Output 5
Sustainable land management for social profitability developed, with special emphasis on reversing land degradation

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Rationale

Strategic and component research to date has been conducted largely at the plot or field scale, where interactions among various agricultural enterprises are seldom considered. Although TSBF-CIAT's strength remains at the plot level, the diversity of forces impinging on the plot naturally draws attention towards a hierarchical systems-based approach. The next generation of work will be at higher scales, particularly the farm and landscape scales. The rationale for working at the farm scale is the need to improve nutrient use efficiency through better allocation of the limited organic and inorganic resources among different enterprises, taking into consideration inherent soil variability within the farming system. Inadequacies in supplies of both organic and inorganic nutrients have created strong fertility gradients even within the smallest farms. Smallholder farmers typically remove harvest products and crop residues from their food producing 'outfields' and devote their scarce soil inputs to their smaller market 'infields', resulting in large differences in soil productivity over time between these two field types. Understanding how to manage the limited nutrient supplies across such fertility gradients is a key component in raising productivity in fields of staple crops.

Interest in the quality and health of soil has grown with the recognition that soil is vital not only to production of food and fiber, but also the smooth functioning of the ecosystem, and overall environmental stability. Agriculture needs economically viable and ecologically sound soil management practices that provide sufficient food and yet maintain environmental stability, ecological integrity, and the quality of essential resources. Strategies for sustainable management include conserving essential soil components, minimising erosion, balancing production with environmental needs, and making better use of renewable resources. In this regard, soil health is a major indicator of sustainable management. Criteria for indicators of soil health are useful in defining ecosystem processes and sensitivity to managements and climatic variations and in integrating physical, chemical and biological soil properties. Numerous experts *e.g.* agricultural specialists, producers, conservationists, and policy makers, etc might extensively need those criteria and data for sustainable management practices. Although soils gain certain biological, chemical and physical properties within a given ecosystem, the ultimate determinant of soil productivity, sustainability and health is the land manager. The assessment of health and quality of soil is the primary indicator of sustainable management and environmental remediation. Examples given include approaches for assessing soil health, defining the economic and environmental sustainability of land management practices, and translating our science into practice.

Environmental services, particularly hydrological response and soil erosion control, can be managed effectively only at larger landscape scales. Research at the watershed scale is critical in the tropical regions, and given that projections indicate that eastern and southern Africa, and Central America will be critically short of water in the coming decades, extending TSBF-CIAT's research agenda into this area is warranted. Research projects funded by the Water and Food Challenge Program for the Volta in West Africa basins and on the Quesungual systems in Central America offer the opportunity to address constraints related to water and its interaction with soil fertility and other environmental challenges. Research conducted with partners in regional networks and consortia and the GEF-UNEP funded BGBD project will contribute to development and promotion of sustainable land management (SLM) practices.

To see ISFM principles applied by a wide variety of actors at scales ranging from the farm level to the national or continental levels means addressing the problems of how to use knowledge gained at one scale to interpolate or extrapolate knowledge for decision making at another scale. In recent years TSBF and other natural resource management programs have confronted the challenge of extending their research findings for successful impact on farm. Conveying the numerous components and complexity of interactions involved in natural resource management is very different from the extension of new crop varieties through demonstration plots. In the latter, the results are quick and easy to see, whereas the results and possible benefits of natural resource management strategies may not be readily apparent and often take time to manifest themselves. The rise of the participatory movement in agricultural research has also emphasized the importance of responding to farmers' perceptions and needs rather than assuming that formal science provides solutions in its own right.

Key research questions

1. What is the minimum set of social, economic and biophysical indicators for preventing and reversing land degradation?
2. What are the drivers of land degradation?
3. Does hot-spot management provide a driver for wider-scale investment in ISFM?
4. What are the stakeholders, technologies and incentives necessary to enable SLM?
5. What are the global benefits (ecosystem services) from SLM?

Milestones 2005

No milestones listed for this output in the CIAT Medium-Term Plan 2005-2007.

Highlights

- Preliminary data from a study in Kenya, Ghana and Zimbabwe to assess the interaction between organic resource quality, aggregate turnover, and agro-ecosystem nitrogen and carbon cycling, showed substantial effects of organic resource quality on crop performance. The quality of the applied organic resources also appeared to influence the presence of large macro-aggregates in the well-structured Embu soil.
- The watershed analysis approach using Hydrological Response Units (HRU) has been useful for targeting Fuquene and Altomayo watershed areas where certain land use or management alternatives are profitable for the farmer and can modify positively the environmental externalities.
- ECOSAUT model is a multicriteria tool that enables the user to understand, measure and valuate the trade offs between economic and social benefits caused by a land use alternative and its environmental impact. Its use in the Altomayo watershed in Peruvian Andes, concluded that among several alternatives to reduce soil erosion, which increases water treatment costs, the adoption of coffee under shade is the most suitable option. Though the effect of erosion is lower than other alternatives, this result in lower total investment required to implement and it would also recover the investments sooner. Additionally it generates added value in terms of creating jobs.
- In the Fuquene watershed (Andean highlinds of Central Colombia), conversion of native land cover (Mountain forest and Paramo vegetation) into cropland or pastures has resulted in an estimated loss of soil carbon in the range of 50–80 TgC during the last century.
- Conversion of native land to crops or pastures in the Fuquene watershed resulted in a net decrease of the capacity of the soil to consume atmospheric methane thereby impacting negatively the function of the soil as a net sink for greenhouse gases. The use of nitrogen fertilizers in pastures and in crops increases net emissions of N_2O into the atmosphere as compared with the native land cover (Forest and Paramo vegetation). Total N_2O emissions accounted for 2-3% of applied N.
- Support to CENIPALMA in the systematization of soil data in a GIS-linked database was completed in 2005 and outscaling of the tool was initiated in 2006.

- A regional workshop was conducted in Honduras to bring together natural and social scientists from different countries to apply the *Dahlem Desertification Paradigm to* land degradation and recovery of steepland agricultural systems in Central America. Main drivers (both biophysical and socioeconomic) for adoption of the Quesungual slash and mulch agroforestry system were identified and a conceptual model was developed.
- A project to rehabilitate degraded lands through silvopastoral systems and reforestation with native timber species in the Caribbean savannas of Colombia, was successfully negotiated with the Biocarbon Fund. The project will generate significant employment and will enhance livelihoods of poor rural communities including native Indian groups. The Project will generate 0.7 Gg CO_2 equivalents over a 25-year period and will generate CERs (certificates of emission reduction) that could be traded in the emerging carbon markets as part of the Clean Development Mechanism (CDM) of the Kyoto Protocol.

Output target 2006

➢ ***Potential for carbon sequestration estimated for at least one tropical agroecoregion***

Work in progress

Interaction between organic resource quality, aggregate turnover, and agro-ecosystem nitrogen and carbon cycling

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The management and enhancement of soil organic matter (SOM) is pivotal to the sustainable utilization of soils. SOM is a major determinant of soil fertility, water holding capacity and biological activity and is highly correlated to levels of above and below ground biodiversity. A loss of SOM can lead to soil erosion, loss of fertility, compaction and general land degradation. In addition changes in the use and management of soils that result in a decline in SOM can lead to a release of CO_2 to the atmosphere, with practice that increases SOM leading to sequestration of C from the atmosphere to soils. The management of SOM is therefore important at the field, regional and global scale. Important factors affecting the quality and quantity of SOM are climate, soil texture, and organic resource quality of the inputs. The Decision Support System for Organic N management distinguishes 4 classes of organic resources with varying quality. In the current activity, the focus relates to how interactions among organic resource quality, mineral N inputs, and rate of soil aggregate turnover control C and N cycling in natural and agroecosystems across different soil textures and climatic zones. The overall objectives are: (i) to elucidate the linkage among organic resource quality, organic plus mineral resource additions and aggregate turnover, (ii) to determine how this linkage controls C cycling and the use efficiency of N derived from both organic and mineral resources, and (iii) to determine how this linkage varies across soil textures and climates.

To address above objectives, two sets of experiments have been initiated. First, a multilocational field trial has been established in Kenya in Kenya (sub-humid, bi-modal climate), Ghana (humid, bi-modal climate), and Zimbabwe (semi-arid, mono-modal climate) with the following factors and levels: organic resource quality [*Tithonia diversifolia* or *Crotalaria ochroleuca* - Class I, Calli*andra calothyrsus* or *Leucaena leucocephala* - Class II, Maize stover – Class III, Sawdust – Class IV, and Manure], fertilizer [with and without 120 kg N/ha], and organic matter application rate [1.2 and 4 ton C/ha]. In each of above countries, one trail has been established on a relatively heavy and one on a relatively light soil. The trials are currently in their 8th cropping season in Kenya (2 seasons per year), in their 6th season in Ghana (2 seasons per year) and in their 3rd season in Zimbabwe (1 season per year).

Secondly, a decomposition tube experiment with single (^{13}C or ^{15}N) or double (^{13}C and ^{15}N)-labeled organic resources and/or fertilizer was set-up in April 2005, in Embu, Kenya. Tubes were designed that allow measurement of N_2O and CO_2 production and the capture of mineral N at the tube base using anion/cation exchange resins. Subsets of the tubes were harvested at 2, 5, and 8 months after installation and are currently being processed for SOM fractionation and other analyses.

For SOM fractionation, aggregate size classes (>250, 53-250 and < 53 µm) are separated by slaking. To isolate the light fraction the macro- and microaggregate size classes are suspended in 1.85 g cm^{-3} sodium polytungstate. After flotation of the LF, the heavy fraction (HF) of the microaggregates is dispersed in a hexametaphosphate solution (5 g l^{-1}) and passed through a 53-µm sieve to isolate intra-aggregate particulate organic matter (POM). To isolate the microaggregates out of the macroaggregates a newly developed microaggregate isolator, which breaks up macroaggregates while minimizing the breakdown of released microaggregates, is used. Macroaggregates are immersed in deionized water on a 250-µm mesh screen and shaken with glass beads. To ensure that microaggregates are not exposed to further disruption by the shaking, water flows continuously through the device and the micro-aggregates are flushed immediately onto a 53-µm sieve. Once all the macroaggregates are broken up, the material on the 53-µm sieve is manually sieved to ensure that the isolated microaggregates are water-stable. The inter-microaggregate POM, retained on the 53-µm sieve together with the microaggregates, is isolated by density flotation. After density flotation, microaggregates are dispersed in hexametaphosphate and intra-microaggregate POM is isolated by sieving.

Results from the first season after application show clear differences in net response to application of the organic resources for the organics resources belonging to Class I and II (Tithonia, Crotalaria, Calliandra, Leucaena) and for those belonging to Classes III and IV (Maize stover, sawdust), with the latter resulting in lower net increases in maize grain yield – often even decreases – relative to the treatments with Class I and II organic resources applied (Figure 37). Manure results in intermediate net increases, depending on the site considered. Preliminary wet sieving data form the Kenya and Machanga sites, obtained from soil samples taken after 6 seasons, show large treatment-related differences in large macro-aggregate contents (> 2 mm) for the Embu site (Figure 38a). The control contained less large macro-aggregates than all other treatments, except for the treatments 'Maize stover + fertilizer' and 'Sawdust – fertilizer'. In the treatments with the latter two organic inptus, application of N fertilizer substantially changed the concentration of large macro-aggregates, which was not true for the other organic inputs. Concentrations of macro-aggregates between 2 and 0.25 mm were not different between treatments for both the Machange and the Embu sites (Figure 38b).

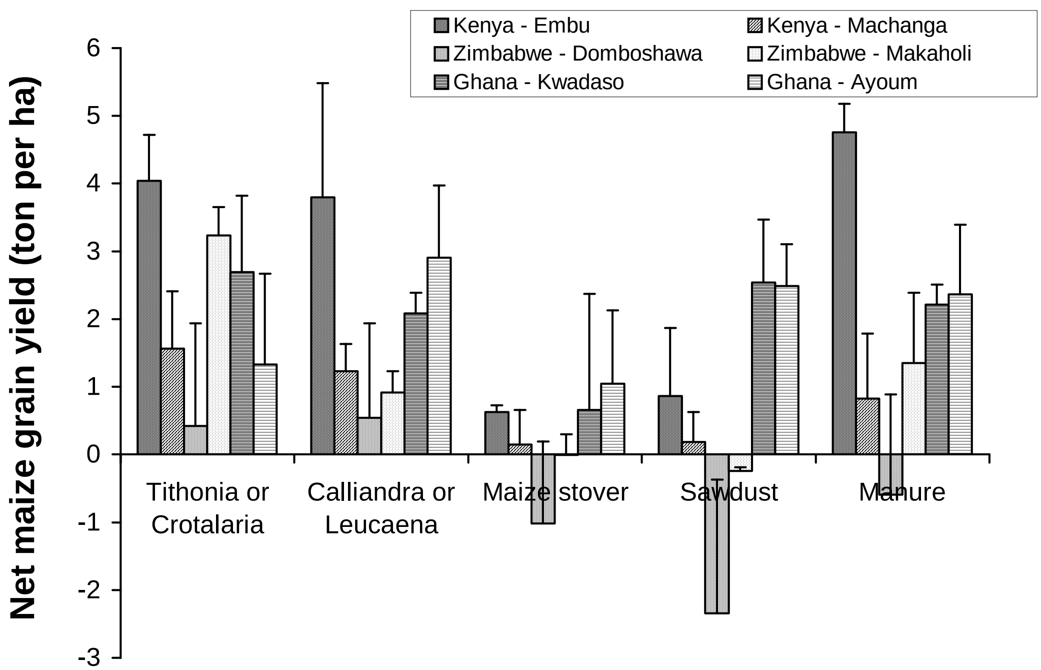

Figure 37. Net response (relative to the no-input control) to added organic resources of varying quality during the first season after their application on the relatively heavy (left side of the legend) and relatively light soils (right side of the legend) in Kenya, Zimbabwe, and Ghana. Note that only the data for the high application rate (4 ton C ha^{-1}) in absence of N fertilizer are presented. In Kenya, Tithonia is used as a Class I organic input while in Ghana and Zimbabwe, Crotalaria is the Class I material used. In Kenya and Zimbabwe, Calliandra is used as a Class II materials, while in Ghana, Leucaena is the Class II material used. Error bars are Standard Deviations.

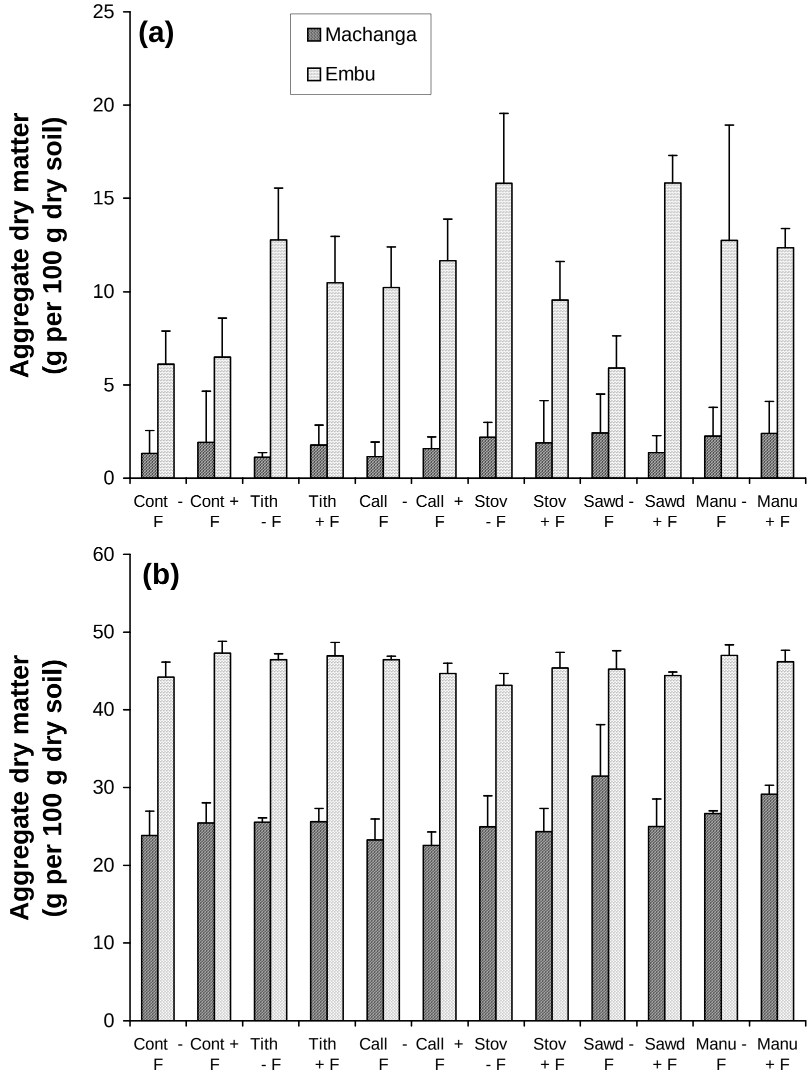

Figure 38. Concentration of aggregates >2 mm (a) and between 2 and 0.25 mm (b) for the Embu and Machanga sites, as affected by organic resource quality and fertilizer application. 'Cont' means 'Control', 'Tith' means 'Tithonia', 'Call' means 'Calliandra', 'Stov' means 'Maize Stover', 'Sawd' means 'Sawdust', 'Manu' means 'Manure, '+ F' means 'With fertilizer' and '- F' means 'Without Fertilizer'. Error bars are Standard Deviations.

Preliminary data show substantial effects of organic resource quality on crop performance, thereby respecting the principles outline in the Decision Support System for Organic N management. The quality of the applied organic resources also appeared to influence the presence of large macro-aggregates in the well-structured Embu soil, although application of fertilizer appears to alter their presence for the lower quality organic resources (maize stover, sawdust). Further fractionation of the macro-aggregates will reveal detailed information regarding aggregate turnover within the studied systems.

Payment for environmental services in the Fuquene watershed (Colombia): carbon stocks and fluxes of greenhouse gases

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The Water and Food challenge program approved to CONDESAN a project to pursue the "Payment from environmental services as a mechanism to promote rural development in the upper watersheds of the tropics". Environmental services considered include the provision of water, biodiversity conservation, prevention of soil erosion and potential for mitigation of net emission of greenhouse gases (GHG) and carbon sequestration. The project will operate in a group of nine pilot watersheds in various Andean countries. The Fuquene Watershed in the central part of Colombia, near Bogota, was selected to initiate the project and to test methodologies that later will be used in the assessment of the other watersheds. The Fuquene lagoon collects the water from the watershed and provides water to a vast number of villages and agricultural fields in neighboring areas. Despite numerous governmental, bilateral and private projects that have operated in the watershed, the lagoon, suffers an accelerated rate of reduction in area/water volume as well as eutrophication, due to several factors including border land recovery by ranchers, pollution of incoming water with sewage sludge, animal manure and nutrients leached from fertilizers etc. The watershed covers an area of 187000 ha. Main production activity in the watershed is intensive cattle raising. The most productive dairy farms in Colombia are likely located in this region. Total area covered by pastures (mainly Kikuyo grass in the lower basin and Ryegrass in the medium to upper part) is 110000 ha (59% of the area). Potato is the main crop in the watershed and is usually managed with conventional tillage, that involves major soil disturbance which promotes soil erosion and nutrient leaching. Total area under crops is around 48000 ha (26% of the area). In recent years as a result of activities from a GTZ project, no tillage systems have been promoted and are slowly gaining acceptance by potato growers. To date, there are some 4000 ha of no till potato now in the watershed.

Our contribution to this project includes the quantification of the status of the most important soil physical characteristics that regulate soil function in relation to water, nutrient storage and leaching. We have also assessed total carbon stocks in soils as well as net fluxes of carbon dioxide, methane and nitrous oxide in the watershed for the dominant land use systems. The purpose is to identify the land use systems that are more beneficial or detrimental to the environment. This information will be contrasted with information on sustainability of land use and the socioeconomic of main production systems collected by other researchers as part of the project. Win-win systems could then be promoted to help policy makers and local authorities to reorder land use in the watershed to maximize benefits for local farmers and communities as well as for neighboring receivers of water and services and for the global environment.

Seven dominant land use systems on similar soils (hydrologic response units-HRU) were selected to fall within four transects: one longitudinal transect crossing the watershed from south to north and three perpendicular transects distributed along the main axes to spread along the watershed. Selected HRU included: Paramo native vegetation, mountain secondary forest, potato crops under conventional and minimum tillage, Ryegrass pastures, Kikuyo intensively managed pastures, and degraded land that not longer supports productive uses. Although, as can be seen in Figure 39, several land use cover are present in the watershed, the selected HRU account for at least 95% of the area of the watershed. These selected HRU were replicated three times trying to cover the spatial variability found in the watershed. A total of 21 sampling plots were selected.

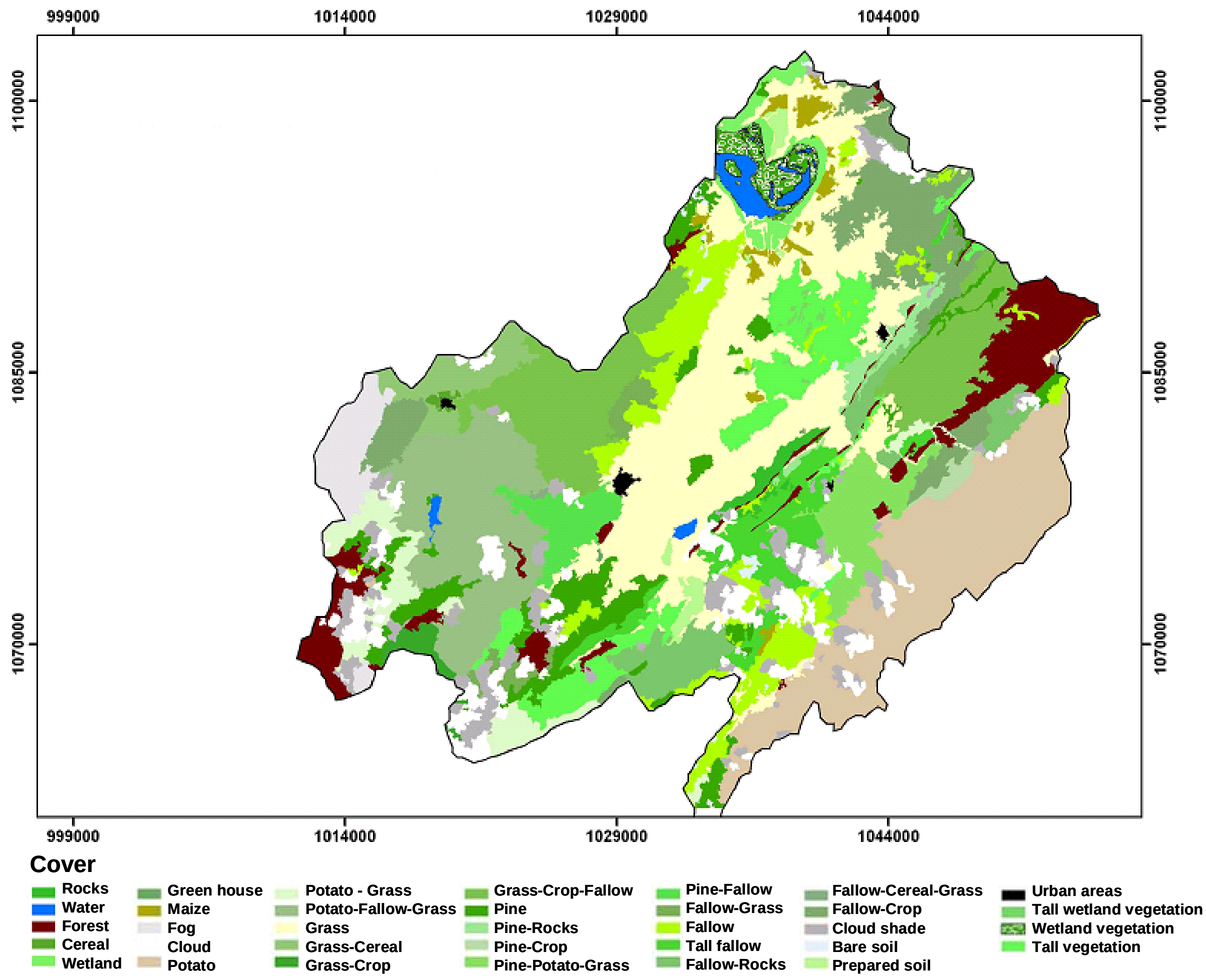

Figure 39. Land cover at the Fuquene watershed, Colombian Andean highlands.

Soil C stocks: In each of the 21 plots, three soil pitches (0.5 × 0.5 × 1m) were open: pitches were located at three altitudinal positions within each plot. Upper part, medium and lower part of the plots. In each pitch, composite soil samples were collected at four depths (0-5, 5-20, 20-40, and 40-100 cm) to measure bulk density and determine total Carbon stocks in soils. Soil samples were analyzed using conventional wet oxidation methods to assess oxidable carbon and by CHN analyzers to measure total carbon. In areas where the history of land conversion from C3 type dominated vegetation (i.e native forest) to C4 dominated species (some grasses, maize, sorghum etc), or from C4 into C3 vegetation, is well known and reliable, ^{13}C determinations were also made in soil samples to assess the rate of replacement of new organic matter and to establish C partitioning between soil pools of different mean residence times.

Soil Physical parameters: At the time of soil sampling, some soil physical characteristics were evaluated in situ: resistance to penetration in the soil profile using a penetrograph and soil shear strength (torcometer). Samples were collected for bulk and particle density determinations measuring saturated hydraulic conductivity, air permeability, resistance to compaction, and water retention characteristics. Some results of the soil physics parameters were presented in the 2004 annual report. As physical condition define how water can be store and move into the soil profile, a good understanding of the behavior of the physical soil profile in relation to water fluxes will allow to define if there are possibilities of contamination with elements coming from fertilizers or not. As also they define, the hydrologic response of the soil in relation to rainfall, they will allow to understand the relationship between rainfall and rainfall acceptance capacity of the soils, runoff production as well as the vulnerability of soils to be eroded. This knowledge will help to track sources of contamination of the lagoon and the loss of the water mirror and will be used to define solutions to control degradation problems.

Greenhouse gases: fluxes of carbon dioxide, methane and nitrous oxide, the three most important GHG related to land use change and agricultural activities, were monitored over one year period to follow at least a full cycle of climatic variations. One of the replications for the seven HRU was selected for monitoring gases. In each plot four replicate sampling points were selected and geo-referenced. A PVC collar (30 cm diameter, 10 cm height) was permanently installed in the soil to a depth of 8 cm. A closed vented chamber is attached to the collar at the time of gas collection. Four gas samples are collected per chamber at times 0, 10, 20 and 30 minutes. Chamber temperature is measured at every sampling time. A biweekly sampling frequency was used. Gas samples were stored in pre-evacuated glass vials and were analyzed within two weeks after collection by gas chromatography (ECD and FID detectors) for CH_4, CO_2 and N_2O. Gravimetric soil water content was measured at every sampling time. Soil redox potential, pH and soil temperature was measured in situ.

In Figure 40, data on total soil carbon stocks are presented for land cultivated with potato using contrasting tillage methods (conventional, highly disturbing and minimum disturbance of the soil). The data corresponds to plots located at the Tausa municipality, one of the most important potato growing areas within the watershed. Though total C stocks in the surface layers seems to be similar between the tillage methods, at deeper layers a net increase was observed in the minimum tillage methods, suggesting that less oxidation of soil organic carbon is occurring in such layers as a consequence of reduced soil removal at harvest. The increased amounts of C found at lower levels in the soil profile may be an indication of migration of organic C from upper to lower layers. Higher Carbon contents in no till or minimum till systems have been extensively documented for a range of crops in temperate regions but much less information is available for tropical climates and virtually none exist for the high elevation Andean Paramos that have been converted into potato plantations.

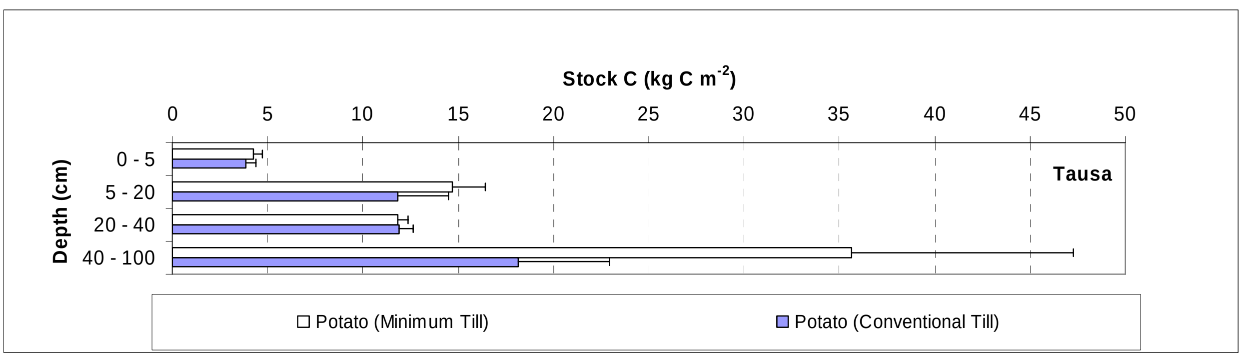

Figure 40. Total carbon stocks in the soil cultivated with potato under conventional and minimum tillage methods at the Tausa municipality, Fuquene watershed.

In Figure 41, we present a consolidated comparison of the dominant land use systems in the watershed and its average carbon stocks in soils. The native land uses (Paramo and mountain forest) consistently contain more carbon in the soil profile particularly at deeper layers. The conversion of native vegetation into pastures or crops has resulted in a significant net decrease in carbon stored in soils. A gross estimate indicates that some 50 to 80 Tg C could have been lost within the watershed due to land use change which has taken place predominantly during the last century. Conversion of forested land into highly productive pastures decreased C levels by almost 50%, while cropping potato also reduced the soil C stocks but to a lower extent. Once the native land is converted into other uses, a rapid process of land degradation is put in motion which usually results in the upper layers of the soil being lost by oxidation and erosion with drastic net losses of C from the land. The levels of Soil C in severely degraded pastures is only around 20% of the content in native land covers.

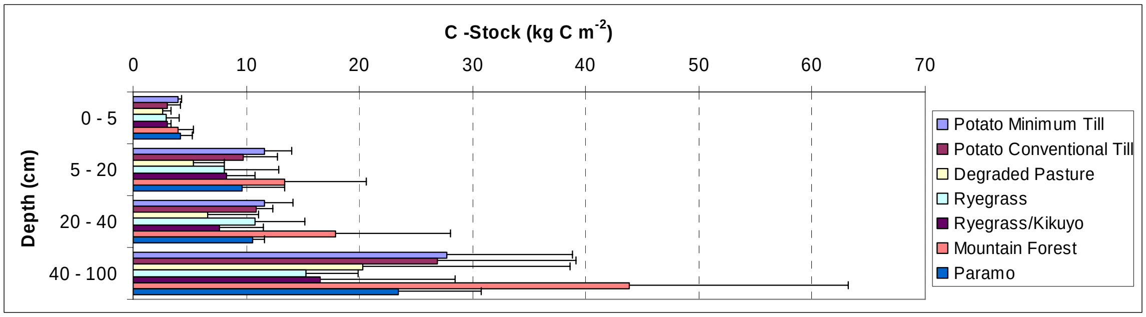

Figure 41. Total carbon stocks in the top 1 meter of soils under the main land use systems of the Fuquene watershed.

Fluxes of greenhouse gases: in Figures 42 and 43, net annual fluxes of methane and nitrous oxide from the dominant watershed land use systems are presented. Most of the land uses constitute an annual net sink for methane with the native land cover (Paramo and forest) being higher sinks. Potato under conventional tillage and Ryegrass pastures also constitute net sinks for methane but at a reduced rate as compared with the natural systems. The conversion from traditional to no till systems in potato results in the land being swuitched from a net sink into a small net source of this greenhouse gas into the atmosphere. Though precise reasons for this have not yet been evaluated, one possibility would be higher moisture content in soils under no tillage as a result of crop residue applications, which may increase the probability of the appearance of anaerobic microsites within the soil where methane is nerated. A further study is necessary to better explain the causes of this shift in function regarding methane oxidation.

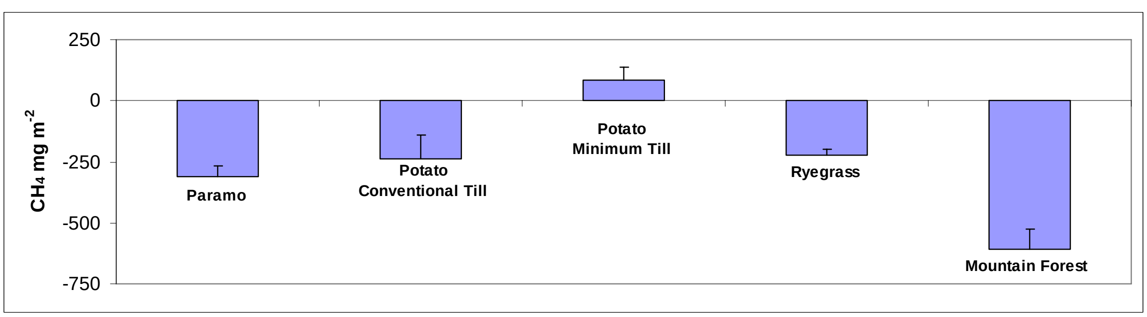

Figure 42. Net annual methane fluxes from the main land use systems in the Fuquene Watershed. Measurement period was August 2004 to July 2005.

As indicated in Figure 43, all land uses emit nitrous oxide into the atmosphere though at different rates: While the native land cover show low rates of emission due probably to low Nitrogen availability associated with low average annual temperatures in the soil (low mineralization rates), net emissions of N_2O increase significantly when fertilizer is applied to pastures and even more at higher doses of N application as used for potato plantations where as much as 300 kg N per year is applied in certain locations within the watershed. The higher emissions under no till potato compared to the traditional till methods was not anticipated because reduced soil disturbances should in principle result in lower N mineralization rates. Nevertheless if the incorporation of plant residues in the no till system favors the increase in soil moisture retention, this process can also result in more favorable conditions for denitrification. Annual losses of nitrogen due to nitrous oxide emission can account for 2-3% of the applied nitrogen, indicating that this environment fits within the high range of N_2O emissions per unit of applied fertilizer.

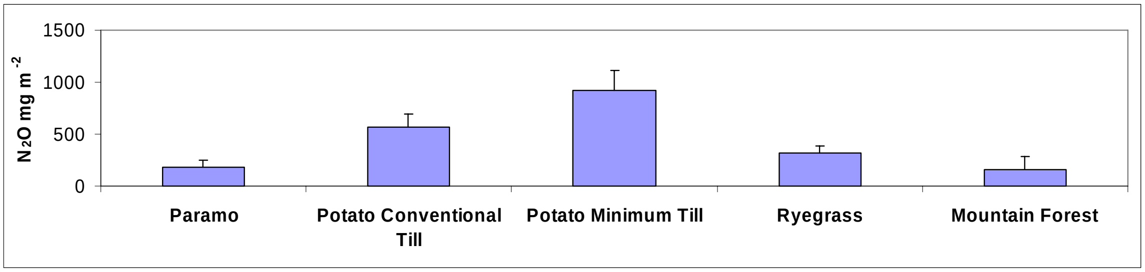

Figure 43. Net annual nitrous oxide fluxes from the main land use systems in the Fuquene Watershed. Measurement period was August 2004 to July 2005.

Integration of annual fluxes of both C and GHG will be done at the watershed level by using similar hydrologic response units and adding them using land cover data from remote sensing and GIS techniques. A Bayesian weight of evidence model is being used to extrapolate carbon stocks in soil as well as fluxes of other GHG to areas where no measurements were directly made in order to estimate total soil C stocks and overall GHG emissions at the watershed level. The overall global warming potential of different HUR will be calculated, and subsequently, a modeling process could be conducted to estimate how the reordering of land use systems in the watershed will influence the interaction with the environment. This analysis will provide valuable information in the analysis of tradeoffs between the provision of environmental services and the productive use of the land in the watershed. Policy makers could use the results from the studies being conducted at the watershed to take informed decisions on best alternatives to recuperate the functions of the watershed as provider of clean water to many rural areas al lower elevations.

Output target 2006

- ***Economic valuation of legume nodulating bacteria and soil structure carried out in at least five countries participating in the BGBD project.***

Work in progress

University of Agricultural Sciences/TSBF-CIAT, 2005. Proceedings of national Workshop on "Evolving Appropriate Methodologies for Economic Valuation of Ecosystem Services of Belowground Biodiversity", 12 -13th May 2005. UAS, Bangalore, India.
During the workshop methodological issues were discussed and a number of case studies were presented. Methodological issues included for example "social use values in the presence of negative externalities". A nice overview of conceptual and methodological issues was presented by Dr. B. V. Chinnappa Reddy. Case studies reported on related to the economic valuation of on-farm soil organic matter losses due to soil erosion in different agro-climatic zones of Karnataka, to the economic impact of striga as parasitic weed below the ground, or to the impact of sustainable agricultural production techniques on BGBD in rice cultivation. The last contribution at the workshop was on a topic of specific relevance to the BGBD project, namely agricultural intensification, ecological irreversibilities and BGBD.

A project publication on the economic valuation of rhizobium inoculation technology is in preparation by the Indonesian BGBD team.

Output target 2007

- ***Decision tools (GEOSOIL; Decision Tree) available for land use planning and targeting production systems in acid soil savannas***

Work in progress

Testing GEOSOIL for oil palm plantations

Y. Rubiano, E. Amezquita and F. Munevar
TSBF-CIAT; CENIPALMA, Colombia

We worked together with CENIPALMA to systematize its soil data in a GIS-linked database and decision support tool for improving planning and decision making regarding the management of palm tree plantations. A consultancy to CENIPALMA project on "Characterization of Soils and Determination of Units of Agronomic Management in Oil Plantations of the Central Zone Palm of Colombia" was attended. The consultancy included a course of training in Basic Concepts of genesis, soil characteristics, sampling, soil improvement and evaluation of soils for oil palm plantation. Additionally, a training course on basic soil cartography geographical information systems, use of GPS and use of the popular MapMaker Program was made.

To socialize GEOSOIL, another training course for users on information entry and rescheduling of graphic for the visualization of the information was done. A qualified student of the National University of Colombia is applying Geosoil to obtain topographic maps, roads, rivers, etc. and thematic aspects in 29 farms. For each farm a customized evaluation was prepared. Manuals of MapMaker Program, a version of Geosoil Manual users and a technical bulletin to be used by SENA instructors were distributed. Results from this scaling up and out efforts will be reported next year.

Output target 2007

➢ ***Biophysical, social and policy niches in the landscape for targeting SLM technologies and enhanced ecosystem services identified and prioritized***

Completed work

Environmental impact of agricultural production practices in the savannas of northern Nigeria
J. N. Chianu, H. Tsujii and J. Awange
TSBF-CIAT, Nairobi, Kenya
The study highlights the salient agricultural production practices that impact on the environment in the savannas of northern Nigeria. Due to population pressure on land and the need to maintain household food supplies farmers have increased their land use intensity and natural resources extraction practices that degrade the environment. Some agricultural production practices were, however, found to be environmental friendly. The study recommends remedial measures that have to be taken to avert agricultural production practices that predispose farmers to practices and extractive activities that undermine the environment.

Socio-Economic Factors Influencing Intensity of Adoption of Fertilizer In The Semi-Arid Areas of Kenya: The Case Study Of Machakos District
A. Bationo
TSBF-CIAT, Nairobi, Kenya
This study was to identify and explain the socio-economic factors which influence the intensity of fertilizer adoption in the semi-arid areas of Machakos district. Specific objectives included: to determine the socio-economic characteristics of farmers in the semi-arid areas of Machakos district; to identify the socio-economic characteristics which influence intensity of fertilizer adoption in the semi-arid areas of Machakos district and; to develop policy strategies for improving the intensity of adoption of fertilizer in the semi-arid areas of Kenya. We hypothesized that "Farmer socio-economic characteristics do not influence the intensity of fertilizer adoption".

According to the study, 45% of farmers adopted fertilizer (Table 37) while 82% adopted manure, the major type of manure being animal manure. Fertilizer adoption was therefore low hence the need for an improvement. The major reason cited for non-adoption of fertilizer was high cost of the input (Table 38). In terms of amounts, the study found out that farmers applied an average of 10.6 kg N ha^{-1} yr^{-1} and 19.3 kg P ha^{-1} yr^{-1} of fertilizer on maize, the major crop of the study area. Most of the farmers applied DAP only (42%) and, a combination of DAP and CAN (36%). This was however below the recommended levels.

Table 37. Adoption of fertilizer**.**

Variable	Category	Percent
Adoption of inorganic fertilizar	No	55
	Yes	45
Type of crop(s) fertilized	Maize only	67
	Maize and coffee	33
Fertilizer combination in the farm	DAP only	42
	CAN only	16
	NPK only	4
	DAP-CAN	36
	CAN-NPK	2

Source: Survey Results, 2005

Table 38. Reasons for non-adoption of inorganic fertilizer.

Factor	Percent
High cost of fertilizar	58
Lack of knowledge on its use	2
Fertilizar destroys the soil	11
Alternatives like manure are available	27
No crops are grown	2
Total	100

Source: Survey Results, 2005

Out of those who adopted manure, 57 % used animal manure, 28% used a combination of animal and compost manure, while 15% used compost manure. This indicates that most of the farmers in the semi-arid areas use animal manure. Farmers prefer using crop residues to feed livestock rather than make compost manure. In terms of amounts, farmers applied an average of 0.47 ton acre yr^{-1} (1.16 Mg ha^{-1} yr^{-1}) of manure on their crops. Farmers who did not adopt manure cited major reasons such as no livestock (61%), No means of transportation (17%) and manure buying is expensive.

A Tobit regression model was estimated and the results showed that seven out of eighteen factors included in the model were significant in influencing the intensity of adoption of fertilizer (Table 39). Off-farm employment, use of improved seeds, cash crop cultivation, agricultural extension and attendance to field days positively influenced the intensity of adoption of fertilizer, while family size and livestock ownership were negatively related with this phenomenon. The study recommended promotion of off-farm activities, improving the accessibility and effectiveness of extension services and reducing the cost of fertilizer as possible strategies for increasing the intensity of fertilizer adoption in the semi-arid areas of Kenya.

Table 39. Tobit regression for factors affecting the intensity of adoption of fertilizer

Variable	Coeff. (β)	Std.Err.	t-ratio	P-value
CONSTANT	-39.312	66.900	-0.588	0.557
AGE	0.801	1.105	0.725	0.469
Gender of the Household head	23.921	20.209	1.184	0.237
Education level	-3.339	2.959	-1.129	0.259
Family size	-8.298	6.173	-1.344	$0.179^{\#}$
No. of family members working on-farm	0.032	6.218	0.005	0.996
Whether family member works off-farm	43.898	22.478	1.953	0.051**
Total farm size	-3.412	2.953	-1.156	0.248
Total value of farm implements	0.000	0.001	0.247	0.805
Hired labour	25.053	23.154	1.082	0.279
Improved seeds	47.913	21.235	2.256	0.024**
Yield	0.412	0.735	0.561	0.575
Cultivation of Cash crop	58.178	25.256	2.304	0.021**
Value of livestock (Kshs)	-55.559	24.487	-2.269	0.023**
Distance to the nearest market	-4.440	5.122	-0.867	0.386
Access to credit by the farmer	-0.367	22.483	-0.016	0.987
Access to extension services	32.414	22.184	1.461	$0.144^{\#}$
Membership to a farmers group	4.326	23.621	0.183	0.855
Attendance to agricultural field days	38.364	19.839	1.934	0.053**

** $P\leq 0.05$, $^{\#}.P\leq 0.20$

Dependent Variable is amount of fertilizer applied/acre/y in kg

Log likelihood function - L (All variables)	= -272.278
Restricted Log likelihood function $-L_0$	= -297.300
Likelihood Ratio Index - LRI $[1- (L/L_0)]$	= 0.084
ANOVA based fit measure	= 0.411643
DECOMP based fit measure	= 0.412132

Source: Survey Results, 2005

The study recommended the following in order to increase the intensity of adoption of fertilizer in the semi-arid areas of Kenya:

- Promotion of off-farm employment activities especially small and medium enterprises by the Government and other stakeholders in the semi-arid areas, to augment income from farm activities. This can be done by establishing micro-credit programs in these areas and improving on the programs (i.e. ensuring accessibility and affordability of credit) where they are already in place.
- Improving the accessibility and effectiveness of agricultural extension services so as to disseminate information on improved soil fertility management practices especially the benefits of increased and optimal use of fertilizer. This can be done by increasing the number of extension staff and updating extension officers on new research findings. This will ensure that farmers make rational decisions while purchasing and applying fertilizer. Farmers should also be taught how to keep good farm records and evaluate the profitability of various enterprises to avoid allocation of economic resources to unprofitable enterprises.
- Reducing the cost of fertilizer. This can be done by improving the rural road infrastructure to reduce transportation costs and providing affordable credit to fertilizer traders to ensure adequate and timely availability of fertilizer to farmers.

Multiscale Analysis for Promoting Integrated Watershed Management
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The ongoing experience of a project implemented by the Consortium for the Sustainable Development of the Andean Region (CONDESAN) in the Fúquene watershed of Colombia is presented. Biophysical and socioeconomic knowledge is integrated in a complex process to offer sound solutions to a wider range of stakeholders affected by the eutrophication of Fúquene Lake. A multiscale analysis is carried out for every step of the process to warrant integrity in the use of information, inclusion and equity in the stakeholders' participation. The ultimate aim is to generate sustainable development processes in the rural sector. By focusing on the internalization of externalities derived from watershed management, transfers of funds from urban to rural populations are stimulated, triggering urban investments in rural environmental goods and services. The process starts integrating key spatial information, which is available at different scales for the site, in order to facilitate envisioning different land-use scenarios and their impacts upon water resources. Subsequently, selected alternative scenarios regarding the impact on the externalities identified are analyzed, using optimization models. Opportunities for and constraints to promoting cooperation among users are identified, using economic games in which more sustainable land-use or management alternatives are suggested. Strategic alliances and collective action are implemented in order to test the feasibility of environmental and economic alternatives. Their implementation is supported by co-funding schemes designed with private and public stakeholders having a role in the study area. Research needs and limitations of the methodology are discussed.

Watershed analysis to identify niches for sustainable land management and use: Altomayo (Peru) case study

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In the transitional zone between the Andes and the Peruvian Amazon, the Mayo River watershed is located The basin is composed by several micro watersheds that supply water to various downstream urban aqueducts, rice irrigation systems and natural reserve areas. The native land cover has been disturbed by deforestation (4.2% yr^{-1}) and installation of coffee and pasture areas. Immigration (more than 50% of Moyobamba province population are immigrants) and favorable coffee prices in the market during the last years have contributed to accelerate natural landscape transformation. Miskiyacu is a micro watershed supplying drinking water to 40000 inhabitants of Moyobamba city. However, the replacement of native forest by farming uses seems to be causing the increment of suspended solids in water flows and therefore, water treatment cost has increased during the last years. During 2005, an environmental and socioeconomic watershed analysis of the Miskiyacu micro-watershed was conducted in order to provide guidelines for designing a mechanism of payment for environmental services (PES). The watershed analysis consisted in: 1) Hydrological modeling using SWAT (Soil & Water Assessment Tool), 2) Socioeconomic and environmental *ex ante* evaluation of land use and management scenarios, and 3) Determination of opportunity cost for implementing the proposed land use scenarios and valuation of environmental services.

For hydrological modeling, information about land cover, relief, soil map units and climatic data were used in order to determine the Hydrological Response Units of the Miskiyacu watershed. Thus, 28 HRU were identified. 8 HRU were prioritized based on the HRUs contribution to the environmental externalities (water flows and sediments) and land use change feasibility. The *ex ante* evaluation of land use and management scenarios was elaborated for the area covered by the prioritized HRUs. This analysis aimed to identify the better land use and management alternatives that provide multiple benefits: provision of environmental services (reduction of sediment yields), increment on rural income and labor employment. In addition, valuation of environmental services was achieved as an instrument to estimate the feasibility of implementing a PES by comparing the results with the values encountered in a previous study of willingness to pay by urban water users.

The evaluated scenarios were: coffee grown under shade, reforestation and live barriers in traditional production systems. The impacts of these potential scenarios were compared with the ones that would be caused if the traditional land use system is maintained (slash and burn – corn cropping – pastures). Installation of coffee under shade on areas currently exploited under the traditional land use system was the most appropriate land use scenario to be promoted by a PES mechanism according with the ex ante evaluation results, because of its multiple benefits. Although all potential scenarios produce less sediments (reduction of about 50%) than the traditional land use system, the coffee under shade scenario permits to increase farmers' income by 89% (Table 40). In contrast, reforestation and live barriers cause a reduction on net income of 5.3% and 9.7% respectively. However, while the traditional land use system requires an initial investment of $\$9^{-1}$ ha, the coffee under shade scenario needs an initial investment of \$176 ha^{-1}. The reforestation initial investment is \$470 ha^{-1}. In addition, the coffee under shade alternative is the only evaluated scenario by which labor employment is incremented (77% higher than the labor employed under the traditional land use system).

Table 40. Environmental and socioeconomic *ex ante* evaluation of distinct land use and management scenarios in the Miskiycau watershed (Peru) for a 10-year period.

	Traditional land use system: slash and burn – corn -pastures	Traditional land use system with live barriers	Coffee under shade on hillsides pasture lands	Reforestation on hillsides pasture lands
Net Income (US$)	76250	68802	144180	72187
Marginal income		-7748	44065	-27927
Initial cash investment (US$)	9	13	176	470
Sediment (t/ha)	21247	10623	11766	10620
Marginal sediments		-10624	-9481	-10627
Water yield (m^3)	2707711	2707711	2395627	2334858
Marginal water yield (m^3)			-312084	-372853
Labor employment	5682	5807.34	10071	5266
Marginal of labor employement		125	4389	-416

Regarding the design of a PES mechanism, the value of economic payments was determined for each scenario by calculating the cost of a ton of reduced sediments. Thus, one Mg of reduced sediments cost \$0.75 or \$35 ha^{-1} yr^{-1} for the live barriers scenario and is required to be paid every year in order to ensure the maintenance of the barriers. In another hand, for promoting shadow coffee is required to pay 1.31 Mg of sediments or \$53.6 ha^{-1} yr^{-1} during the first two years since this alternative only requires the initial investment as an incentive to replace the traditional land use.

In addition to the benefits or cost that can be caused by the land use scenarios and affect the farmers, there are other impacts that could affect the society. Through a value chain analysis considering the impacts on net incomes and labor employment, it was calculated that the coffee shadow scenario increase by 85% the social benefits while the live barriers and reforestation scenarios cause a reduction of 6.5% and 5.8% respectively (Table 40). The reduction of net income by the implementation of the live barriers scenario and the labor employment with reforestation explain these changes in percentages.

Given that the 7136 Moyobamba city families are willing to pay \$1.5 $month^{-1}$ as a contribution for promoting watershed resources conservation, it was calculated that it was only required two months of payments to cover the cost required for promoting coffee grown under shade in the HRU prioritized in the Miskiyacu micro watershed.

Validation of the Dahlem Desertification Paradigm in sub-humid tropics of Central America

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A land degradation workshop was held in Honduras, 14-19 November 2005. This meeting was hosted by the MIS (Manejo Integrado de Suelos) Consortium, as part of collaborative activities with the ARID*net*, a collaborative research network working on land desertification that is supported by the National Science Foundation. The workshop was designed to bring together a variety of natural and social scientists from different countries to extend and expand the development and application of the *Dahlem Desertification Paradigm to* land degradation and recovery of steepland agricultural systems in Central America, including an assessment of the unique "Quesungual" slash and mulch agroforestry system. The DDP is a flexible and synthetic framework to address desertification problems. It recognizes the simultaneous roles of the biophysical and socioeconomic factors in the land degradation process and proposes the identification of key variables and thresholds to more effectively prioritise policy and management interventions.

The workshop addressed three specific objectives. The first was to complete a DDP-based analysis of the opportunities for and limitations to the recovery of an agroecological system in the Guarita municipality, and the potential application of the Quesungual slash and mulch agroforestry system. The second objective was to complete a DDP-based analysis of the development and application QSMAS in the Candelaria municipality. The third objective was to contribute to the continuing evolution of the DDP by developing recommendations for how it might be more effectively applied to land degradation in the seasonally dry tropics.

Participants (Photo 1) visited the two municipalities and interviewed farmers, local organizations and government representatives. Based on information collected several conceptual models were developed as a preliminary step for the application of the DDP framework. Figure 44 shows one of the models developed to understand the main factors associated with the development of the Quesungual.

Photo 1. Participants of the workshop.

The full report is under preparation. However, preliminary results of the analysis indicate that the Quesungual system is a result of a unique balance between production, conservation, food security and income generation. This balance has been driven by several "slow" biophysical and socio-economic variables. We plan to synthesize and submit the results of the workshop to a peer-reviewed international journal and disseminate the results through the MIS and AridNet network.

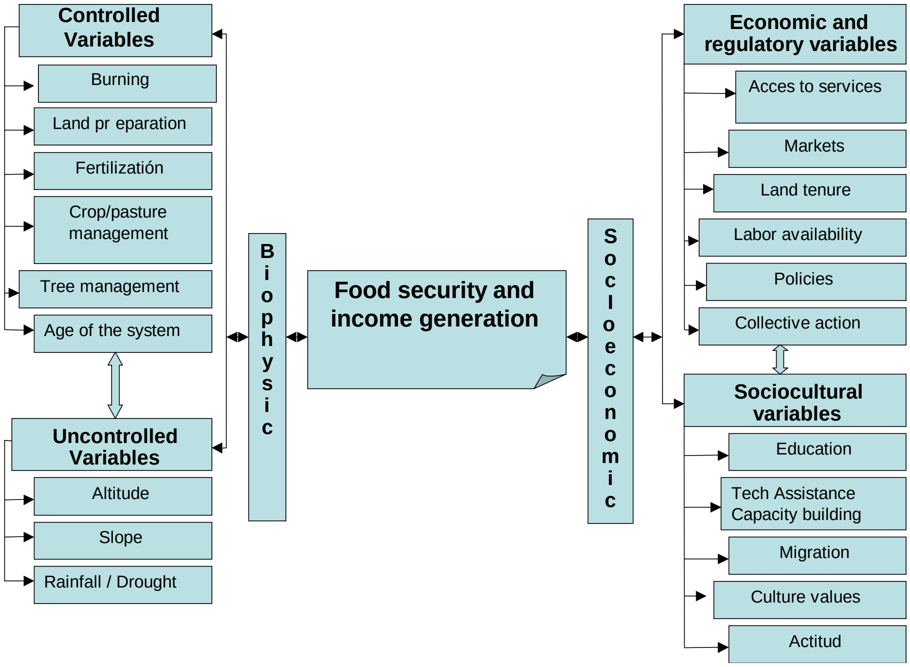

Figure 44. Biophysical and socieconomic factors influencing the development of the Quesungual system.

Output target 2008

- ***Methods for socio-cultural and economic valuation of ecosystem services developed and applied for trade-off and policy analysis used in at least in 2 humid and 2 sub-humid agroecological zones***

Completed work

Model of optimization for ex-ante evaluation of land use alternatives and measurement of environmental externalities (ECOSAUT)

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A multicriteria optimization model was designed for the ex-ante analysis, by means of which optimal values of the decision variables that maximize or minimize watershed management objectives can be identified without violating imposed constraints. Linear programming has been applied successfully to measure the tradeoffs between the economic performance of different activities and the environmental externalities. The Payment for Environmental Services (PES) Project - (CONDESAN, GTZ and CPWF) uses these models to support stakeholders in making decisions about multiple land-use options. It is difficult to find alternatives with complementarities related to the generation of jobs, profitability, environmental conservation and social equity, all at the same time. Thus, the constraints or variables used in the optimization model correspond to the restrictions given by the biological and economic capacities of the system, farmers' considerations, and/or local and regional policies. The decision alternatives refer to the activities (individual or collective) that can exist at the HRU or watershed level and have a relationship with the constraints (Table 41). The biophysical constraints included in the model are the quantity of water, sediments and N and P in the water flows that are affected by land use. The socioeconomic constraints are availability of labor, productive land, levels of income and wealth.

With the use of this model, socioeconomic and environmental constraints are then considered to identify feasible land-use changes. Thus the multiscale biophysical and socioeconomic constraints are integrated in a modeled agroecological system to determine the impact on farmers' net income and environmental externalities caused by land-use and management alternatives. The optimization model calculates the costs of changes in land use and technology under different spatial and temporal scenarios. Optimal solutions are the byproduct of trade-off analyses among stakeholders and satisfaction of multiple constraints. The optimization exercise evaluates *ex-ante* the economic and social potential of the alternatives in improving the quality of life, and the results can stimulate private and official investors to fund some of the alternatives.

By using the optimization model, acceptable values for decision variables and optimal income thresholds (e.g. land uses, sales of agricultural products and services, loans) are identified and adjusted to an acceptable level of environmental impact. Sensitivity analysis provides quantitative information regarding the value of the imposed environmental and socioeconomic constraints; in other words, the shadow price. Shadow prices are useful for determining the price of services and goods that do not have a market price (production of sediments, water flows, etc). This value is equal to the reduction in net income when the system has to be adjusted to reduce one unit of the negative externality. The magnitude of the shadow price depends on farmers' socioeconomic and biophysical conditions. Thus the shadow prices will correspond to the value of resources, which is critical to the externalities issue covered by the PES project. It is not related, for example, to the total amount of soil N and P, but to the quantity that moves across boundaries, the value of that N and P downstream right into Fúquene Lake and surrounding towns, and the value of the reduction of the externality by its source.

Table 41. Principal variables and decision alternatives in the ECOSAUT model.

VARIABLES[1]	**DECISION ALTERNATIVES SCENARIOS**									
	Rotations of crops (ha yr^{-1}) with/without minimum tillage & green manures	**Permanent forests (ha)**	**Permanent pastures with/without green manures**	**Feed concentrates for cattle production (Mg yr^{-1})**	**No. cows**	**Farm incomes (sales of meat, milk, wood, harvest) (Mg yr^{-1})**	**Environmental incomes for environmental services provided: water (cm^3 yr^{-1}) and CO2 (Mg yr^{-1})**	**N and P pollution residual waters (Mg yr^{-1})**	**Buys & sells of labor according to job profiles**	**Bank loans**
Net incomes (per period simulated) (objective function)	X	X	X	X	X	X	X		X	X
Capital	X	X	X	X	X					X
Cash flows (by yr)	X	X	X	X	X	X	X		X	
Land availability (upper, medium and downstream watershed) (ha)	X	X	X							
Erosion thresholds by land use (Mg yr^{-1})	X	X	X							
Hydrological balance, contribution to the superficial aquifer (cm^3 ha^{-1} yr^{-1})	X	X	X		X		X			
N contributed to water flows by land uses (Mg ha-1 yr-1)	X	X	X	X	X			X		
CO_2 fixation by vegetative cover (Mg ha^{-1} yr^{-1})	X	X	X							
Labor profiles by land uses (no. Work days yr^{-1})	X	X	X						X	
Wood production by planted forests (Mg ha^{-1})		X								
Wood production by native forests (Mg ha^{-1})		X								
1Energy production for livestock (Megacal K^{-1} ha^{-1})	X		X	X	X					
Protein production for livestock (Kg dry matter Ha^{-1})	X		X	X	X					
Dairy production (Mg yr^{-1})					X					
Meat production (Mg yr^{-1})					X	X				

[1] X indicates the presence of a relationship between an alternative and a variable.

In summary, ECOSAUT is a model created for:

- Representing agro-ecological systems and relate it with natural resource management issues, to find out solution alternatives for problems that are often complex.
- Conducting *ex-ante* impact assessment of land use changes in a given watershed.
- Conducting *ex-ante* impact assessment for long-term periods because changes in environmental externalities are related with gradual biophysical processes such erosion, changes in soil properties, eutrophication, etc.
- Integrating environmental and socioeconomic variables to evaluate alternatives according with the environmental and socioeconomic impact (environmental services, income and employment).
- Distinguishing which is the variables state that describes the performance of the system. For example the magnitude of environmental externalities (water yield, sedimentation, etc) that could indicate the environmental impact of local actions on the society.
- Ex post impact assessment when selected land use alternatives are implemented.
- Carrying out trade off analysis to determine if variables are competitive, substitutive or complementary due to possible shared impact on the maximized function (incomes, employment, etc).
- Providing quantitative information (shadow prices) about how important are system constraints during economic maximization and environmental impact minimization.
- Determining the value of environmental externalities through shadow prices, if modeling has considered economic cost and benefits of evaluated alternatives.

This model and approach are being used in the analysis of the five pilot Andean watersheds (Colombia, Ecuador, Peru and Bolivia) in order to support the identification of land use alternatives and management practices for production systems to allow the internalization of externalities. The main externalities that are subject of analysis and interventions are sedimentation, water pollution, and decrease of water yield in dry seasons and carbon sequestration.

Work in progress

Rehabilitation of degraded lands through silvopastoral systems and reforestation of marginal lands in the Caribbean savannas of Colombia. MDL project to use carbon trading for pasture rehabilitation and sustainable development

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Land degradation in the tropical savannas of northern Colombia has advanced dramatically in the last decades as a consequence on improper cattle ranching and strong droughts that have been exacerbated recently. Rehabilitate the productivity of pastures is a major concern for farmers, local and regional authorities. This project aims to enhance the productivity and natural resource base of 2,000 hectares of degraded lands by fostering the improved use of agricultural and tree material, notably through the expanded use of a silvopastoral system developed by the Colombian National Agricultural Research Organization (CORPOICA). This system consists in the planting of forage shrubs very well adapted to the region (*Gliricydia sepium*, *Cresentia Cujete* and *Leucaena leucocephala*) with high-value timber species (*Pachira quinata*, *Switenia macrophylla* and *Tabebuia rosea*). The original degraded pastures are recuperated using improved grasses, fertilizer application and other interventions to correct soil compaction. In the vast areas where land degradation has advanced to a severe grade, the project will implement reforestation using native tree species (*Albizia saman*, *Guazuma ulmifolia*, *Anacardium excelsum*, *Tabebuia billbergii*, etc.). In this case grasses will also be established in the soils most devoid of vegetation, to favor rapid land cover, minimize erosion, and accelerate the rebuild of soil organic matter. Priority in reforestation will be given to areas surrounding water streams and undulating terrain where soil erosion is a major problem. External resources will be employed to cover up-front costs linked to the establishment of the system and that exceed the capability of local producers to allow its expansion at a significant enough rate to slow the process of land degradation. The project expects to cover 200-400 farms in the region surrounding Monteria.

The project is expected to sequester 0.17 Gg CO_2e (CO_2 equivalents) by 2012 and 0.38 Gg CO_2e by 2017. Total carbon accumulation of 23 Mg CO_2 equivalents per hectare per year could be obtained in the reforestation sites given the high tree number per unit area used for the reforestation (tree cover will reach 60% in the fourth year and 90% in year 10). The improved management will increase the storage of carbon both above- and below-ground. The recovery of the degraded land and reestablishment of a grass and tree cover will favor biodiversity and will reduce erosion, triggering in turn other environmental benefits. Rural communities living of small scale livestock production will benefit through an increase in their income and in the sustainability of their livelihood (currently threatened by land degradation). Local residents will also enjoy social benefits through the creation of direct employment for the tree nurseries, planting operations, fencing and maintenance of the established silvopastoral and reforestation systems. The local economy will be stimulated by the increased resources being injected in the economy through the project implementation and especially through higher productivity. Local and regional institutions including academic bodies will benefit from capacity building in topics related to CDM projects and silvopastoral systems. The activities proposed will not change land ownership and are not expected to result in leakage outside the project boundaries. The additional income from carbon sequestration will be key for the development of the activities, while the increase in income they will generate will clearly increase the incentive of farmers to keep them permanently.

The project is developed by Centro Internacional de Agricultura Tropical (CIAT), and the Colombian National Agricultural Research Organization (CORPOICA), and the Environmental Corporation of the Sinu And San Jorge Rivers (CVS) The project has been successfully negotiated with the BIOCARBON Fund as a CDM project and will be the first of this type to be implemented in Colombia. Farmers have been already selected and organized in an association of producers and the project operations in the field will start towards the end of 2006. Transaction costs of this project will be carefully assessed to help in the identification of suitable MDL projects in Latin America to be promoted as CDM activities.

Output target 2008

- ***In at least four of the countries participating in the BGBD project, policy stimulated to include matters related to BGBD management, and sustainable utilization***

Work in progress

This activity will commence during phase II of the CSM-BGBD project and work will commence in 2007 to achieve this output target. Individual scientists studying different BGBD species will determine the species loss in any niche and country synthesis to determine species richness and /or loss of richness per land use, niche or management type and present the findings in reports and published papers. Quantitative analyses will be carried out on the link between land use intensity and BGBD and from the analysis; it will be possible to relate land use intensity and other variables to BGBD loss. Socio-economic scientists in each participating country together with the GCO socio-cultural consultant and natural resource economics consultant will analyse jointly with the country scientists and prioritize thematic areas to be addressed by the project in order to achieve maximum benefits and impacts of the project outcomes before embarking on phase two implementation in 2006. Each of the partner countries will in a participatory process with conservationists, communities and farmers identify thematic problem areas to be addressed and collective joint action select demonstration sites. Each partner countries will engage a policy analyst to study and highlight BGBD policy gaps and thereafter find mechanisms of involving policy makers and politicians in the process so that the identified gaps and/or areas are addressed.

Progress towards achieving output level outcome

- *Principles of sustainable land management integrated in country policies and programs*

This output is aimed at restoring degraded agroecosystems to economic and ecologic productivity, while recovering the function of such lands as providers of a range of ecosystem goods and services. Tools developed over the past few years are starting to be used by farmer associations to better plan the use of their land. An example of that is the use of GEOSOIL decision support system for planning oil palm in the acid soil savannas of Colombia. During 2005, important advances were made towards the development and testing of methods for assessing and putting value on environmental services, particularly at the Fuquene Watershed in the Colombian Andes. Intensive field monitoring coupled to the use of special software allowed to identify the most suitable options at the watershed scale to balance productivity and socioeconomic profitability and the maintenance of ecosystem functions. Methods will be refined in 2006 to include the potential to generate tradable Carbon in the watershed and how this could facilitate the adoption of desirable land use management practices. The use of similar approaches allowed to define that shaded coffee is the most suitable land use option for farmers in the Altomayo Watershed in Peru to provide not only income and job generation, but also reduced impact on the environment. In a contrasting drier agroecosystem, the steepland region of Lempira in Honduras, significant advances were made towards understanding the drivers behind the adoption of the Quesungual slash and mulch agroforestry system. This knowledge is already being used to promote the expansion of the systems into an even drier region in Nicaragua. The potential of two key ecosystems in Latin America, the Amazon rainforest and the acid soil savannas, to serve as net sinks for atmospheric carbon and to play a role in mitigating climate change, was assessed.

The interactions between the policy environment and the socio-cultural and economic condition have been addressed through studies that look for enabling environments. By this the support systems are meant to address financial and technological infrastructure as well as the extension services for scaling out win-win land use and management alternatives. Research showed that specific strategic alliances are required for the poorest farmers to benefit from financial mechanism that would allow them to adopt new technologies.

Progress towards achieving output level impact

- *Reversing land degradation contribute to global SLM priorities and goals*

A special project to rehabilitate extensive areas of degraded lands in the Caribbean savannas from Colombia through the use of silvopastoral systems and reforestation with native species was successfully negotiated with the Biocarbon Fund. This is the first initiative to use Carbon trading to cover part of the cost of the actions required to stop and reverse land degradation. Though this is a long term initiative, expected impact on the livelihoods of poor rural communities, including native Indians is very high. Outcomes from the special projects mentioned above are helping to set the scene for the articulation of future plans for payment of environmental services in rural areas. Governments, particularly in Latin America could use the outcomes of such initiatives to define policies to reverse land degradation at local and regional levels. With the partnership of a large interdisciplinary team, CONDESAN is aiming to provide local and regional authorities with guidelines to help policy makers in the definition of incentives and mechanisms to include payment from environmental services as part of the local land use planning.