than what you say (Antonio Oseguera, Galeras).

13.Diversify activities

I also work a little as a builder and in a blacksmiths. I have worked as a farmer extension agent in a soil conservation project. And now I am working with a house-improvement project. I am the supervisor of this project in five communities (Heremenegildo Valladares, Arrayanes).

I do a little photography to earn a little more money it adds to what I can earn from the farm (Alfré Flores, Lizapa).

14.Community leaders

I have always been asked to be the leader in various community activities. At the moment I am president of farmers' association here in Lavenderos and ten years ago I took a course so that I could be a church leader (Tomás Barahona, Lavenderos).

11.2.2 Why do farmers innovate?

The farmers themselves identified a number of reasons why farmer innovation is important. See Table 4 and the series of farmer quotations below.

Table 4 Farmers' reasons for the need to innovate

1.	Food and economic security
2.	To be a good steward of the earth
3.	Improve the conditions of the community
4.	Leave a strong heritage to our children
5.	For self esteem
6.	Continue with farming

1. Food and economic security

For me, the important things in life are my friendships and the contacts that I have. And in order to keep this going, I need to improve my farm and try and obtain some credit. The truth is that everything I am talking about depends on me having some income (Alfré Flores. Lizapa).

2. To be a good steward of the land

A belief in God does not involve just the spiritual camp, it involves the whole question of human development. We ought to integrate and be involved in all activities linked to the development of the community especially agriculture. We should be leaders and not bosses, saying 'let's do this' rather than 'you do this' (Tomás Barahona, Lavenderos).

3. Improve the conditions of the family and community

There is a need to work hard to ensure that the family and community benefit (Alfré Flores, Lizapa).

4. Leave a strong heritage to our children

I want to continue working so that my children have more opportunities. They are going to inherit this farm but it will be divided up amongst them so I also want to be able to give them an education. An education will help them for the rest of their lives (Elías Zelaya, Pacayas).

5. For self esteem

A very important part of the work is the friendship and appreciation that other people show for you when you have helped them. When I visit villages where I used to work, I am received as if I was an important person ...... this is very important for me (Alfré Flores, Lizapa).

6. Continue with farming

For me the question is simple to continue farming, to continue creating new ideas so that I can protect my land. I have to conserve my land if I want to continue farming (Alucio Niñez, Lavanderos).

11.2.3 Farmer-leader recommendations for future agricultural development programmes

Most institutions arrive with good intentions, but many times with wrong ideas (Aguinaldo Sauceda, Casitas)

The farmers evaluated 12 development organizations that have worked in the Güinope area. Consistent with its reputation, the exercise showed that World Neighbors had done the strongest work. The farmers then drew up a list of recommendations for a future development programme (Table 5). The objective of the exercise was to identify how a development programme might be able to foster those internal and external factors that are conducive to farmer innovation.

Table 5 Farmer recommendations for a future agricultural development programme

1.	Develop a global vision of the history, needs, and interests of the community
2.	Respect local customs and local knowledge
3.	Work with community leaders
4.	Do not try and be too ambitious and find that at the end little is achieved
5.	Ensure that the project employs good extension workers
6.	Focus on human development as opposed to the technologies alone
7.	Work through local farmer extension agents
8.	Promote and encourage farmer experimentation and involvement
9.	Avoid competition between organisations
10.	Avoid paternalism

1. Develop a global vision of the history, needs, and interests of the community

In terms of agriculture, this was really a zone where we grew only maize. We hadn't discovered vegetables. It was only when World Neighbors arrived that they opened our eyes to the possibilities, the fact that we could actually grow vegetables in this zone ..... World Neighbors showed us we had been sleeping on top of this huge potential without realising that it was there (Alfré Flores, Lizapa).

In the first place, as head of a project, you ought to identify what the priority needs of the community are (Alucio Nuñez, Lavenderos).

There are a number of weak NGOs, weak in the sense that they are created to complement a financial need. There is someone who is offering funding and the NGO organizes itself but does not take into account what the community needs (Alfré Flores, Lizapa)

2. Respect local customs and local knowledge

They shouldn't forget our customs, our knowledge, and who we are (Alfré Flores, Lizapa).

3. Work with community leaders

We began working with World Neighbors in 1981 and in 1984 they opened more doors for us because we began to teach and train others in the communities (Alfré Flores, Lizapa)

4. Do not try and be too ambitious and find that at the end little is achieved

The organisations in many ways want to embrace loads of things with few personnel to do the work. The results are not very positive (Alfré Flores, Lizapa).

The institutions come with good objectives .... but in the end they seldom achieve the objectives (Mario Zavala, Casitas).

5. Ensure that the project employs good extension workers

The extension worker is the representative of the organisation in the field. If the extension worker does a bad job, people are going to say that the institution is bad (Alfré Flores, Lizapa).

If an extension worker says that he is going to arrive at such a time on such a day, he should be there. Otherwise we begin to loose patience and whatever group feeling there was begins to disintegrate (Tomás Barahona, Lavenderos).

World Neighbors was good because the Guatemalans came with a work spirit and a determination to help us improve our lives (Antonio Oseguera, Galeras).

6. Focus on human development as opposed to the technologies alone

The other very important thing is that the project sees the farmers as the most important factor and doesn't just concentrate on the material things (Mario Zavala, Casitas)
In the first place you have to begin with the farmer, you have to transform the farmer with these technologies. The farmer comes first and afterwards the technologies (Alfré Flores, Lizapa).

7. Work through local farmer extension agents

As you leave Tegucigalpa on the road to the north, the first village you come to was where I worked. I didn't feel as though I was an employee but rather a student of World Neighbors (Alfré Flores, Lizapa).

8. Promote and encourage farmer experimentation and involvement

The best way to teach farmers is the way used by World Neigbors. The organisation worked with a few farmers and when others came to ask about the work, World Neighbors said that they would teach the farmers but only in the farmers' fields (Hermenegildo Valladares, Arrayanes)

9. Avoid competition between organisations

The competition between organisations can be very bad, each organisation tries to monopolise the population and farmers are grabbed by one organisation and then the other. They ought to coordinate the activities of the different organisations....the problem is greater when one organisation is offering subsidies and another not, the majority decide to go with the organisation offering money (Hermenegildo Valladares, Arrayanes).

10. Avoid paternalism

The only really bad thing that I have seen is when they paid people to conserve the soil. We worked but it was for the money and food. Recently I passed by where we had worked and there is nothing; it is as though the Ministry of Natural Resources had never had a project here (Jorge Durón, Galeras).

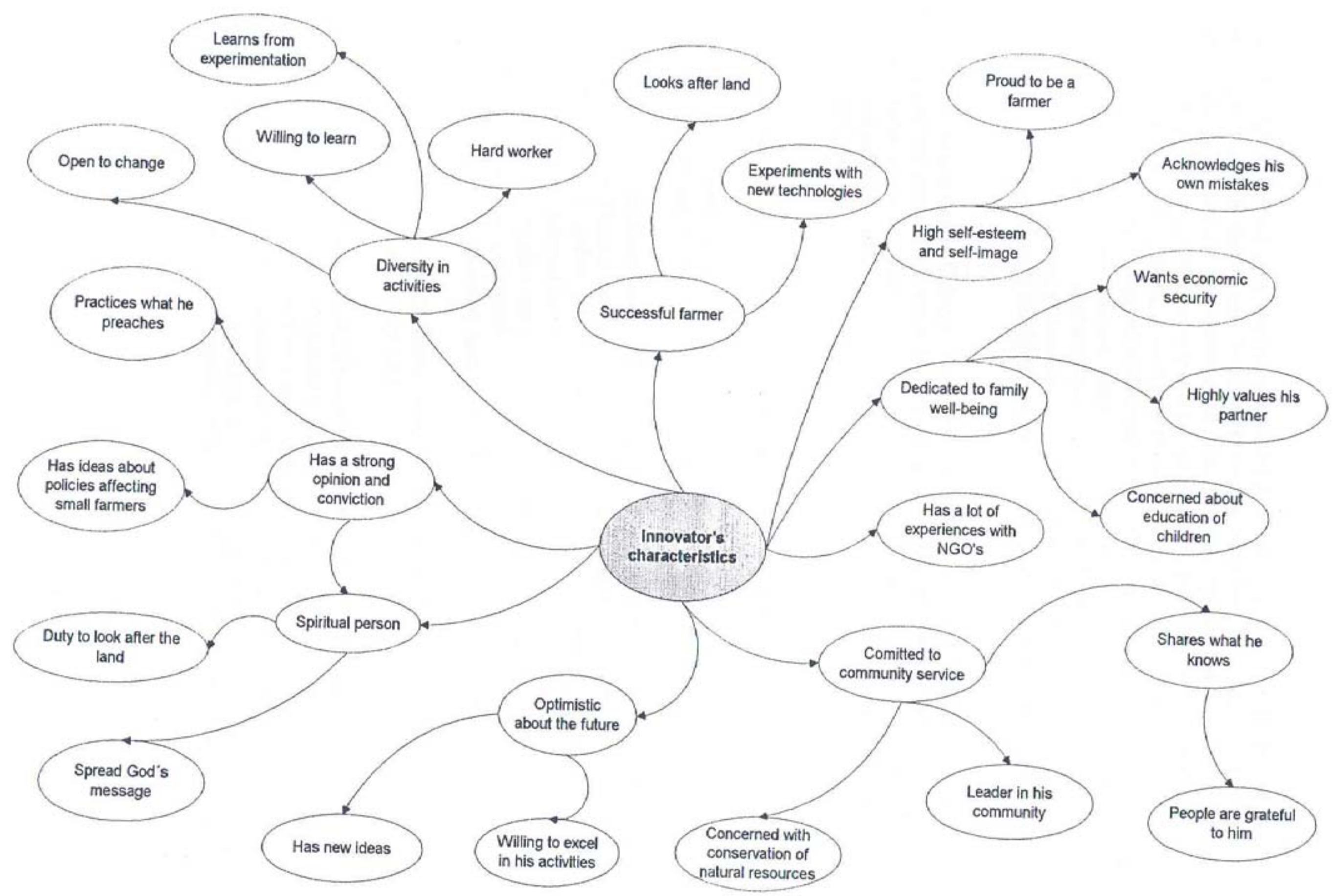
11.2.4 Conclusions from the qualitative study of farmers' innovations

Innovation, farmers personal characteristics and agricultural development

- Farmer innovators in Güinope demonstrate a complex number of characteristics that they themselves identified as those that distinguish them as innovators. In addition the reasons why they innovate the consequences of a plethora of personal-level interactions, especially regarding changes in family and community relationships as well as spiritual development. Concept Map 1 on page 82 summarises this complexity. There are several important lessons that have a strong bearing on future development work.

- Projects can be better designed and directed so that they enhance some of these personal characteristics and/or remove the obstacles to farmers' developing these characteristics. The complexity of the situation offers hope because projects can focus on enhancing one of two farmer characteristics from a list of several. This accounted for some of the success of the World Neighbors project in Güinope. According to farmers World Neighbors managed to break the vicious circle of low self esteem leading to a reluctance to innovate which in turn lead to stagnation in agriculture which in turn lead to low self-esteem.

Concept Map 1: Farmer innovators' characteristics based on field work in Güinope, Honduras



- Some farmers may well never show interest in innovating but the innovators in Güinope stated that on several occasions that it was the work of World Neighbors that enabled them to overcome some of the obstacles to innovation. As many of the farmer innovators attest to (see also Chapters 8 and 12) World Neighbors taught farmers that they themselves have the capacity to manage and improve there farms. This was a revelation to most farmers and it is not an exaggeration to say that what happened in Güinope in the 1980s was a revolution. There are many farmers in Güinope today who are adapting and improving their agricultural systems because they have much greater confidence now than before 1980. Farmers did not build up this confidence by being the recipients of transfer of technologies via food for work schemes, but rather by working alongside World Neighbor's extension agents and seeing the beneficial results of their labour.

- The study was carried out in Güinope nine years after World Neighbor's project finished. Several of the farmer innovators stressed that not only are they adapting SWC technologies, but they are also better able to overcome new challenges such as dealing with commercialisation of their agricultural products and securing rural credit. The process is once again linked to farmers having the confidence and self-esteem to experiment with different SWC technologies or new crops.

Farmers' cosmovision and appropriateness of programmes that focus on SWC

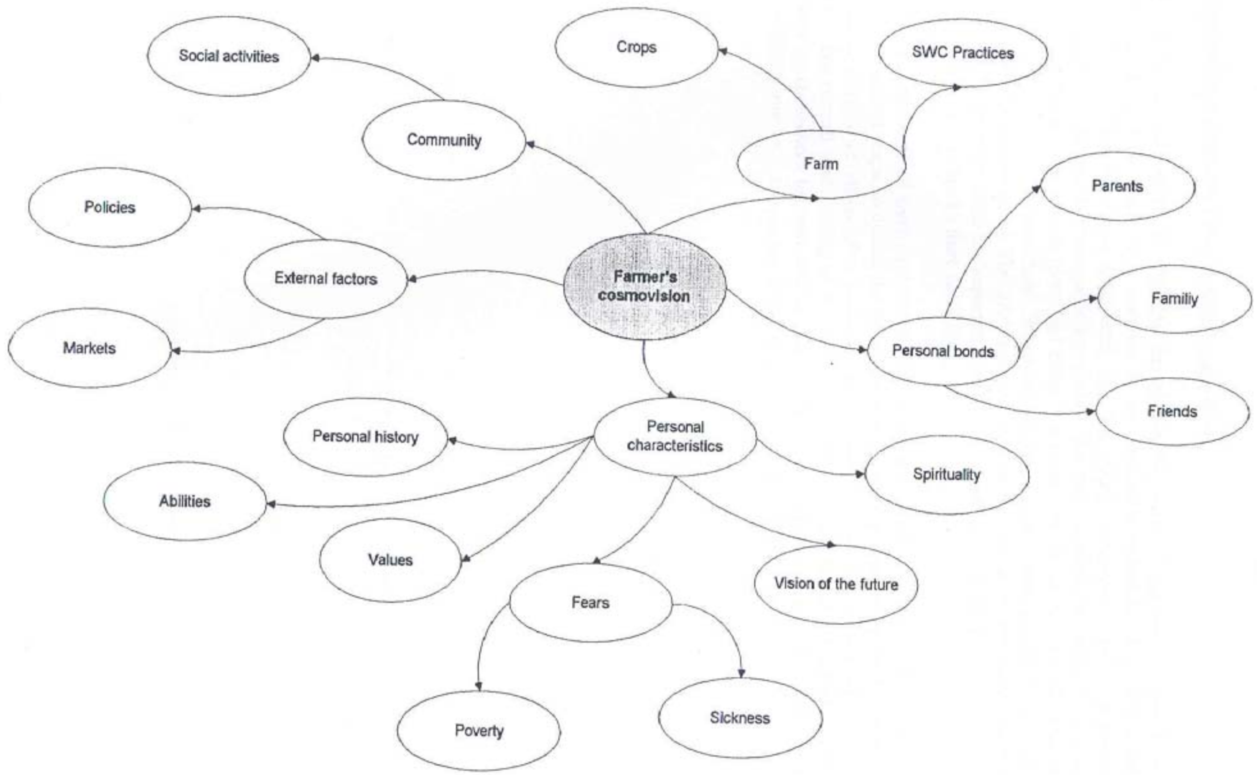
The qualitative studies outlined in Chapter 8 dealt specifically with the theme of whether SWC is actually a priority for farmers. More detailed conclusions appear in Chapter 12.

- Concept Map 2 (page 84) demonstrates that farmer innovation is applied to several aspects of farmers' lives. Farmers' focus is not exclusively on SWC technologies, their attentions may be directed at their families and/or religion. More detailed qualitative surveys carried out in Choluteca and Güinope confirmed this (see Chapters 8 and 12).
- Farmers are managing a complex world of natural resources, human values and economics in which SWC is but one small component.
- SWC programmes need to recognise that farmers have other interests/concerns beyond the conservation of soil.
- Often a farmer's priority non-SWC problem needs to be resolved before the farmer is in a position to deal with SWC problems (see Chapter 12).

Farmer innovators' evaluation of past and present SWC/development projects

Farmer innovators suggestions on how development project could be better run can be place in two categories: the type of the work promoted by a development organisation (see above and Chapter 12)) and the way that the programme's activities are promoted. Farmers' comments on the latter, extension methodologies, concur with suggestions on extension methodologies detailed in Bunch (1985) and in Bunch's contribution to the manual (one of the outputs of the research project) (See Chapter 13).

Concept Map 2: Farmers' perception of his reality, based on field work in Güinope, Honduras



11.3 Quantitative approach versus qualitative approach

The study of farmer innovations in Güinope has shown the value of qualitative research in agricultural/forestry research. There is a tendency to see qualitative studies as only suitable for exploratory forays and for developing hypotheses, and that strong explanations, including causal attributions, can only be derived through quantitative studies. However, as Miles and Hubermann point out (1995), seeing that an experimental group had effect *X* and that controls did not, actually tells us nothing about what went on in the 'black box'. We do not understand how or why it happened, and can only guess at the mechanisms involved. The same applies to the quantitative study of farmer adaptations and innovations. The study revealed the importance of several variables in the adaptation/innovation process but offered no clue as to why there was a link. .

The qualitative survey identified some of the mechanisms involved in the farmer innovators' decision-making process. Concept maps facilitated the visualisation of the relationship and hierarchy between concepts within a holisitic vision of a particular theme, in this case human and agricultural development. The overall study clearly revealed the complex network of processes involved and the need to look at the connections between variables and processes; showing that events include underlying variables, and that variables in turn are not disembodied but have connections over time.

12. FARMERS PERCEPTIONS AND NEEDS. DO WE SPEAK THE SAME LANGUAGE?

Larrea's research showed that soil erosion control and SWC in general are not necessarily priorities for farmers. Farmers in Güinope stressed that development projects need to address farmers' needs. Further qualitative research in Güinope and Choluteca was designed to determine farmers' understanding of the processes of land degradation, to identify what their priority needs are, and to solicit more suggestions on what farmers would like to see from a development programme.

12.1 Land degradation and farmers needs

Farmers were asked how they judged good land and what criteria they would use when selecting a new piece of land to farm (Table 6). They were then asked to list the agricultural problems (and causes) that they face in their every days lives as farmers. These problems/causes and associated farmer actions to alleviate the problems are listed Table 7 and displayed in concept maps on pages 88 and 89.

Table 6 Farmers' criteria of what constitutes good land

Güinope	Choluteca
Close to road	Close to house
Close to house	Dark colour soil
Has irrigation	Woody vegetation
Good drainage	Without rocks
Flat land	Non-sandy
Dark colour soil	High organic matter content
Without rocks	High productivity
Deep A-horizon	
High organic matter content	
High productivity	
Woody vegetation	

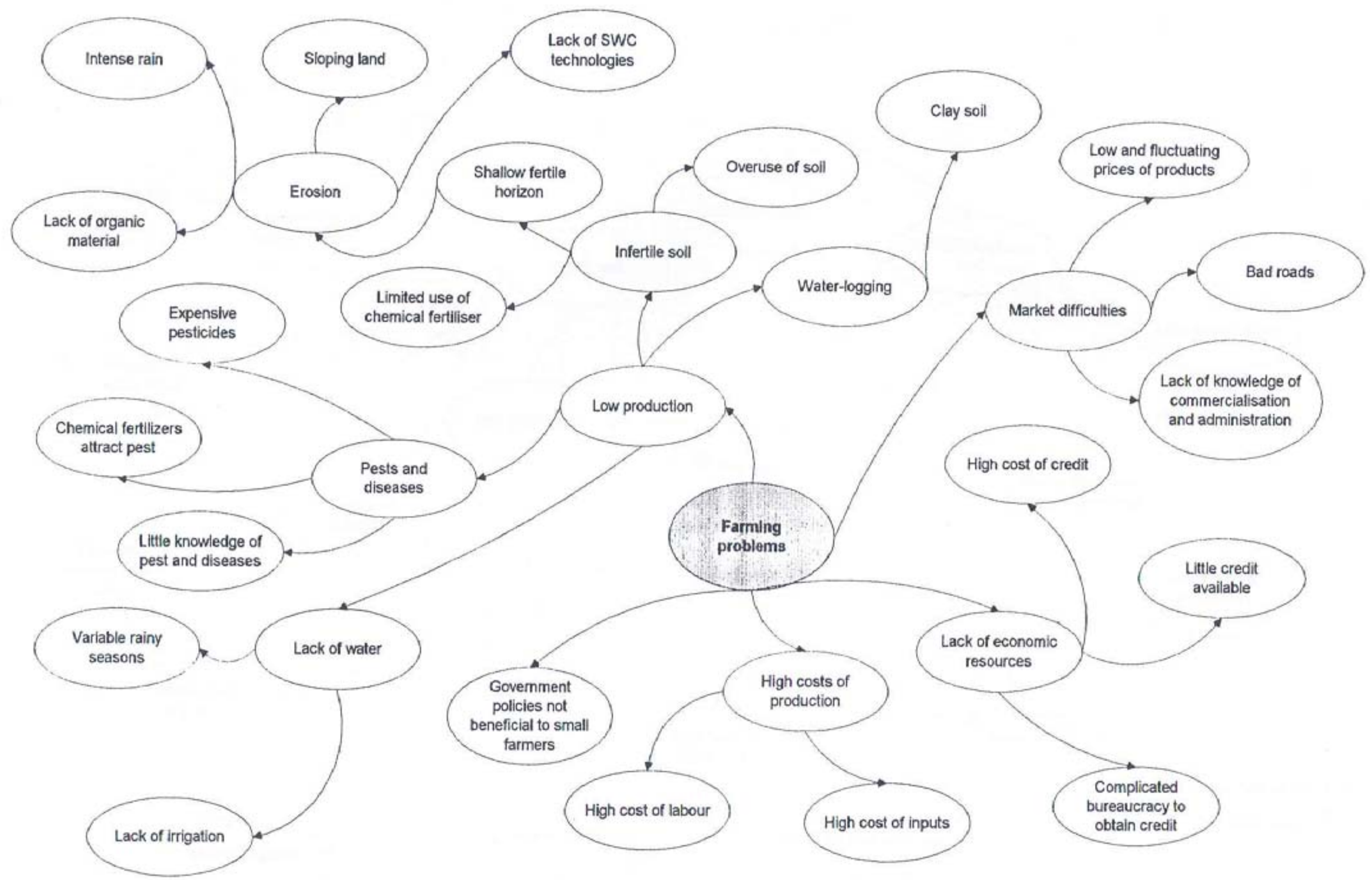
Farmers in Güinope use many more criteria than farmers in Choluteca. This almost certainly reflects the past and present activity of development organisations in Güinope region such as World Neighbors. The indicators tend to be descriptive and are based on the soil chemical and physical characteristics as opposed to biological ones.

In terms of the most important characteristics, farmers repeatedly voiced a strong preferences for land close to the house irrespective of its other characteristics. This is linked to the time spent walking to the fields and the dangers of theft (especially fruits) from the fields. Kass (pers comm. [soil scientist at CATIE]) has reported that some of the farmers in the highlands of Guatemala were reluctant to plant fruit trees even though they favoured them because of their fear of the fruits being robbed from the isolated farm plots.

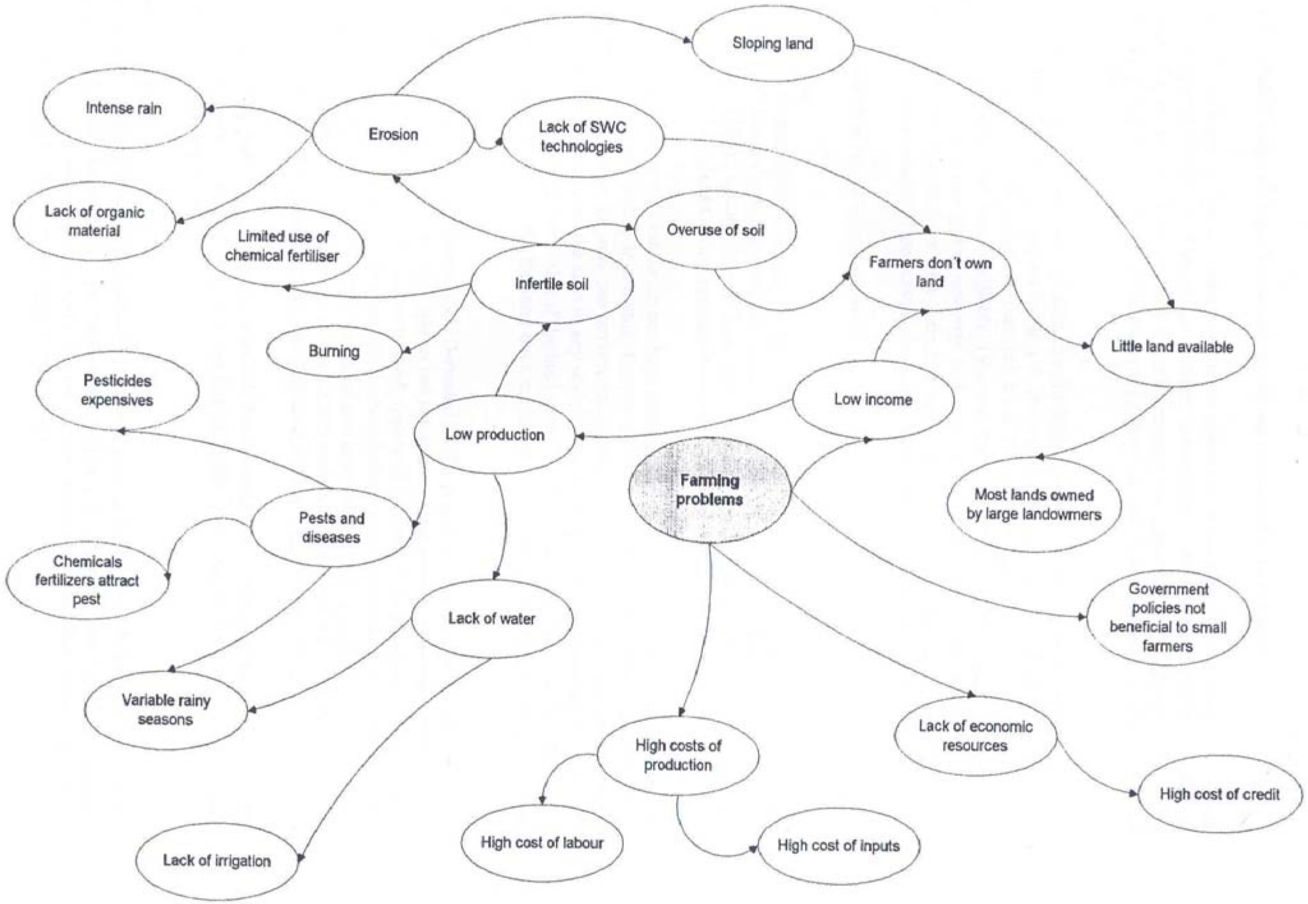
Table 7 Problems faced by farmers and how they are trying to resolve some of them

	Güinope			Choluteca	
Problems	**Causes**	**Actions**	**Problems**	**Causes**	**Action**
Land is rugged	Clay texture	Incorporate organic material	Low yields	Fertiliser expensive Burning	Put land in fallow
Erosion	Sloping land Sandy soil Intense rain Little organic material Few/no SWC technologies	Minimum tillage Live & dead barriers Drainage ditches Soil cover	Erosion	Land is not protected Lack of organic material	Live & dead barriers Cover crops Minimum tillage
Thin top soil	Erosion Few/no SWC technologies	Same as above	Lack of water	Variable rains	
Waterlogging	Clay soil	Incorporation of maize stalks and weeds	sloping land	Good land taken by landowners	
Low yields	Infertile soil Lack of fertiliser Overuse of soil Pests and diseases	SWC technologies Chemical fertilisers Stop burning	Pests and diseases	Less rain Chemical fertilisers attract pests	Burn land Pesticides (bought and homemade)
Lack of water	Variable rains	Irrigation	Isolated plots	Same as above	
Pest & diseases	Pesticides expensive Lack of knowledge Chemical fertilisers attract pests	Crop rotation Pesticides	little income	Bad harvests Do not own land	Sow fruit trees Work off-farm
Lack of economic resources	Inputs expensive Credit is scarce & expensive		Lack of economic resources	Pesticides expensive Credit expensive	
Government policies does not help farmers	Government does not consider farmers to be important		Scarce access to hired labour	Expensive and not available	
Scarce access to hired labour	Hired labour expensive		Farmers do not own land	Land expensive Large landowners	
Difficulty in selling produce	Price fluctuation Roads poor		Land impoverished	Little land available Land overused	

Concept Map 3: Agriculture linked problems as perceived by farmers in Güinope, Honduras.



Concept Map 4: Agriculture linked problems as perceived by farmers in Choluteca, Honduras.



12.1.1 Knowledge of degradation and problems associated with the land

Farmers knowledge of land degradation is more advanced in Güinope than in Choluteca due to World Neighbor's influence. One of the farmers' messages was that before the 1980s farmers in Güinope did not believe that you could actually improve the quality of the soil/land (see Chapter 11 on the increased self-esteem of farmers when they realised that they could manage their land more efficiently).

Very few farmers mentioned soil erosion as a problem. Erosion was mentioned more by farmers in Güinope. This is not surprising as farmers in the region have seen soil accumulating behind live and dead barriers and have realised that had it not been for the barriers, most of this soil would have been lost from the farmer's fields. However there is a danger in believing everything that farmers say. In the focus group meetings and semi-structured interviews farmers mentioned the problems of pests and diseases. One farmer, however, pointed out that there is tendency to blame pests and diseases when the true reasons for a reduced/stagnant yield are unknown.

12.1.2 Problems most cited by farmers

Land security

One of the key messages, especially in Choluteca, is the enormous influence that lack of secure access to land has in the decision-making process *vis-à -vis* the adoption of SWC technologies (see also Bonner, 1995). Secure access does not necessarily entail land ownership. In all three communities in Choluteca the first problem mentioned by farmers was lack of access to land.

Many of the farmers in Choluteca do not have title (*dominio pleno*) nor usufruct rights (*dominio útil*). They tend to rent land from wealthier farmers and often the right to farm the land is for one or two years and sometimes for only one harvest (the *primera* or *postrera*). Many farmers expressed their reluctance to "improve" the land in any way primarily because they were not going to reap the benefits. But another reason was that if the land were "improved" and if yields rose *etc.* the owners of the land would actually take the land back earlier than may have been the case if the land had been used as normal.

Some farmers openly criticised the USAID-funded LUPE project saying that its recommendations were all very worthwhile but that the project did not address their primary problem of lack of land. Such factors such as land tenure/access to land may well be beyond the capability of the farmers or extension agent to change but they can set the boundaries within which any improvement in land use and management must be decided, designed and implemented. If this reality is not taken into account there will be more examples of the LUPE project where the SWC technologies are in danger of being rejected by farmers because they do not address the farmers' needs.

In Güinope were there is a much more equitable land distribution system and most farmers either have *dominio pleno* or *dominio útil.* Not one farmer in the focus groups mentioned lack of tenure or access to land as a problem.

Lack of credit

Another major issue mentioned by farmers in both regions is lack of credit. Without official title it is almost impossible for farmers to get rural credit. And very few farmers want to use their land as collateral because production is too risky. Farmers in Güinope complained that without access to limited credit, they were unable to improve their farms.

12.2 Farmers' actual needs versus farmers' perceived needs

12.2.1 Emphasis on control of soil erosion and SWC

Qualitative and quantitative research in Honduras has demonstrated the complexity of a farmer's universe and the fact that neither the control of soil erosion nor SWC in general are necessarily priorities for farmers. There has, however, been a tendency for development programmes to place great emphasis on SWC. Should we be surprised that farmers do not readily adopt and incorporate our knowledge of crop-tree interaction into their management systems? Their decision-making process is influenced by a plethora of factors including the their needs and a series of social, economic and political constraints and opportunities.

12.2.2 Land husbandry

In agricultural programmes, productivity is often seen as a by-product of the project and soil conservation has been elevated to the primary research object. The World Neigbor's programme in Güinope was a success partly because the programme ensured, through the use of chicken manure, a rapid rise in maize production *i.e.* the emphasis was on productivity as opposed to the number of live barrier or stone walls established. As Shaxson (1992) have argued, what is needed is a more holisitc approach to many programmes, one which consider the farmer's needs, resources and aspirations and where the emphasis is on greater conservation-effective agricultural production rather than SWC *per se*.

an alternative seldom-used approach is to consider the development of rural people, rather than of the land, as the primary focus of development actions. By working with and increasing their skills and enthusiasm to manage their own affairs, we can improve their receptivity to, and ability to make use of, relevant technical knowledge about conservation-effective use of their environment for their own benefit (Shaxson, 1992).

12.2.3 Live barriers in land husbandry

Live barrier of tree, shrub and grass species can play a major role in land husbandry programmes. From a technical point of view barriers can deal with the horizontal component of the erosion process (runoff) while cover crops (or other cover) can protect the soil from raindrop impact. Live barriers can also make substantial contributions to household economics through the provision of fruits and fodder *etc.*

Some farmers in Choluteca said that they liked live barriers because it helps them to achieve better spacing of maize, and yields are higher. Farmers and extension agents/researchers may literally be speaking a different language. The extension agent talks about the end to stop soil erosion and to plant live barriers of *V. zizanioides,* the farmer on the other hand does not perceive there to be a soil erosion problem and may not want his field planted with a non-productive live barrier such as *V. zizanioides*. SWC work may be more successful in terms of farmer adoption/adaptation, if extension agents, under the land husbandry umbrella, start talking abut the virtues of live barriers to facilitate the spacing of maize and the advantages of planting fruit trees and sugar cane across the contour *etc.* rather than stressing the need to control erosion. Many live barrier species favoured by farmers are less effective at retaining soil but from a farmer's point of view they are much more efficient.

13. DISSEMINATION AND TRAINING

13.1 Manual

Throughout Central America there is no shortage of technical manuals on SWC (section 2.3.5) and many of them contain similar information on the establishment and management of live barriers. It became clear that the project could have a larger impact if the proposed manual focused on the basic concepts of land husbandry (as opposed to SWC *per* se) as well as on a methodology for deciding if live barriers are appropriate and subsequently what live barriers to use in a given farming situation. The manual is being produced with CATIE with chapter contributions from different people. The manual will be published at the beginning of 1998. The structure of the manual is as follows:

Part 1 CONCEPTS

Chapter 1: Introductory chapter on the principles of good land husbandry, the link between live barriers and cover crops, and the structure of the manual - Jon Hellin and Francis Shaxson [independent consultant].

Chapter 2: Farmers' perceptions of soil and its problems. This chapter is based on quantitative and qualitative work carried out under ZF0019/R6292CB. It is intended to demonstrate that SWC, and especially control of soil erosion, is not a priority for farmers - Jon Hellin and Sergio Larrea.

Chapter 3: Principles of good extension work - Roland Bunch [COSECHA].

Part 11 METHODOLOGY

Chapter 4: Identification, ranking and selection of problems to be tackled on the farm and the identification of which SWC technologies are appropriate. A matrix has been developed to facilitate the selection process - Jon Hellin and Sergio Larrea.

Chapter 5: Identification of suitable species to be used in live barriers. Again a matrix has been developed which emphases the “secondary” benefits of live barrier such as the production of fruits etc. - Jon Hellin and Sergio Larrea.

Part III ESTABLISHMENT AND MANAGEMENT

Chapter 6: Establishment of live barriers - Jorge Faustino [CATIE].

Chapter 7: Management of live barriers - Jorge Faustino [CATIE].

ANNEXES - Jon Hellin, Jorge Faustino [CATIE] and Sergio Larrea.
i) Results of soil erosion experiments in Central America
ii) Simple cost-benefit analyses of selected live barriers
iii) Species sheets
v) Contact organisations in Central/South America
vi) References (including technical manuals on SWC)

13.2 Publications

Hellin, J. and Larrea, S. In press. **Ecological and socio-economic reasons for adoption and adaptation of live barriers in Güinope, Honduras**. In Proceedings of the 9th Conference of the International Soil Conservation Organisation, August 1996, Bonn, Germany.

Hellin, J. and Larrea, S. 1997. **Razones para adopción y adaptación de barreras vivas en Güinope Honduras**. In *Desarrollo Agroforestal y Comunidad Campesina*. Number 28, April - May 1997, pages 2-5.

Newsletter

A seven page article on farmers' use of live barriers in Honduras, written by Jon Hellin and Sergio Larrea, appeared in the September 1996 issue of ENABLE - the newsletter of the UK-based *Association for Better Land Husbandry*.

13.3 Internal Reports:

Quarterly Report	1 July - 30 September 1995
Quarterly Report	1 October - 31 December 1995
Quarterly Report	1 January - 31 March 1996
Quarterly Report	1 April - 30 June 1996
Quarterly Report	1 July - 30 September 1996
Quarterly Report	1 October - 31 December 1996
Quarterly Report	1 April - 30 June 1997

Calendar Year Report	1 January - 31 December 1995
Calendar Year Report	1 January 1996 - 31 March 1997

Annual Progress Report	1 July 1995 - 30 June 1996
Annual Progress Report	1 July 1996 - 30 June 1997

Field Trip Report	8 August - 19 September 1995
Field Trip Report	20 October 1995 - 2 March 1996
Field Trip Report	19 March - 20 August 1996
Field Trip Report	19 September 1996 - 3 March 1997

13.4 Poster presentations

Jon Hellin presented a poster entitled *Ecological and socio-economic reasons for adoption and adaptation of live barriers in Güinope, Honduras* at the 9th Conference of the International Soil Conservation Organisation which was held at the end of August 1996 in Bonn, Germany.

Jon Hellin presented a poster entitled *Barreras vivas y cultivos de cobertura: ¿hacia la seguridad alimentaria y agricultura sostenible*? at the DFID and GTZ-funded Latin American Regional Workshop on "Cover crops: components of integrated systems" held in Mérida, Mexico, 3-6 February, 1997.

13.5 Lectures/presentations

- Sergio Larrea presented the preliminary results of his research to third-year students at the *Escuela Agrícola Panamerica* (EAP) in November 1996.

- Jon Hellin presented the preliminary results of ZF0019/R6292CB to representatives of 10 development organisations in Honduras. The presentation in December 1996 was part of a three-day meeting designed to present results from the DFID-funded CONSEFORH project.

- Simultaneous translation into Spanish by Jon Hellin of a lecture by Francis Shaxson (land husbandry specialist) on the *Principles of better land husbandry* to staff and students at EAP under the auspices of a GTZ development programme for the School. January 1997.

- Sergio Larrea gave a talk in February 1997 on farmer innovation in the Güinope region. The presentation was to representatives of a number of Central American and German Catholic NGOs and was organised under the auspices of the German Catholic Church development organisation MISEREOR.

- Jon Hellin presented a two hour seminar on the project's research activities to students of the Faculty of Agricultural Engineering at Cornell University (USA) in April 1997.

- Jon Hellin and Sergio Larrea delivered two lectures on in June 1997 to second year students at EAP. The lectures, which were given to over 200 students, were part of a course on rural sociology and were entitled *Desarrollo Rural: ¿Si la tecnología es la respuesta, cuál es la pregunta?*

- Jon Hellin jointly presented a two-hour seminar with Bismarck Mendoza (*Universidad Nacional Agraria*, Managua) entitled *Factores ecológicos y humanos en la conservación de agua y suelo, y productividad* to 4th and 5th year students of the *Facultad de Recursos Naturales y del Ambiente* (FARENA) at the *Universidad Nacional Agraria*, Managua Nicaragua. August 1997.

13.6 Official visits to the live barrier/cover crop experimental site in Choluteca

- Consultative group of the *Corporación Hondureña de Desarrollo Forestal* (COHDEFOR). This group meets once a month and is made up of the national and international heads of all donor projects working with COHDEFOR. July 1996.

- A group from the Swiss-funded *Programa para la agricultura sostenible en laderas en America Central* (PASOLAC) visited the trial site and surrounding communities in June 1997. PASOLAC is based in Nicaragua but has activities in Nicaragua, Honduras and El Salvador.

- A group from PASOLAC and the Honduran Coffee Institute. The latter is interested in conducting research into erosion in coffee plantations and was interested in seeing the use of catchpits to monitor soil erosion. September 1997.

13.7 Workshops with farmers from Güinope

Sergio Larrea produced a summary document of each of the workshops held with farmer innovators in Güinope (Chapters 7 and 11). The documents entitled *Se hace camino al andar:*

Reflexiones de agricultores con 15 años de experiencia en desarrollo rural and *Segundo encuentro de agricultores de cambio en Güinope: explorando los orígenes de la innovación y sus aplicaciones al desarrollo rural* were distributed to all the participating farmers and several local NGOs.

13.8 BBC World Service

Jon Hellin visited Güinope on in May 1996 with Daniel Dickinson, a journalist from the BBC World Service. Research carried out under ZF0019/R6292CB was included in a seven-minute programme on sustainable agriculture in Honduras which was broadcast on the BBC World Service's "Farming World" in July 1996.

Jon Hellin visited Güinope on 26 June 1997 with the British environmental journalist Charlie Pye-Smith and was interviewed for a programme for the BBC World Service on sustainable agriculture.

14. CONTRIBUTION OF OUTPUTS

14.1 Contribution towards DFID's development goals

The project's goal is the *contribution of trees to productivity of tree/crop based systems increased*. This in turn is designed to contribute to the goal of the Forest/Agriculture Interface System, *productivity and productive potential of forest/agriculture interface increased through environmentally and economically sustainable management and exploitation of forest resources.* The Forest/Agriculture Interface System is in turn designed to contribute to DFID's fundamental aims and objectives *to reduce poverty, promote economic growth and reform, and, mitigate national environmental problems*.

The achievement of the project's goal, the System's goal and DFID's aims and objectives is, and will continue to be partially dictated by the decisions taken by farmers.

Research has shed light on the contribution that live barriers of tree, shrub and grass species can make to reducing erosion and contributing to greater agricultural stability. Project results point to the fact that live barriers should be used in combination with technologies, such as cover crops and sparsely-located trees, to ensure that the soil surface is better protected.

The project has also demonstrated that in Honduras, farmers' problems and needs are not generally technical but rather socio-economic. Farmers are unlikely to adopt and adapt technologies such as live barriers, however suitable they are from a technical point of view, unless those technologies simultaneously address their social and economic needs.

If live barriers and other SWC technologies are to contribute towards DFID's development goals, they ought to be promoted as part of multi-disciplinary and holisitc strategies that encompass farmers' needs, aspirations and resources.

14.2 Promotional pathways

14.2.1 Organisations already targeted

Target institutions stated in the proposal included: forest and agriculture policy and extension departments; NGOs; DFID; USAID; CATIE. Many of these organisations, including Honduran-based forest/agriculture extension departments, have been involved in the FRP-funded research activities directly and indirectly since 1995.

Many of the results have already been made available to these target institutions through publications, seminars and visits to the live barrier/cover crop trial site (Chapter 13).

14.2.2 Follow up action/research

The manual, which will be published and distributed by CATIE in early 1998, will be the primary means to promote research results (Chapter 13). In addition, Jon Hellin will continue to work in Honduras until early 1998. During this period research findings will be further promoted as follows:

- A joint paper with Gaye Burpee on farmer-friendly methods to measure soil erosion (in preparation).
- Paper on farmer perceptions of soil erosion for GTZ-funded magazine *Desarrollo Agroforestal y Comunidad Campesina* (in preparation).
- Article on live barriers for *Agroforestry Forum* (in preparation).
- Article on use of catchpits for calculating soil loss for PASOLAC manual (to be published in Nicaragua in 1988).
- On-going discussions with IFPRI on implications on policy of FRP-funded research.
- Collaborative work with John Quinton (Silsoe College) providing data for RNRRS-funded research on modelling effects of live barriers.

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Soil 1 USDA Typic Ustropept
Coarse loamy, gypsic, isohyperthermic

LOCATION	Santa Rosa research station, Choluteca, Honduras
AUTHORS	J. Hellin, D. Kass
GENERAL LANDFORM	hilly terrain
PHYSIOGRAPHIC UNIT	mountain foot slope
MICRORELIEF	rills
SURFACE CHARACTERISTICS: rock outcrop	occasional
stoniness	some stones at surface
slaking/crusting	none
SLOPE PROCESSES: soil erosion	evidence of considerable erosion, much of A horizon probably lost to erosion
PARENT MATERIAL: type, texture	unconsolidated limestone fragments, coarse
depth to lithological boundary	90 cm
remarks	
EFFECTIVE SOIL DEPTH	90 cm
WATER TABLE	no watertable observed
DRAINAGE	well-drained
PERMEABILITY	no slowly permeable layer observed
MOISTURE CONDITIONS PROFILE	moist
LAND USE	first year maize crop, had been in fallow for at least seven years
CLIMATE	wet-dry tropical

PROFILE DESCRIPTION

A1	0-20 cm	dark greyish brown (10YR 4/2, moist) sandy loam; weak fine subangular blocky to granular; soft-slightly hard, slightly sticky non-plastic, very friable; many fine pores; fine roots throughout, moderate biological activity; clear, wavy boundary to
B2	20-64 cm	brownish yellow (10 YR 6/8 moist) gravelly loamy sand; weak, fine crumbs; soft, very friable, non-sticky and non-plastic; abundant small and medium pores, common fine and large roots, moderate biological activity; gradual irregular boundary to
B3	64-90 cm	matrix brownish yellow (10 YR 6/6, moist) with prominent, many, coarse inclusions of decomposing parent material ,white (5Y 8/1 moist) loamy coarse sand,; weak fine crumb; loose, loose, non-sticky, non-plastic; some fine pores, few, fine roots, less evidence of biological activity than above horizons; clear, wavy boundary to
C	90-164+ cm	white matrix (5Y 8/1 moist) with prominent, many inclusions of yellowish red fragments (5Y 5/8, moist) coarse sand; weak, fine, crumb; loose, loose, non-sticky, non-plastic; no pores, no roots, no biological activity; augured to 190 cm, no change in properties.

ANALYTICAL DATA

Physical properties

Horizon	% sand	% silt	% clay	Bulk density ($t\ m^{-3}$)	Moisture content 33kPa (gg^{-1})	Moisture content 1500 kPa ($g\ g^{-1}$)
1 A1	63.2	19.6	17.2	1.419	0.2415	0.1412
1 B2	69.2	21.6	9.2	1.461	0.1619	0.0614
1 B3	75.2	18.0	6.8	1.571	0.1529	0.0611
1 C	79.2	15.6	5.2	1.557	0.1465	0.0551

Chemical properties

Horizon	pH (H_2O)	pH (KCl)	CIC (cmol kg-1)	Ca	Mg	K	Na	Organic C	Base saturation	New Zealand P retention	Citrate soluble P	Oxalate extractable Al	Oxalate extractable Fe
A1	6.6	5.4	12.49	6.61	1.40	0.47	0.02	2.17	68.05		6.6		
B2	6.4	4.2	9.82	3.61	1.05	0.20	0.05	0.43	50.00	9.9		0.1	0.1
B3	6.3	3.4	7.03	5.41	1.44	0.06	0.07	0.03	99.29	5.1		0.0	0.1
C	6.4	3.4	6.72	7.51	0.77	0.04f	0.04	0.02	124.40				

A1 is not thick enough to be a mollic epipedon. B2 has a slight color change and increase in clay content over B3 so it can be considered a cambic horizon. Soil is therefore an Inceptisol. Not enough sand (too many rock fragments) to be an Psamment. Due to Ustic moisture regime, is Ustropept. Ustropept takes precedence over Ustrochrept in key (soil would also key out as Ustrochept but Ustropept comes first in key). Higher Ca that CIC indicates free calcium compounds, probably gypsum because test for free carbonates was negative. USDA classification is therefore Typic Ustropept since it does not have properties for Lithic, Vertic, Aquic, Oxyaquic, or Oxic Ustropept.

Soil 2 USDA Typic Haplustoll
Loamy, gypsic, isohyperthermic

LOCATION	Santa Rosa research station, Choluteca, Honduras
AUTHORS	J. Hellin, D. Kass
GENERAL LANDFORM	hilly terrain
PHYSIOGRAPHIC UNIT	mountain foot slope, facing NE
MICRORELIEF	rills
SURFACE CHARACTERISTICS: rock outcrop	occasional
stoniness	some stones at surface
slaking/crusting	none
SLOPE PROCESSES: soil erosion	evidence of considerable erosion, much of A horizon probably lost to erosion
PARENT MATERIAL: type, texture	unconsolidated limestone fragments, coarse
depth to lithological boundary	90 cm
remarks	
EFFECTIVE SOIL DEPTH	90 cm
WATER TABLE	no watertable observed
DRAINAGE	well-drained
PERMEABILITY	no slowly permeable layer observed
MOISTURE CONDITIONS PROFILE	moist
LAND USE	first year maize crop, had been in fallow for at least seven years
CLIMATE	wet-dry tropical

PROFILE DESCRIPTION

A1	0-22 cm	Very dark greyish brown (10YR 3/2, moist) sandy clay loam; moderate, medium angular blocky; slightly hard, friable, slightly sticky and slightly plastic ; many fine pores; medium roots throughout, much biological activity, especially termites; clear, smooth boundary to
B2	22-60 cm	yellowish red (5YR 5/8 moist) sandy clay loam; moderate, medium-coarse angular blocky; slightly hard, friable, slightly sticky and slightly plastic; abundant small and medium pores, common medium few fine roots, much biological activity, especially termites; gradual wavy boundary to
B3	60-90 cm	reddish yellow (5 YR 6/8, moist) with prominent, few, coarse inclusions of decomposing parent material light grey (10YR 7/2 moist) sandy, clay, loam; weak fine angular blocky to granular; soft,very friable, slightly sticky, and slightly plastic; few fine pores, few, medium roots, less evidence of biological activity than above horizons; clear, wavy boundary to
C	90-142+ cm	white matrix (2.5 Y 8/1 moist) with prominent, many inclusions of reddish yellow fragments (5YR 6/8, moist) coarse sand; weak, medium, angular blocky; soft, very friable, , non-sticky, non-plastic; no pores, no roots, no biological activity; augured to 200 cm, no change in properties

ANALYTICAL DATA

Physical properties

Horizon	% sand	% silt	% clay	Bulk density ($t\ m^{-3}$)	moisture content 33kPa (gg^{-1})	moisture content 1500 kPa ($g\ g^{-1}$)
2 A1	61.2	19.6	19.2	1.344	0.2099	0.1483
2 B2	55.2	23.6	21.2	1.551	0.2047	0.1334
2 B3	59.2	23.6	17.2	1.578	0.2179	0.1057
2 C	65.2	23.6	11.2	1.494	0.1920	0.0678

Chemical properties

Horizon	pH (H_2O)	pH (KCl)	CIC (cmol kg-1)	Ca	Mg	K	Na	Organic C	Base saturation	New Zealand P retention	Citrate soluble P ($mgkg^{-1}$)	Oxalate extractable Al	Oxalate extractable Fe
A1	6.9	5.5	15.45	10.62	2.64	0.34	0.01	2.08	88.09		5.5		
B2	6.9	4.3	15.36	10.92	3.43	0.03	0.03	0.39	93.82	10.0		0.1	0.1
B3	6.7	3.9	17.17	12.12	3.95	0.03	0.09	0.13	94.29	7.5		0.1	0.1
C	6.5	3.4	13.64	11.82	4.26	0.02	0.08	0.01	118.62				

A1 is dark enough, thick enough and contains enough organic matter to be a mollic epipedon. Slight clay bulge in B2 is sufficient to make it a cambic horizon though insufficient for argillic horizon.. Soil is therefore a Mollisol. . Due to Ustic moisture regime, is Ustoll. Does not have properties for Durustoll, Natrustoll, Argiustoll, Paleustoll, Calciustoll, or Vermustoll so is Haplustoll. Within the Haplustolls, we do not have sufficient climatic data (have to know if dry for more or less than 90, 120.or 180 days in 6 of 10 years) so will have to leave it as Typic Haplustoll. Mollic epipedon is not thick enough for Cumulic or Pachic Haplustoll unless assumed that more than half of it has eroded away. Higher Ca that CIC indicates free calcium compounds, probably gypsum because test for free carbonates was negative.

Soil 3 USDA Entic Haplustoll
Coarse-loamy, gypsic, isohyperthermic

LOCATION		Santa Rosa experimental station, Choluteca, Honduras
AUTHORS		J. Hellin, D. Kass
GENERAL LANDFORM		hilly terrain
PHYSIOGRAPHIC UNIT		mountain foot slope, facing EN
SLOPE		65-75%
MICRORELIEF		rills
SURFACE CHARACTERISTICS:	rock outcrop	occasional
	stoniness	some stones at surface
	slaking/crusting	none
SLOPE PROCESSES:	soil erosion	evidence of considerable erosion, much of A horizon probably lost to erosion
PARENT MATERIAL:	type, texture	unconsolidated limestone fragments, coarse
	depth to lithological boundary	150+cm
	remarks	
EFFECTIVE SOIL DEPTH		150+
WATER TABLE		no watertable observed
DRAINAGE		well-drained
PERMEABILITY		no slowly permeable layer observed
MOISTURE CONDITIONS PROFILE		moist
LAND USE		first year maize crop, had been in fallow for at least seven years
CLIMATE		wet-dry tropical

PROFILE DESCRIPTION

A1	0-45CM	Dark brown (10YR 3/3, moist) gravelly loamy sand; moderate, fine angular blocky to medium granular; soft, very friable, slightly sticky and slightly plastic ; many large and medium pores; abundant large and medium roots throughout, much biological activity; clear, straight boundary to
B2	22-60 cm	dark yellowish brown (10YR 4/4 moist) stony, loamy coarse sand; weak, fine, granular; loose, loose, non-sticky and non-plastic; few small and medium pores, common medium few roots, some biological activity; clear, smooth boundary to
B3	60-90 cm	yellowish red (5 YR 5/8, moist)matrix with distinct, common inclusions of decomposing parent material light grey (5YR 7/1 moist) coarse sand; weak fine granular; loose, loose, non-sticky, non-plastic; no pores, no roots, no evidence of biological activity, gradual, wavy boundary to
C	90-142+ cm	yellowish brown (10 YR 5/6 moist) matrix with white (2.5 Y 8/1 moist) inclusions angular, gravelly, coarse sand; weak, fine, granular; loose, loose, , non-sticky, non-plastic; no pores, few large roots, no biological activity; augured to 200 cm, no change in properties

ANALYTICAL DATA

Physical properties

Horizon	% sand	% silt	% clay	Bulk density ($t\ m^{-3}$)	moisture content 33kPa (gg^{-1})	moisture content 1500 kPa ($g\ g^{-1}$)
2 A1	63.2	19.6	17.2	1.383	0.1719	0.1114
2 B2	67.2	21.6	11.2	1.544	0.1303	0.0788
2 B3	73.2	17.6	9.2	1.818	0.1179	0.0632
2 C	79.2	11.6	9.2	1.766	0.1383	0.0683

Chemical properties

Horizon	pH (H_2O)	pH (KCl)	CIC (cmol kg-1)	Ca	Mg	K	Na	Organic C	Base saturation	New Zealand P retention	Citrate soluble P ($mgkg^{-1}$)	Oxalate extractable Al	Oxalate extractable Fe
A1	6.8	5.4	15.36	12.42	2.48	0.22	0.00	2.26	98.44		7.2		
B2	7.1	4.1	12.51	14.23	2.89	0.05	0.03	0.21	137.49	5.8		0.1	0.1
B3	6.7	3.5	12,17	14.23	3.05	0.04	0.06	0.08	142.81	5.2		0.0	0.1
C	6.5	3.4	11.63	12.72	3.47	0.04	0.13	0.02	140.67				

A1 dark enough and contains enough organic matter to be a mollic epipedon. B2 shows no clay increase or other alteration to be a cambic horizon. Soil is therefore a Mollisol. Due to Ustic moisture regime, is Ustoll. No accumulation of clay, carbonates, or gypsum to be Durustoll, Natrustoll, Paleustoll, Calciustoll, Argiustoll, or Vermustoll. Therefore the soil is a Haplustoll. Since there are not salic horizons, lithic contents within 50 cm of surface, moisture for less than 90 days in moisture control sector, vertic properties and moisture for less than 120 days in moisture control section, oxic or andic properties, pumice fraction, mollic horizon thicker than 50 cm and texture finer than loamy sand, aquic conditions, carbon acuumulation at depth, or a brittle horizon, soil is not Salorthidic, Ruptic-Lithic, Torrertic, Udertic, Vertic, Torroxic, Oxic, Andic, Vitritorrandic, Vitrandic, Cumulic, Pachic, Anthraquic, Flavaquentic, Aquic, Oxyaquic, Torrifluventic, Torriorthentic, Aridic, Fluventic, Duric, Udorthentic, or Udic Haplustoll. Because of lack of cambic horizon , is probably an Entic Haplustoll. ,.
Higher Ca that CIC indicates free calcium compounds, probably gypsum because test for free carbonates was negative

Soil 4 Entic Haplustoll, fine-loamy, gypsic, isohyperthermic

LOCATION	Choluteca, Honduras
AUTHORS	J. Hellin, D. Kass
GENERAL LANDFORM	Hilly terrain
PHYSIOGRAPHIC UNIT	mountain foot slope, facing N, less sun than other sites
SLOPE	65-75%
MICRORELIEF	rills
SURFACE CHARACTERISTICS: rock outcrop	occasional
stoniness	some stones at surface
slaking/crusting	some of material upslope seems to have moved downhill and be buried at 90-135 cm depth and have undergone further soil genesis in place. Material above this horizon must have arrived later.
SLOPE PROCESSES: soil erosion	evidence of considerable erosion, much of A horizon probably lost to erosion
PARENT MATERIAL: type, texture	unconsolidated rock fragments, coarse
depth to lithological boundary	180 cm
Remarks	
EFFECTIVE SOIL DEPTH	180cm
WATER TABLE	no watertable observed
DRAINAGE	well-drained
PERMEABILITY	no slowly permeable layer observed
MOISTURE CONDITIONS PROFILE	moist
LAND USE	first year maize crop, had been in fallow for at least seven years
CLIMATE	wet-dry tropical

PROFILE DESCRIPTION:

A1	0-40 cm	Dark brown (7.5YR 3/2, moist) angular gravelly sandy loam with about 10% gypsum? fragments; moderate, fine subangular blocky; soft, very friable, slightly sticky and slightly plastic ; many fine, medium, and large pores; abundant large, medium and fine roots throughout, much biological activity; diffuse and irregular boundary to
B1	40-90 cm	red (10 R 4/6 moist) coarse sandy loam; moderate, fine, angular blocky to fine granular; loose, very friable, sticky and plastic; abundant small and medium pores, common medium few roots, considerable biological activity; gradual and wavy boundary to
A2b	90-135 cm	dark red (2.5 YR 4/6) angular gravelly sandy clay loam with about 50% volume small, red stones; weak, fine, granular; loose, friable, slightly sticky and slightly plastic; few pores; common fine roots; limited biological activity; clear and wavy boundary to
B2b	135-162 cm	red (10 R 5/8, moist)sandy loam; weak, fine, crumb; soft, friable, slightly sticky and slightly plastic; fine and medium pores, few roots; moderate biological activity; clear and smooth boundary to
C	162-180+	pinkish white (7.5 YR 8/2 moist) matrix with many, prominent, medium

cm	red (10 R 5/8) inclusions; moderate, medium, angular blocky; slightly hard, friable, sticky and plastic; few pores, few fine roots, no biological activity; augured to 200 cm, stone line at 180 cm

Analytical data
Physical properties

Horizon	%sand	%silt	% clay	Bulk density (t m^{-3})	moisture content 33kPa (gg^{-1})	moisture content 1500 kPa ($g\ g^{-1}$)
4 A1	55.2	21.6	23.2	1.369	0.1977	0.1288
4 A2b	45.2	31.6	23.2			
4 B1	57.2	19.6	23.2	1.564	0.1810	0.1186
4 B2b	55.2	23.6	21.2	1.399	0.2278	0.1397
4 C	51.2	25.6	23.2	1.653	0.1582	0.1076

Chemical properties

Horizon	pH (H2O)	pH (K Cl)	CIC (cmol kg-1)	Ca	Mg	K	Na	Organic C	Base saturation	New Zealand P reten-tion	Citrate soluble P ($mgkg^{-1}$)	Oxalate extract-able Al	Oxalate extract-able Fe
A1	6.6	5.1	14.45	8.01	3.53	0.34	0.02	1.62	82.35		0.9		
A2b	6.0	4.3	10.21	8.11	2.76	0.13	0.04	0.34	108.13			0.1	0.2
B1	6.3	4.4	15.24	8.11	2.81	0.16	0.01	0.63	72.76	9.2		0.1	0.1
B2b	5.9	3.9	15.68	4.41	4.00	0.13	0.04	0.18	54.72	13.4		0.1	0.2
C	6.1	3.5	12.86	4.21	7.39	0.13	0.04	0.09	125.82				

A1 is dark enough and contains enough organic matter to be a mollic epipedon. No textural, color, or carbonate change in B1 for cambic horizon. Soil is therefore a Mollisol. Ustic moisture regime makes it an Ustoll. No argillic or petrocalcic horizon so must be Haplustoll. . Could argue that

Mollic epipedon was originally more than 50 cm thick—at least 10 cm lost by erosion and because of texture finer than loamy fine sand is Pachic Haplustoll. Otherwise,   Entic Haplustoll.
Higher Ca that CIC indicates free calcium compounds, probably gypsum because test for free carbonates was negative.

Soil 5 — Typic Ustropept , fine loamy, gypsic, isohyperthermic

LOCATION	Choluteca, Honduras
AUTHORS	J. Hellin, D. Kass
GENERAL LANDFORM	Hilly terrain
PHYSIOGRAPHIC UNIT	mountain foot slope, facing East
SLOPE	35-45%
MICRORELIEF	rills
SURFACE CHARACTERISTICS: rock outcrop	occasional
stoniness	some stones at surface
slaking/crusting	none
SLOPE PROCESSES: soil erosion	evidence of considerable erosion, much of A horizon probably lost to erosion
PARENT MATERIAL: type, texture	unconsolidated rock fragments, coarse
depth to lithological boundary	150 cm
Remarks	
EFFECTIVE SOIL DEPTH	150 cm
WATER TABLE	no watertable observed
DRAINAGE	well-drained
PERMEABILITY	no slowly permeable layer observed
MOISTURE CONDITIONS PROFILE	moist
LAND USE	first year maize crop, had been in fallow for at least seven years
CLIMATE	wet-dry tropical

PROFILE DESCRIPTION:

A1	0-18 cm	brown (10YR 4/3, moist) sandy loam; moderate, fine subangular blocky to granular; soft, friable, non-sticky and slightly plastic ; abundant medium and fine pores; abundant large, medium, and fine roots throughout, much biological activity; clear, wavy boundary to
B2	18-75 cm	yellowish brown (10YR 5/6 moist) sandy loam; weak, fine, angular blocky to granular; soft, very friable, non-sticky and non-plastic; few small and medium pores, common fine, medium, and large roots, some biological activity; irregular, diffuse boundary to
C	75-140+	light gray (2.5 YR 7/2 moist) sand matrix with many prominent, fine yellowish red (5YR 5/8 moist) and dark grey (5Y 4/1 moist) inclusions; weak, medium, subangular blocky to granular; soft,very friable , non-sticky and non-plastic; few roots, no biological activity; augured to 200 cm, no change in properties

Analytical data

Physical properties

Horizon	%sand	%silt	% clay	Bulk density (t m^{-3})	moisture content 33kPa (gg^{-1})	moisture content 1500 kPa (g g^{-1})
5 A2	63.2	15.6	21.2	1.288	0.2151	0.1220
5 A2b	57.2	25.6	17.2	1.372	0.1838	0.0883
5 C	65.2	25.6	11.2	1.464	0.1666	0.0710

Chemical properties

Horizon	pH (H2O)	pH (K Cl)	CIC (cmol kg-1)	Ca	Mg	K	Na	Organic C	Base saturation	New Zea-land P reten-tion	Citrate soluble P (mgkg^{-1})	Oxalate extract-able Al	Oxalate extract-able Fe
A2	6.7	5.2	11.49	6,61	1.56	0.19	0.04	1.94	73.11		1.6		
B2	6.1	3.5	13.02	9.82	1.91	0.02	0.06	0.58	90.71	9.6		0.1	0.1
C	6.5	3.5	9.96	9.52	1.19	0.02	0.08	0.08	108.53				

A1 is not dark or thick enough organic matter to be a mollic epipedon but meets criteria for ochric epipedon. B2 has sufficient color change to be cambic horizon. Soil is therefore an Inceptisol, an Ochrept. Ustic moisture regime so Ustrochrept. Probably dry for more than 180 days in 6 of 10 years so Aridic Ustrochrept. A1 is not thick enough to be a mollic epipedon. B2 has a slight color change and increase in clay content over B3 so it can be considered a cambic horizon. Soil is therefore an Inceptisol.. Not enough sand (too many rock fragments) to be an Psamment. Due to Ustic moisture regime, is Ustropept. Ustropept takes precedence over Ustrochrept in key (soil would also key out as Ustrochept but Ustropept comes first in key. Higher Ca that CIC indicates free calcium compounds, probably gypsum because test for free carbonates was negative. USDA classification is therefore Typic Ustropept since it does not have properties for Lithic, Vertic, Aquic, Oxyaquic, or Oxic Ustropept.

Major determining factors in classification of these soils is the presence or absence of mollic epipedon. Mollic epipedon should have color value less than 3, contain at least 5.8 mg g-1 C and be at least 18 cm thick and remain soft in dry weather. Last characteristic was difficult to verify because visit was made at end of rainy season. Classification of soils 2,3, and 4 as mollisols is based on color, corganic C content, and thickness of surface epipedon. This classification may change if soils are found to have hard surfaces during dry season. It is also possible that mollic epipedons were formerly thicker, making them Pachic Mollisols. Soil is very coarse textured, with many small gravelly fragments. Textural analyis in laboratory, after coarse material was eliminated, indicated more than 20% clay in some cases. Some soils could therefore be considered inceptisols. For classification at subgroup level, more data on moisture conditions during the dry season (during 10 years) is needed. Therefore, classification of several soils may change if more data becomes available.

On Thursday, December 4, a second site was visited near Zamorano. According to the farmer, there had been some slumping from hills above the site. The area was at a higher elevation than the other site.

There was evidence of considerable leaching both from the transported material above a darker horizon and from the material below the darker horizon.

Soil 6 Typic Placaquod loamy, siliceous, thermic

LOCATION	? Honduras
AUTHORS	J. Hellin, D. Kass
GENERAL LANDFORM	valley bottom
PHYSIOGRAPHIC UNIT	foot slope
SLOPE	10-15%, facing East
MICRORELIEF	rills
SURFACE CHARACTERISTICS: rock outcrop	occasional
stoniness	some stones at surface
slaking/crusting	none
SLOPE PROCESSES: soil erosion	relief not favorable to erosion
PARENT MATERIAL: type, texture	sand
depth to lithological boundary	150+ cm
Remarks	
EFFECTIVE SOIL DEPTH	1.1 m
WATER TABLE	Water table at 110 cm
DRAINAGE	restrocted
PERMEABILITY	good
MOISTURE CONDITIONS PROFILE	moist/wet
LAND USE	vegetables, pine. Associated scrub
CLIMATE	wet-dry subtropical, isothermic

PROFILE DESCRIPTION:

A2	0-30 cm	light brownish grey (2.5YR 6/2, moist) sand; weak, fine granular to none; loose, loose non-sticky and non- plastic ; few medium pores; abundant large, medium and fine roots throughout, some biological activity; gradual and wavy boundary to
Bir	30-35 cm	dark red (2.5YR 4/8 moist) cemented sand (placic horizon); too thin to evaluate structure and consistency; abundant roots pentrate; gradual and wavy boundary to
A2b	35-65 cm	very dark grayish brown (10 YR 3/2 moist) loamy sand with about 50% volume small, red stones; weak, medium, angular blocky; soft, very friable, non-sticky and non- plastic; few medium and fine pores; common fine roots; some biological activity; clear and wavy boundary to
ABirb	65-80 cm	grey (10 YR 5/1, moist)sand matrix with many prominent coarse yellowish red (5YR 4/6) mottles ; weak, fine, angular blocky; soft, very friable, non-plastic and non-sticky; no pores, few roots; restricted biological activity; clear, straight boundary to
C	80-110+ cm	dark grey gley (Gley 7/1) dry; 4/1 moist) silt with massive structure; slightly hard, friable, non-sticky and non-plastic; no pores, no roots, no biological activity; augured to 180 cm, no change seen

Analytical data

Physical properties

Horizon	%sand	%silt	% clay	Bulk density (t m^{-3})	moisture content 33kPa (gg^{-1})	moisture content 1500 kPa (g g^{-1})
6 A2	69.2	23.6	7.2	0.932		
6 A2b	57.2	27.6	15.2	1.126	0.3362	0.1317
6 ABrb	57.2	29.6	13.2	1.025		
6 B1r	67.2	23.6	9.2			
6 C	43.2	39.6	17.2	1.043		

Chemical properties

Horizon	pH (H2O)	pH (K Cl)	CIC (cmol kg-1)	Ca	Mg	K	Na	Organic C	Base saturation	New Zealand P reten-tion	Citrate soluble P (mgkg^{-1})	Oxalate extract-able Al	Oxalate extract-able Fe
A2	6.2	4.7	3.29	0.92	0.99	0,32	0.00	0.17	67.78		0.5		
A2b	5.6	3.9	6.38	0.90	0.52	0.33	0.05	0.66	28.21	10.1		0.1	0.2
AB1	5.9	4.0	5.41	1.02	0.67	0.37	0.13	0.14	40.48	9.4		0.1	0.2
B1r	5.8	4.4	4.00	1.42	0.84	0.22	0.03	0.32	62.75	5.1		0.0	0.1
C	5.8	3.9	4.81	1.06	0.67	0.42	0.07	0.01	46.15				

Both A2 and ABirb met criteria for albic horizons. A2b would appear to meet criteria for spodic horizon.

Evidence of water movement to 35 cm (red nodules in A2b). Soil is Aquod. Placic horizon (Bir) present so is Placaquod. Only Andic and Typic Placaquods defined so it Typic because has no Andic properties.

High water table and low nutrient contents would be principal limitation in cultivating this soil. Fertilizer application and surface drains would probably be needed to ensure production year after year.l

None of the soils seen could be considered to have high agricultural potential. Textures were all relatively coarse and water holding capacity would be a problem with all soils. All of the soils at the first site have very little structure so would be extremely susceptible to erosion by wind and water. Considerable erosion has probably already occurred although area was only planted to maize once previously, about seven years ago according to farmers at site.

ANNEX 2 CUESTIONARIO PARA LA DETERMINACION DE VARIABLES QUE AFECTAN LA INNOVACION EN TECNICAS DE CONSERVACION DE SUELOS (Enfasis en barreras vivas)

0. Nombre del encuestador:___________________________.

1. Nombre del agricultor: ____________________________.

2. Comunidad: ____________________________.

3. Fecha: __________.

A. Características propias del agricultor

4.Edad jefe de familia	
5.Años manejando la finca	
6.Grado en la escuela	
7.Años de vivir en la Comunidad	

8.	En prácticas de conservación de suelos
No. de capacitaciones	

9.Género	Edad años	No. de personas	Trabajan en la Finca		
			Siempre	A veces	Nunca
Hombres	+ 16				
	8-16				
	- 8				
Mujeres	+ 16				
	8-16				
	- 8				

10. ¿Ha trabajado para alguna institución de desarrollo?
10.1. Si. ¿Cuáles?______________________ 10.2. No.

11. Dedicación a la agricultura:
11.1. Total 11.2. Parcial. Otras actividades:___________

12. ¿Porqué trabaja en agricultura?
1.____.
2.____.
3.____.

13. ¿Alguna vez se prestó dinero para realizar prácticas agrícolas? (si responde No pasar a la 16)
13.1.Si. 13.2. No. ¿Por qué? _______________.

14. ¿En general cómo le fue en sus experiencias pasadas con dinero prestado?
14.1**.** Mal 14.2. Regular 14.3. Bien

15. ¿Cuáles fueron los problemas/beneficios de esta experiencia?

15.1. PROBLEMAS	15.2. BENEFICIOS

16. ¿Si tuviera la oportunidad de trabajar con dinero prestado lo haría?
16.1.Si. 16.2.No. ¿Por qué?________________

17. ¿Perteneció o pertenece a alguna organización de la comunidad? (Si responde No pasar a la 20)

17.1. Si.	Tipo de Asociación	Cargo ocupado
__	productivas(cooperativas)	________________
__	servicio a la comunidad	________________
__	religiosa	________________
__	recreativa	________________

17.2. No ¿Por qué?________________

18. ¿En general cómo le fue en sus experiencias pasadas con estas organizaciones?
18.1. Mal 18.2. Regular 18.3.Bien

19. ¿Cuáles fueron los problemas/beneficios de estas experiencias?

19.1. PROBLEMAS	19.2. BENEFICIOS

20. ¿Si tuviera la oportunidad en el futuro de seguir trabajando en alguna organización, lo haría?
20.1. Si. 20.2. No. ¿Por qué? ________________.

21. ¿Vende algunas veces sus productos? (Si responde No pasar a la 24)
21.1. Si. ¿Qué productos? _________ 21.2. No. ¿Por qué?________________

22. ¿En general cómo le va con la venta de sus productos agrícolas?
22.1. Mal 22.2. Regular 22.3. Bien

23. ¿Cuáles fueron los problemas/beneficios de estas experiencia?

23.1. PROBLEMAS	23.2. BENEFICIOS

24. ¿Si tuviera la oportunidad en el futuro de seguir vendiendo sus productos lo haría?
24.1. Si. ¿Qué productos? _________ 24.2. No. ¿Por qué?________________.

25. ¿Enseñó alguna vez las técnicas de conservación de suelos?

25.1. Si. 25.2. No.

26. ¿Qué Instituciones de desarrollo han trabajado con usted en prácticas de conservación de suelos?

26.1.Vecinos Mundiales. 26.3. LUPE

26.2.Proyecto Manejo 26.4. Zamorano. 26.5. Otras__________

27. Los rendimientos en sus cultivos han ido:

27.1. Mejorando 27.2. Manteniéndose. 27.3. Empeorando.

¿Por qué?____.

28. ¿Usted cree que la gente pagaría más por una parcela con obras de conservación (Barreras, zanjas.)?

28.1.Si___________ 28.2.No______________.

B. Características de la finca y de las innovaciones

29. Características de las parcelas.

Parcela: (nombre)	Area (mz)	Tiempo para llegar	Tenencia de la parcela	Calidad del suelo	Pendiente de la parcela	Acceso a Riego	Uso de Animales	Uso de mano de obra	Cultivos sembrados			
									Cultivo	Cultivo	Cultivo	Cultivo
			1P. 2A. 3.D. 4O. ______	1.B 2.R 3.M	1P. 2M. 3MI.	1.SI 2.NO	1.SI 2.NO	1.SI 2.NO				
			1P. 2A. 3D. 4O. ______	1B. 2R. 3M.	1P. 2M. 3MI.	1.SI 2.NO	1.SI 2.NO	1.SI 2.NO				
			1P. 2A. 3D. 4O. ______	1B. 2R. 3M.	1P. 2M. 3MI.	1.SI 2.NO	1.SI 2.NO	1.SI 2.NO				
			1P. 2A. 3D. 4O. ______	1B. 2R. 3M.	1P. 2M. 3MI.	1.SI 2.NO	1.SI 2.NO	1.SI 2.NO				
			1P. 2A. 3D. 4O. ______	1B. 2R. 3M.	1P. 2M. 3MI.	1.SI 2.NO	1.SI 2.NO	1.SI 2.NO				
			1P. 2A. 3D. 4O. ______	1B. 2R. 3M.	1P. 2M. 3MI.	1.SI 2.NO	1.SI 2.NO	1.SI 2.NO				

Claves:

Tenencia de la tierra:	Calidad del suelo:	Pendiente:
1P. Propia.	1B. Buena.	1P. Plano (menos de 10%)
2A. Alquilada.	2R. Regular.	2M. Medio inclinado (de 10% a 40%)
3D. Del padre.	3M. Mala.	3MI.Muy inclinado (más de 40%)
4O. Otro.		

C. Caracterización de las innovaciones

30. ¿Continuó con las prácticas de conservación?
30.1. Si. ¿Por qué? ____
30.2. No. ¿Por qué?____

31. Uso de barreras vivas

Parcela (Nomb.)	Año inicio	Tipo de Barrera	Origen de la idea	Modificación				Modificación			
				Año	Barrera	Por que	Origen de la idea	Año	Barrera	Por que	Origen de la idea

32.¿Qué otros usos le da a sus barreras?

Tipo de barrera	Uso
____________	____________
____________	____________
____________	____________

33.¿Qué otras técnicas alternativas utiliza para retener el suelo a parte de las barreras vivas?

Prácticas	**Año de inicio**	**Qué problemas quiso solucionar**	**Cuál fue el origen de la idea?**

34. ¿Utilizó alguna vez gallinaza en su finca? (Si responde No, pasar a la 38)

34.1. Si. 34.2.No

35.¿Con quien aprendió a usar la gallinaza?

35.1. Vecinos Mundiales. 35.4. Otro agricultor

35.2. Proyecto Manejo. 35.5. Otro___________.

35.3. LUPE.

36. ¿Aproximadamente en que año empezó a utilizar la gallinaza?___________.

37. ¿En estos últmos años ha bajado usted el uso de la gallinaza en sus parcelas?

37.1. Si ¿Por qué?____.

37.2. No. ¿Por qué?____.

38. ¿Qué otras formas de fertilización está utlizando?

39.1. Químico. ¿Por qué? __________. ¿Como surgió la idea?__________.

39.2. Abonos verdes. ¿Por qué? __________. ¿Como surgió la idea?__________.

39.3.Otro_________ ¿Por qué? __________. ¿Como surgió la idea?__________.

39. ¿Utilizó alguna vez zanjas de drenaje en sus parcelas?(Si responde No pasar a la 44)

39.1. Si. 39.2. No

40. ¿Con quien aprendió a usar las zanjas?

40.1. Vecinos Mundiales. 40.4. Otro agricultor

40.2. Proyecto Manejo. 40.5. Otro___________.

40.3. LUPE.

41. ¿Aproximadamente en que año empezó a usar las zanjas?_______.

42. ¿Ha continuado manteniendo las zanjas?

42.1. Si. ¿Por qué?_________________________________.

42.2. No.¿Por qué?__________________________________.

43. ¿Utiliza alguna otra forma de drenar el agua el agua en sus parcelas?

43.1. Si. Cual______________________________________.

43.2. No.

INDICES USED TO SUMMARISE THE VARIABLES IN THE ABOVE

FARM INDEX

The characteristics of each plot were evaluated using the above questionnaire. The value of the plot was subsequently weighted according to its area. An average of the weighted values was calculated by adding the weightings of each plot and dividing this figure by the total cultivated area of the farm.

Variable	**Value**		**Maximum value**	**Weighting (%)**
Time to arrive at the plot	More than 40 min.	(1)	3	10
	From 21-40 min.	(2)		
	From 0-20 min.	(3)		
Tenancy of the plot	Rented	(1)	3	30
	From parents	(2)		
	Own	(3)		
Soil quality in the plot	Bad	(1)	3	20
	Regular	(2)		
	Good	(3)		
Slope in the plot	Flat	(1)	3	15
	Sloping	(2)		
	Very sloping	(3)		
Facilities of the plot (see below)	None	(0)	3	10
	Low	(1)		
	Regular	(2)		
	High	(3)		
Crops in the plot	None	(0)	3	15
	Maize, millet, beans	(1)		
	Perennial crops	(2)		
	Vegetables	(3)		
	TOTAL		18	100

FACILITIES OF THE PLOT

Variable	**Value**		**Maximum value**
Acess to irrigation of the plot	No	(0)	1
	Yes	(1)	
Use of animals in the plot	No	(0)	1
	Yes	(1)	
Use of hired labour in the plot	No	(0)	1
	Yes	(1)	
	TOTAL		3

DEGREE OF ADOPTION

Adoption was defined as the use of those technologies promoted by the NGO World Neighbors from 1981-1989 and LUPE

- Stone barriers
- Live barriers of *P. purpureum* and/or *P. purpureum* x *P. typhoides* and/or *V. zizanioides*
- Drainage ditches
- Chicken manure
- Chemical fertiliser

Each technology was awarded one point and depending on the area of the plot, the sum of the adopted technologies were weighted per plot.

DEGREE OF INNOVATION

Innovation was defined as the use of new technologies or the use of technologies in a different way to how they had been promoted e.g. farmers adapting live barriers by using different species to those promoted. Each plot was given a value depending on the number of adaptations accounted for. The value of the plot was weighted according to its area. The degree of innovation was defined as the average of the weighted values. This was calculated by adding the weightings of each plot and dividing this figure by the total cultivated area of the farm.

Type of adapation	**Weighting**
Other means of protecting the soil	12
Started using different combinations of species in live barriers 1980-87	11
Other means of retaining soil 1988-96	10
Started with one different live barrier species between 1980-87	9
Started using different combinations of species in live barriers 1988-96	8
Started with one different live barrier species between 1988-96	7
Changed from Napier or King grass barriers to combination of species 1980-87	6
Changed from Napier or King grass barriers to one other species 1980-87	5
Changed from Napier or King Grass barriers to combination of species 1988-96.	4
Changed from Napier or King Grass barriers to one other species 1988-96	3
Changed from vetiver grass barriers to another species after 1994	2
Changed from another barrier species to Napier or King Grass or stone wall	1

DEGREE OF AMENABILITY TO CHANGE

This was defined as the sum of the degrees of adoption and adaptation.