Soil Degradation and Crop Productivity Research for Conservation Technology Development in Andean Hillside Farming

A Proposal for:

Der Bundesminister für Wirtschaftliche
Zusammenarbeit und Entwicklung (BMZE)

Executing Agency: CIAT

International Center for Tropical Agriculture
Centro Internacional de Agricultura Tropical

June 1995

SOIL DEGRADATION AND CROP PRODUCTIVITY RESEARCH FOR CONSERVATION TECHNOLOGY DEVELOPMENT IN ANDEAN HILLSIDE FARMING

Special Project Funding

A Proposal for: BMZE

Executing Agency: CIAT International Center for Tropical Agriculture / Centro Internacional de Agricultura Tropical

Collaborating Partners:

- Institut fuer Pflanzenproduktion in den Tropen und Subtropen der Universitaet Hohenheim, F.R.G., Germany
- Corporación para Estudios Interdisciplinarios y Asesoría Técnica (CETEC),
- Fundación para la Investigación y el Desarrollo de la Agroindustria Rural (FIDAR),
- Consorcio Interinstitutional para una Agricultura Sostenible en Laderas (CIPASLA),
- Corporación Autónoma Regional del Cauca (CVC), Colombia

June 1995

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List of Acronyms

BMZE	Der Bundesminister für Wirtschaftliche Zusammenarbeit und Entwicklung. Germany (Federal Ministry of Technical Cooperation and Development)
CETEC	Corporación para Estudios Interdisciplinarios y Asesoría Técnica
CIAT	Centro Internacional de Agricultura Tropical, Cali, Colombia (International Center for Tropical Agriculture)
CIPASLA	Consorcio Interinstitucional para una Agricultura Sostenible en Laderas (Regional Network)
CGIAR	Consultative Group on International Agricultural Research
CVC	Corporación Autónoma Regional del Valle del Cauca
DTM	Digital Terrain Model
DSSAT	Decision Support System for Agrotechnology Transfer
EPIC	Erosion Productivity Impact Calculator
FEDECAFE	Federación Nacional de Cafeteros de Colombia
FIDAR	Fundación para la Investigación y Desarrollo de la Agroindustria Rural
GOs	Governmental Organizations
GIS	Geographic Information System
GTZ	Gesselschaft für Technische Zusammenarbeit, Germany (German Agency for Technical Cooperation)
IBSRAM	International Board for Soil Research And Management
MAS	Management of Acid Soils - Consortium
MM	Man Months
NGOs	Non-Governmental Organizations
PERFECT	Productivity Erosion Runoff Function to Evaluate Conservation Technics
SRG	Scientific Resource Group
SWNMI	Soil Water and Nutrient Management Initiative
TDR	Time-Domaine-Reflectometry
UNDP	United Nations Development Program
USLE	Universal Soil Loss Equation

1.0 Summary

Title: ***Soil Degradation and Crop Productivity Research for Conservation Technology Development in Andean Hillside Farming***

Objective of Research:

The overall objectives of the project are to generate basic knowledge on soil degradation and erosion processes of Andean Inceptisols and develop conservation effective cropping systems including on-farm testing and transfer of technology.

Abstract:

In the Andean region, land use through arable crops with inappropriate technology has led to progressive soil degradation and erosion. In extreme cases the entire top soil has been lost within one generation leaving agricultural land unproductive. However, due to its healthy climate and reasonable infrastructure the medium altitude areas of the Andes in Northern South America are regions of increasing population pressure. This results in growing demand on soil and water resources which are threatened by overexploitation and mismanagement. The cultivation of arable short cycle crops such as cassava, maize and beans on steep slopes without appropriate soil conservation measures results in soil erosion, increased runoff and reduced water quality and quantity. Hence there is an urgent need for agricultural technologies which conserve the soil, maintain productivity and avoid water pollution and sedimentation downstream.

The CIAT cassava program, recently joined by the hillsides program and the interprogram project initiative, together with the Institute for Plant Production in the Tropics and Subtropics, University of Hohenheim, Germany have been searching for appropriate conservation technologies for Andean hillside agriculture in the past few years.

A viable set of conservation components was identified and developed as a response to distinct soils, cropping patterns, farm types and farm environments. Technically and economically feasible components of soil management practices with reasonable levels of adoption potential, e.g., several barrier options, undersown forage crops and minimum tillage practices were characterized as to their effects on soil losses and soil properties related with erodibility and soil productivity.

Long term data collection from erosion trials is providing the information necessary to calculate relationships between climatic and soil characteristics and erosion, using mathematical models adjusted to the Andean environment of northern South America. Part of this research on physical factors related to soil erosion - in particular on soil erodibility - has been finalized and adjusted mathematical model equations are available. Stability of soils in the region is also influenced by tillage - and cropping practices. These, in turn, have an important impact on soil biological processes responsible for the production of organic aggregating agents. The identification of such "Soil health indicators" requires further research. Additional research is also necessary on rainfall erosivity and the water factor in soil-conserving cropping systems. Major emphasis will be put during the two-year extension phase on socioeconomic implications and on possibilities to improve adoption levels by linking soil conservation technology development to income and market opportunities. Accumulated experience from on-farm research, interinstitutional collaboration and component development with small farmer communities set a solid base for these research issues.

This research will be concluded during the two-year extension phase of the project. Data collection and analysis is well advanced through individual thesis research. In the two year extension phase, this information needs to be compiled in a single data base covering a ten-year time span at the end of the project. Linking the data with GIS information and procedures available at CIAT will provide a solid basis for predicting risk of soil loss in agricultural production systems on Andean inceptisols of the region and for giving appropriate soil conservation recommendations.

To finalize research and transfer of results a two-year extension is proposed. The extension phase requires a financial support of US $445,840 for CIAT and US $303,365 for the University of Hohenheim to achieve the objectives of the project.

Cooperating partners:

The execution of the proposed extension phase will be carried out jointly by:

- the Centro Internacional de Agricultura Tropical (CIAT), Colombia
- the Corporación para Estudios Interdisciplinarios y Asesoría Técnica (CETEC).
- the Fundación para la Investigación y el Desarrollo de la Agroindustria Rural (FIDAR)

- the Consorcio Interinstitutional para una Agricultura Sostenible en Laderas (CIPASLA)
- the Corporación Autónoma Regional del Cauca (CVC)
- the Institut fuer Pflanzenproduktion in den Tropen und Subtropen der Universitaet Hohenheim, F.R.G.

Names of principal scientists:

CIAT Senior Scientists involved in project activities will be:

- Dr. Edgar Amezquita, Soil Physicist, Hillsides/Tropical Lowland Program
- Dr. Bill Bell, CIAT, Head of GIS unit
- Dr. Rupert Best, Leader, Cassava Program
- Dr. Mabrouk El Sharkawy, Physiologist, Cassava Program
- Dr. Bronson Knapp, Acting Leader, Hillsides Program
- Dr. Joyotee Smith, Agric. Economist,Tropical Lowlands/Hillsides Program

Senior Staff of the University of Hohenheim:

- Prof. Dr. Dietrich E. Leihner, Director, Institut fuer Pflanzenproduktion in den Tropen und Subtropen der Universitaet Hohenheim
- Dr. Karl Muller-Samann, Project Coordinator, Cassava Program

Names of staff to be financed:

- *CIAT staff:* Two Colombian graduate research assistants (2 x 24 MM) (One to conduct M.Sc. thesis research and one doing a Ph.D.). One research assistant; M.Sc in GIS (12MM)
- *German staff:* Postdoctoral scientist (24 MM) Two Ph.D. students (12 and 24 MM)

Budget Total and Breakdown by Activities and Year (Current US$):

The total budget is US$749,205, broken down as follows:

Budget	Year 1	Year 2	TOTAL
CIAT			
Personnel	128,800	115,350	*244,150*
Travel	7,500	10,000	*17,500*
Research and Operations	30,000	25,000	*55,000*
Training and Workshops	18,100	38,950	*57,050*
Indirect costs (20%)	35,680	36,460	*72,140*
Total CIAT	*220,080*	*225,760*	*445,840*
HOHENHEIM UNIVERSITY			
Personnel	134,875	112,440	*247,315*
Travel	15,300	16,000	*31,300*
Research and Operations	11,500	13,250	*24,750*
Total Hohenheim Univ.	*161,675*	*141,690*	*303,365*
GRAND TOTAL ALL PARTNERS	***381,755***	***367,450***	***749,205***

2.0 Background, Justification and State of Knowledge

Most flat, fertile lands of tropical America are already intensely farmed today. The need for increased agricultural production thus puts additional pressure on the three last frontier areas of the continent: the rain forest, the low fertility acid savannas and the Andean hillsides (Gómez A., 1988). The tropical hillsides, once cultivated with annual crops become highly susceptible to erosion caused by heavy rains. Soil degradation is already apparent in large areas of the Andean region. This process is posing a growing threat to both the environment and agricultural production in Latin America (Burgos, 1987; Statistisches Bundesamt, 1988; Oldeman et al., 1990). In the case of Colombia, nevertheless, only limited research has been done on soil erodibility under conditions of natural and seminatural ecosystems (Imeson and Vis, 1982) and on deep Andosols in the coffee zone (Gómez, 1988). No such research exists for the important soil order of little developed inceptisols under agricultural use. A recent enquiry with IBSRAM also indicated that for South-east Asia, virtually no research data exist concerning erosion processes on Asian Inceptisols (Sajjapongse, pers. com).

In 1986, the University of Hohenheim started a collaborative project with CIAT as a small, DFG-funded activity which subsequently received financial support from BMZE. Right from the beginning the objectives of the project were both of a basic and applied nature, aiming at the establishment of relationships between climatic as well as soil properties and erosion processes on the one hand and developing soil conservation technologies for the production of crops, principally cassava, on the other hand.

Basic and applied research aspects were matched by a dual approach of on-station and on-farm research. The Universal Soil Loss Equation (USLE), a soil loss model developed by Wischmeier & Smith (1978), was chosen as the central methodological approach for predicting and describing erosion hazard of soils and different land use practices. Over the last seven years a huge amount of data on climate, soils, soil loss and crop performance from over 40 erosion plots on two Andean slopes with tropical Inceptisols was systematically collected and evaluated.

In the light of alternative models nowadays widely used in developed countries, it was repeatedly discussed with project staff whether to continue work with the USLE model which is one of the older empirical models to "predict soil losses". However, continued work based on USLE offers several advantages. It is a transparent model with a logical structure that links very well to agricultural practices. It is relatively easy to handle, non destructive and allows continued long term monitoring of soil losses and soil loss dynamics on the same plots, requiring limited technical- and laboratory facilities.

Furthermore, it forms the basis for the EPIC model (Erosion Productivity Impact Calculator; USDA, 1985) with which the project is working to simulate relationships between soil degradation and crop productivity. Also, a considerable data base on USLE factors has already been accumulated in the project. A switch to another model would partly invalidate these data and the existing infrastructure. Finally, the model permits comparison of results with data from other soil erosion research in Colombia as well as other Latin American countries where USLE has been the most widely used model. (Imeson and Vis, 1982; Vuuren, W.E. van, 1982; Bronzoni, G. and Villalobos, F. 1989).

The development of soil conserving cropping technologies for the Inceptisols of the Andean hillsides was mentioned as a second major objective of previous and on-going research. Whilst technology development in the project was initially focussing on cassava, other crops such as cowpea, bush beans, forages and distinct rotation elements, including enriched fallows have been included more recently (CIAT, 1992; Reining, 1992; CIAT, 1993; Ruppenthal, 1995). Identified practices, effective in reducing soil erosion and run-off, at the same time maintaining crop productivity include elements such as live grass barriers, contour ridges, permanent covers with less competitive forage legumes, reduced tillage and transitory components with an immediate benefit to farmers.

With progress being made as regards to both the knowledge of basic processes of erosion under Andean hillside conditions and practical soil conservation technology, the project in its extension phase will forcefully move into widening the applicability of scientific research results, e.g., ascertain the predictability of soil loss based on parameters that can be determined over larger areas and relate these to crop productivity.

Sustained adoption of technology rarely is achieved by only providing functional technology (Nimlos and Savage, 1991; Laing and Ashby, 1992). Development of soil conservation technology, therefore, will be complemented by research on social and economic aspects of soil conservation technology acceptance by the end user. Circumstances and conditions under which adoption can be induced by linking soil conservation technology development with income and market opportunities in small farmer environments are of special interest (Barbier, 1990). This type of approach figures amongst the most promising (Hudson, 1991) and can be dealt with in the project building on own technical experience, established relationships with farmers, input from one of the CIAT economists and on already existing socioeconomic characterization of farm households and markets in the Rio Ovejas pilot area.

2.1 Results from previous project phase

A more comprehensive report on results obtained during the first phase of the project is being submitted separately.

2.1.1 Research on factors, processes and prediction of soil erosion in tropical inceptisols.

Research on the above mentioned factors was carried out on forty erosion plots on two sites in the Cauca Department:

- Santander de Quilichao; 990 masl, annual precipitation bimodal, 1799 mm; potential evaporation 1589 mm; average temperature 23.8 C; soil classified as amorphous, isohyperthermic oxic Dystropept.
- Mondomo; 1450 masl; annual precipitation bimodal, 2133 mm; average temperature 18.2 C; soil classified as kaolinitic-amorphous, isohyperthermic oxic Humitropept.

During past research, special attention was given to the erodibility factor "K", describing a soil's inherent susceptibility to erosion and to the rainfall factor "R" which characterizes erosivity of rains. Both factors together largely determine the proneness of a given physical environment to soil erosion.

Calculated model values for K were consistently lower than those obtained by direct measurements. This indicates the need for the modification of USLE equations under Andean hillside conditions.

Research in the project indicated that the erodibility factor "K" is not a constant. In accordance with observations by Lal and Elliot (1994), it turned out to be a very dynamic soil characteristic with a tendency to increase during prolonged soil exposure. Over a period of 6 years, erodibility was increasing and only in the 7th year, it showed a decline. The observed increase in erodibility of the inceptisols, which was subject to a clear acceleration after about two years of cultivation was related to losses in soil organic matter and possibly soil binding organic substances. The recent inversion of that trend, which only occurred after the soils had undergone a severe process of degradation seems to be related to the mineral composition of the soil, mainly sesqui-oxydes which again favored the formation and accumulation of stable aggregates. This could also be demonstrated by measuring soil resistance to rain drop impact in the laboratory. Moreover soils from Mondomo were more susceptible to rain drop impact than soils from Quilichao, suggesting different conservation strategies for the two sites (CIAT, 1995).

Based on observed differences between calculated and empirically determined K-factors an attempt was made to modify, simplify and economize the procedure used for "K" determination in the USLE-model.

Considering six physical surface soil variables, out of 26 parameters evaluated, it was possible to formulate a model equation which explained 88 % of the variability of real soil losses for both sites, Quilichao and Mondomo (Castillo et al., 1995).

Research was also done with regard to the rainfall factor "R" of the USLE model as to its accurateness under tropical conditions in Southern Colombia. Complementary to the registering rain gauges used since 1987 to determine the amount and intensity of rainfall, in 1993 an electronic raindrop-sensor computer system (Distrometer) had been used. The equipment allows the researcher to describe the relationships between rain intensity, drop size distribution and total energy, the factors determining erosivity of rainfall events. Very preliminary results from a set of 35 rains recorded suggest no major differences with regard to drop size distribution between the tropical Andean test site (Santander de Quilichao) and temperate regions of North America, where these parameters were first evaluated (Wischmeier and Smith, 1958).

The hypothesis with regard to this observation is that 35 rainfall events are too small a sample for the range of drop sizes and energy loads of rain occurring in the northern Andean region, in particular since the 35 events recorded did not include really heavy, torrential rains. Additional measurements to be carried out during the 1996 and 1997 cropping seasons are therefore needed to examine this hypothesis and base R-factor calculations on a solid and sufficiently representative set of data.

2.1.2 Relationships between erosion induced soil degradation and crop productivity

Removal of top soil by erosion affects physical and chemical soil characteristics and consequently crop yield (Langdale and Shrader, 1982).

Nevertheless, farmers are mostly reluctant in implementing soil conservation, because degradation processes are slow and on a short-term basis frequently masked by the use of fertilizers and/or improved varieties. Knowledge on the relationships between soil erosion levels, soil degradation and crop productivity is therefore needed to put a cost figure to soil degradation, allowing one to confront costs of yield losses with potential costs of implementing soil conservation programs.

Results obtained from growing sorghum and peanut on soils with different levels of erosion or soil removal, showed very severe yield reductions on oxic Dystropepts. Even large amounts of fertilizer could not compensate the loss of only 5 cm of top soil in the case of Sorghum. For peanut which reacted somewhat less sensitive, yield reductions were still very drastic, the impact of real erosion processes being stronger than those simulated through scalping. When erosion had removed the top soil layer to a depth greater than 13 cm or when soils were scalped to that same depth, this resulted in total yield losses when no fertilization was applied and in extremely poor yields with complete soil amendment (Flörchinger and Müller-Sämann, 1995).

Soil organic matter, N, K, inorganic P and aluminum saturation were soil chemical characteristics with highest correlations to yield reduction. These results will be complemented by data on the impact of soil physical deterioration. Findings will permit calibration of the EPIC computer model for conditions of Andean Inceptisols.

2.1.3 Development of productive, soil conserving cropping systems

Research with different cassava cropping systems has consistently shown, that forage legume intercropping, once the legumes are established, can drastically reduce erosion. Forage legumes tolerating acid, low P-soils, temporary shade and dry weather conditions include species such as *Centrosema acutifolium*, *Centrosema macrocarpum*, *Galactia striata*, *Zornia glabra* and *Chamaecrista rotundifolia*. However, yield reductions resulting from reduced tillage plus undersown legumes were sometimes as high as 50% and hence too strong to be accepted by farmers, even if forage yields of 3-5 t/ha of dry matter per year are taken into consideration (Müller-Sämann et al.1994).

Morphological and physiological characterization of highly competing and less competing legumes such as *Chamaecrista* is undertaken to develop strategic principles for the design of less competitive cassava-legume intercropping systems. Research, concentrating on competition mechanisms below ground, could show that denser rooting systems of legumes not necessarily exert more competition if compared with species of similar biomass production and less extensive rooting (Muhr et al., 1995a; Muhr et al., 1995b).

Sheet erosion occurring in Santander de Quilichao mandated a better soil cover, which in this specific case was attempted through the use of forage legumes. The prevailing rill erosion in Mondomo, however, suggested that farmers put more emphasis on conservation strategies aimed at reducing the amount and velocity of runoff.

Grass barriers, if properly planted and managed, can provide this runoff-reducing effect. When tested on moderate slopes they were as effective in reducing soil losses as intercropped cover legumes. Competition with adjacent crops depended very much on the grass species, growth type, biomass production and type of root interference. Vetiver grass was most effective in controlling soil erosion and competed least with cassava.

Grasses such as elephant grass, guatemala grass and lemon grass competed more and are adequate in situations where farmers can derive income from these in the form of forage or sellable products e.g., essential oils (Tscherning et al., 1995). Data sets on productivity and management implications of these components under on-farm conditions have been compiled for agro-economic evaluations. As a result of farmers' reactions to proposed soil conservation technologies work on component development was extended to multispecies strip cropping, temporary, sown barrier - and rotation elements with potential immediate benefit including species like pearl millet, rice and legumes. These options also might widen the opportunities for the application of minimum tillage practices in a small farmer hillside environment.

2.1.4 Interaction with farmers and institutions

Linkages with farmer groups, governmental and non-governmental institutions for early validation of components were further developed. This is leading to adjustments, new ideas, initiatives and the dissemination of technology components.

At present three on-farm experiments with run-off plots, including ditches for the collection of eroded soil are managed together with staff from two NGOS (CETEC and FIDAR) and an governmental organization (CVC). CVC set up replicates of demonstration trials in other watersheds within their mandate area and recently also in rural colleges.

The project was also successful in getting CETEC linked to the farmer group in the hilly cassava growing area of Buenos Aires where the project already had established observation and demonstration plots. CETEC, an organization active in the area of rural development, sustained land management, production and marketing of higher value farm products, rural credits and farm-household training is now setting the stage for a more integrated approach to soil conservation. It includes better crop management, access to credit, market opportunities and co-lateral social activities, which all together should create a favorable environment for soil conservation technology adoption (e.g., sowing of erosion control strips with millet to support commercial small farm egg production).

Similar activities are undertaken with FIDAR, another NGO doing adaptive research and training in the area of agricultural production and resource management. The NGO, which also has wide experience in the development of rural agroindustries, received financial support through the project to assist a women's group to set up and successfully manage a small essential oil extraction plant. This should allow farmers to obtain some benefits from the 25 km of Citronella grass hedgerows, planted on their fields to control soil erosion.

With an indigenous farmers group in Toribio a project has been developed to grow Physalis peruviana between barriers of Vetiver grass.

Plots for multiplication of soil conservation germplasm could successfully be handed over to local organizations. Dwarf elephant grass (*Pennisetum purpureum* var. Mott) was among the most successful introductions and is now widely used as a barrier for forage production in cut-and-carry operations.

Contacts with the regional office of the National Coffee Federation (Fedecafé) were maintained. Collaboration included germplasm exchange, participation in field days, training workshops for extensionists and farmer groups and designing of soil conserving cropping systems.

Contacts with national cassava programs in Brazil and Ecuador could also be established and the CIAT project coordinator was invited for a consultancy to a UNDP funded Cassava project in North East Brazil.

2.1.5 Training and information dissemination

The project has started to build a documentation base on research results and technologies tested. The documentation base includes the annual reports of the CIAT cassava program until 1994, five technical papers, two German Ph.D. theses, one Colombian Master thesis as well as two Colombian and two German graduate theses. Extension leaflets are being developed in collaboration with FIDAR on the subject of barriers as elements of soil conservation.

Postgraduate training experiences from on-going and previous projects contributed significantly to the development of a three-weeks intensive postgraduate course on "Soil Degradation and Conservation in the Tropics". It was offered for the first time by Hohenheim University in August/September 1994 with 13 participants from Latin America, Africa and Asia. This course is supposed to become a permanent component of the Hohenheim Tropical Center's annual postgraduate training program (The course program is added as a separate document). Agronomists from national cassava programs in Brazil and Ecuador have made a request for in-service training in CIAT in the second half of 1995.

3.0 Project Objectives for the Extension Phase

During the extension phase, research within the project will put more emphasis on socioeconomic aspects. The basic research on biophysical aspects of soil erosion and degradation will be finalized. Ongoing agronomic research by the project itself will be phase out and conservation component development transferred to cooperating GOs and NGOS and the interinstitutional consortium (CIPASLA) in the Rio Ovejas watershed. The final two years of the project will also be used to build a general data base including all climatic, soil, plant and socioeconomic information generated since the start of the project in 1986.

Specific objectives for the extension phase are:

- finalize research on rainfall erosivity and water status of soil conservation systems of the northern Andean Region (German Ph.D.);
- identify and validate soil indicators of instability/degradation, verify indicators both at plot and watershed level (Colombian Ph.D.);
- finalize data evaluation and model calculations on relationships between soil degradation and crop productivity, i.e., quantify ecological and economic cost of soil degradation. (Finalization of German Ph.D. project conducted during previous project phase);
- evaluate costs and income potential of traditional and innovative conservation components linking them to identified market opportunities (Colombian M.Sc. thesis);
- validate and transfer soil conservation effective cropping system technology through collaboration with local institutions and farmer communities;
- train scientists and disseminate information;
- build a consolidated data base on project results so far obtained.

In achieving these objectives, the project expects to produce the following outputs:

- improved knowledge on erosion processes and predictability of erosion on Andean inceptisols, i.e., erodibility and erosivity;
- established relationships between soil erosion induced soil degradation and crop productivity for economic assessment of costs of soil erosion and assistance to political decision makers;
- practical conservation technology with high potential of adoption developed through intensive cooperation and information exchange with public and private organizations and farmers;

- trained students and scientists;
- documentation of results from basic and applied research on soil conservation technology development and transfer; production of a soil conservation manual. Organization of a regional conference on soil conservation in the tropical Andes;
- establishment of a ten years data base on climate, dynamics of soil development, soil losses, crop productivity and socioeconomic background information from erosion plots and on-farm research in Southern Colombia.

The expected outputs will contribute to stabilize crop productivity and to preserve natural resources in ecologically vulnerable mountain areas. Together with co-lateral activities such as the Hohenheim training course on "Soil degradation and Conservation in the Tropics" they will strengthen national institutions involved in soil conservation and international collaboration in this area.

As a project within the MAS (Management of Acid Soils) - Consortium, the project in its extension phase - would also link to the System-wide Soil, Water and Nutrient Management Research Initiative (SSWNMRI) including non CG-centers like IBSRAM (International Board for Soil Research and Management).

4.0 Workplan

Major activities and outputs of the two year extension phase of the project are illustrated in Figure 1. The implementation schedule (Gantt chart) for each main project activity is shown in Appendix A. Figure 2 shows the project organization for the technical reporting and financial management. Both the hillsides and the cassava program of CIAT in collaboration with the Institute of Plant Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart, FRG, will be in charge of the execution and supervision of the project. Both CIAT programs will provide logistic, administrative and technical assistance as before.

National institutions concerned with rural development and sustainable resources management, such as CETEC, FIDAR, CVC, the regional CIPASLA consortium and local farmer communities will collaborate in on-farm testing, evaluation and improvement of technologies. A Colombian Ph.D. student (J. Castillo) will do research on validating indicators of soils' susceptibility to erosion as influenced by tillage and cropping practices. A Colombian M.Sc. student to be named by CIAT will be responsible for socio-economic studies related to soil conservation and market opportunities facilitating soil conservation technology acceptance by farmers. Colombian graduate students will have the opportunity for graduate thesis research in soil conservation/crop production. A German Ph.D. student (C. Kloppmann) will do his dissertation research on rainfall erosivity and soil water aspects during the extension phase of the project. Another German Ph.D. student, Ms. F. Floerchinger, has conducted her field research during the previous project phase and will use the first year of the extension phase for data evaluation and model calculation.

The project coordinator (K. M. Mueller-Saemann) will transfer agronomic research to local institutions and farmer communities, produce a soil conservation manual and organize a regional workshop on soil conservation in the tropical Andes. With the assistance of the CIAT GIS-unit, a consolidated mega-data base will be constructed using biophysical, agronomic and socioeconomic information from all previous project phases.

The following components of the workplan are organized according to working units established within each of the institutional partners.

Figure 1

Project Description

Structure Linking Project Activities to Project Outputs

Program Goal

To increase incomes and agricultural sustainability in less favoured hillside areas by improving the level of soil conservation and crop productivity.

Project Purpose

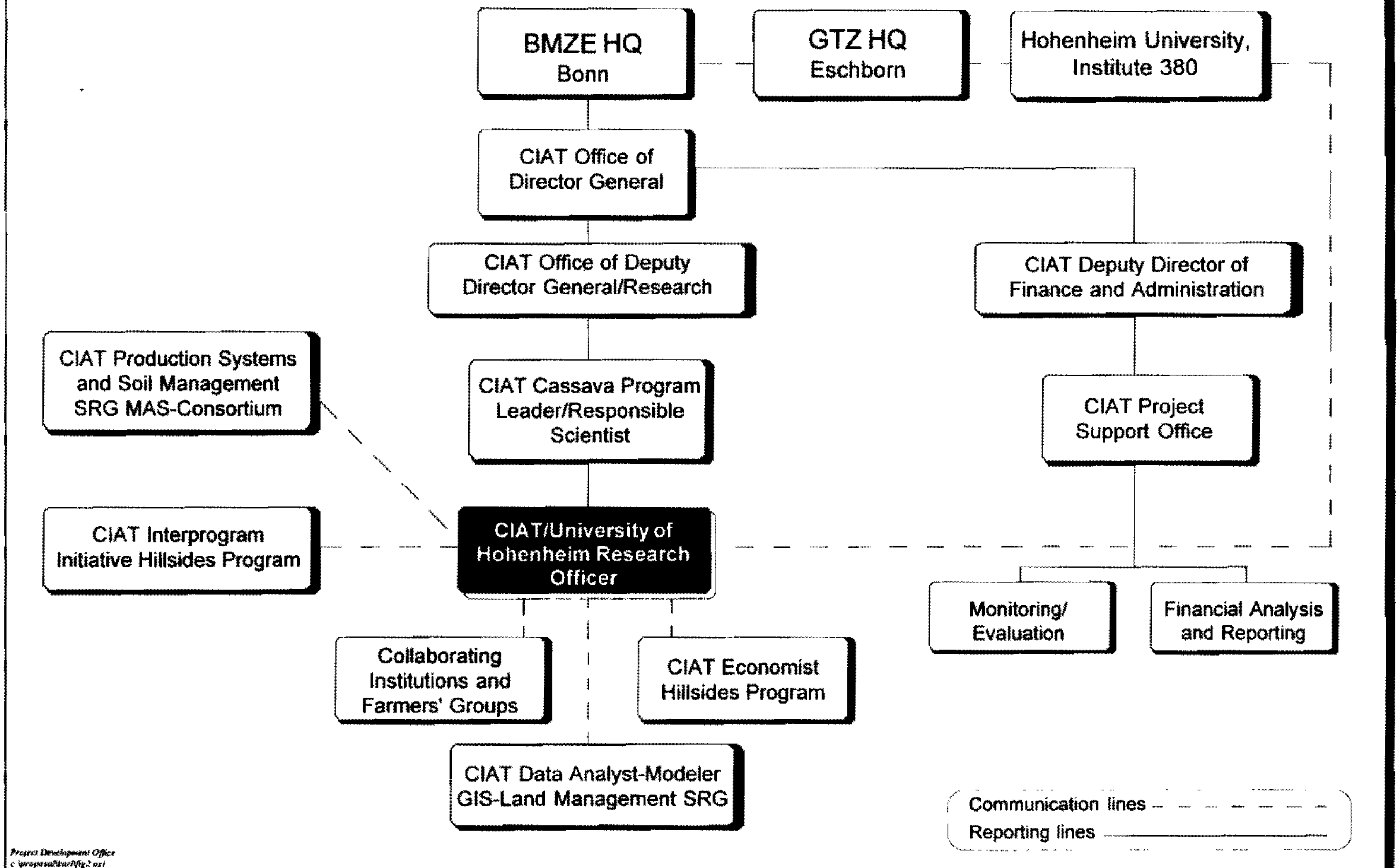
To generate and disseminate knowledge on soil degradation and erosion processes of Andean inceptisols and develop conservation effective cropping systems and management guidelines.

Outputs	Improved predictability and prevention of soils erosion	Improved knowledge of the impact of soil erosion on crop productivity	Adapted and Effective Soil Conservation Technology Developed and Tested	Trained Scientists	Documentation and Dissemination of Information	Project Managment
Activities	→ Develop drop size-energy load-rainfall intensity relationship. → Finalize R-factor calculation and mapping of erosivity. → Validate indicators for soil health with respect to soil erodibility. → Relate indicators to soil/crop management.	→ Determine soil characteristics indicative of degradation. → Relate crop productivity to degradation and adapt calculation model. → Finalize ecological and economic appraisal of cost of soil erosion. → Characterize conservation practices with respect to soil water balance.	→ Measure effect of conservation practices on crop production. → Conduct economic evaluations of technological options. → Study socioeconomic trade-offs between conservation and production/market opportunities (adoption problem). → Ex-ante validation of conservation components and development of market opportunities to soil conservation components. → Cooperate with national institutions in demonstration plot establishment and technology transfer.	→ Co-supervise Colombian masters and Ph.D. thesis research. → Supervise post-doctoral and doctoral students' research. → Publish technical articles.	→ Publish CIAT manual on soil conservation. → Create mega-database on project results and pilot application of a dataset to the Rio Ovejas watershed. → Offer regional workshop on soil conservation.	→ Revise design based on donor suggestions. → Finalize contract with donor. → Prepare/submit technical and financial progress reports. → Participate in project evaluation. → Submit end-of-project report to donor.

Project Development Office

Figure 2

Project Organization Chart



4.1 Predictability of soil erosion--influence of soil management on erodibility indicators

Two factors of the biophysical environment need to be well known before models to predict soil erosion can be developed or adapted: Physical and chemical soil properties as well as characteristics of rainfall, described in the USLE-model by the K and R factors. Both require a substantial amount of basic research in a specific region before they can be used as prediction tools. Research results obtained during previous project phases have allowed to adapt calculation procedures for the USLE K factor, describing soil erodibility under conditions of Andean inceptisols. A mathematical model involving six soil variables has been developed allowing to estimate the inherent proneness of the Andean inceptisols under study to erosion with reasonable accuracy (see chapter 2.1 of this proposal and the separate report on project results and achievements). No further research on the USLE K factor will therefore be developed within the project during the extension phase but the results will be made available to other Colombian and neighboring country institutions for further testing and application.

The above mentioned research has, however, not considered the impact that tillage, cropping practices and rotation systems have on soil aggregation, microbial activity and biologically influenced stability, which may undergo short-term changes although soil organic matter content remains unchanged (Haynes and Swift, 1990; Castillo, 1994). A Colombian Ph.D. research program (J. Castillo) has, therefore, been started in 1995. It focuses on the identification of soil biological and -physical parameters as indicators of soils' changing susceptibility to erosion and their modification under different tillage and cropping practices. This research will be brought to a conclusion during the extension phase of the project.

The working hypothesis is that total soil organic matter content is a parameter not sensitive enough to describe short-term changes in aggregate stability induced by specific tillage and cropping practices. However, there is evidence that organic aggregating agents, such as hot water extractable carbohydrates which only form a small fraction of total soil O.M. can detect these considerable short-term changes (Haynes and Francis, 1994).

The workplan for this research, therefore, includes the measurement of:

a) stable aggregate fractions (according to Rasiah and Kay, 1994).
b) living organic biomass (fumigation extraction method).
c) hot water extractable carbohydrates (according to Haynes and Swift, 1990);

and the measurement of the following parameters for validation of applied indicators:

d) infiltration rates and hydraulic conductivities;
e) run-off and sediment load of run-off;
f) soil loss from run-off plots.

Soil sampling has started in 1995 and will be continued throughout 1996 until the end of the '96 cropping period in March 1997. Soil samples are taken from 0-3, 3-10 and 10-20 cm depth five times through the cropping season (start and end of 1st rainy season, start and end of 2nd rainy season, end of long dry season).

No new experiments are being set up but the run-off/erosion plots in Quilichao and Mondomo as well as plots set up in 1994 by the CIAT Interprogram Project in the Rio Ovejas watershed will be sampled.

The existing tillage/cropping practice history for plots in Quilichao and Mondomo is shown in Table 1. In the Rio Ovejas watershed, soils with the tillage/cropping history outlined in Table 2 will be sampled.

Through this research, soil indicators will be available for being used as tools to diagnose soil erodibility status based on biological processes which are not taken into account by models such as USLE. Tillage and/or cropping practices may thus be evaluated with regard to their long- and short term effect on soil stability allowing to formulate precise recommendations for land management in tropical hillsides, where soil erosion is the single most important factor of soil degradation. Furthermore, researchers and extensionists will be enabled to issue an early warning if the indications to be developed show that land use practices are conductive to an enhancement of erodibility rather than stability.

4.2 Predictability of soil erosion - rainfall erosivity and hydrological aspects

Erosivity is best estimated by direct measurements of a rainstorm's energy load. The data base for these measurements, however, is limited to a few regions only and must be expanded to other agriculturally important areas such as the South American Andes where data are still lacking. Empirical equations that relate rainfall energy with intensity are urgently needed, especially for tropical regions characterized by high intensity rainstorms.

Table 1. **Cropping sequences on run-off and erosion measurement plots in Santander de Quilichao and at the Mondomo site** [1)]

Treatment	1994/95	1995/96 *	1996/97	Observations
1	bare fallow	bare fallow	bare fallow	1 x year, tillage
2	Cassava	Maize	Cassava	+ chicken manure
3	Cassava	Cassava	Cassava	permanent cassava
4	Cassava	Maize/mulch	Cassava/residue mulch	continuous min. tillage
5	Cassava after fallow	Maize sole crop	Cassava after Maize	
6	Cassava	Maize	Cassava	+ vetiver barrier + chicken manure
7	Cassava	Maize	Cassava	+ continuous legume ** intercrop

* Maize is planted due to root diseases especially in those plots with previously undersown legumes.

** The legume to be tested will be *Chamaecrista rotundifolia*

1) If not otherwise specified all Cassava treatments receive 30 kg N, 26 kg P, 50 K
Maize receive 46-40-25 kg.ha^{-1} N, P, K as mineral fertilizer and chicken manure is applied at rates of 2 t/ha and cropping cycle.

Table 2. **Cropping sequences and treatments in the interprogram trial in Pescador, Cauca** [*)]

Treatment	1994/95	1995/96 *	1996/97	Observations
1	Cassava sole	Cassava sole	Cassava sole	Tillage [1)]
2	Cassava + legume mixture	Cassava [2)] legume mixture	Cassava + legume mixture	Legumes undersown
3	Cassava/maize/ beans	Cassava/maize beans	Cassava/maize beans	Intercropping
4	Bean sole	Bean sole	Bean sole	
5	Maize sole	Maize sole [2)]	Maize sole	
6	Bare fallow	Bare fallow	Bare fallow	Ploughed once a year

*) 5 t/ha of organic chicken manure is applied to all crops in the first two cycles and then levels will be determined according to soil analysis.

1) All plots ploughed with oxen

2) Reduced tillage starting from the second season onward (ploughing only the row to plant).

Equations relating intensity to kinetic energy of rainfall have been developed for various tropical regions including Zimbabwe (Hudson, 1965), northern Nigeria (Kowal and Kassam, 1976) and southern Nigeria (Lal, 1976).

For northern South America, the project is so far the only single source of information which should allow the researchers to develop equations to describe these relationships. First attempts to characterize rainfall erosivity in the Andean region of northern South America by project staff have based calculations exclusively on rainfall intensity, using the equation developed by Wischmeier & Smith (1958) to estimate the USLE R-factor. Although a preliminary evaluation of the soil loss predicting power of R gave promising results, correlations between the calculated R-factor and empirically determined soil loss were lower than those obtained in the USA where the USLE model was developed suggesting the need for an adaptation of the mathematical relationships based on direct measurements of the kinetic energy of rainfall in the region. According to Lal and Elliot (1994), the use of the USLE EI_{30} index can be used reliably only if the intensity-energy equations for the region are available. In its extension phase, the project will therefore develop such an intensity - energy equation for the northern South American Andes since adopting deliberately any index to estimate erosivity without evaluating this relationship can lead to grossly erroneous estimates of soil loss.

The direct measurement of rainfall erosivity involves the monitoring of splash and energy load of rain simultaneously.

4.2.1 Measurement of splash

The sand splash will be measured with sieved, chemically treated quartz sand of a standard size fraction maintained at a constant soil-water-potential and packed to a standard density in 89 mm diameter aluminum cups which are placed in the field within larger recipients to collect the sand displaced by rain drops. The procedure followed in the project had been established by Allison (1947) and was described for field research purposes by Lal and Elliot (1994).

For direct measurement of erosivity, quantitative sand splash data obtained from individual rainfall events are related to simultaneously monitored parameters of energy load, such as total amount of rainfall, rainfall intensity, total energy, median drop size, distribution of drop size and number of drops.

4.2.2 Median drop size, -number and -distribution

These parameters will be measured through impact assessment with a pressure transducer (Distrometer, Fa. Distromet Ltd., Basel, Schweiz) which has been purchased during the previous project phase. So far a limited and not yet representative number of test runs have been made at Quilichao. For these measurements the distrometer sensor head has to be placed in the field and connected to a Laptop computer (under roof nearby) equipped with appropriate software to translate rain drop impact into drop size, size distribution and drop number data. This information will then allow to calculate other parameters such as total energy. Measurements will be carried out during three consecutive rainy seasons.

4.2.3 Rainfall amount and intensity

Both parameters are being continuously monitored by self-registering rain gauges, according to Hellmann, Lambrecht Co. model 1509-20, Göttingen, Germany.

4.2.4 Data application

Data collected from the experimental site will be used to develop an intensity-energy equation for the watershed under study.

This will help researchers to characterize rainfall erosivity in the region. The Ph.D. student will search for rainfall intensity data for the region and the data will be processed to produce rainfall intensity (erosion risk tables)

Limited data are available in the CIAT-GIS unit and will allow researchers to produce a map of rainfall erosivity based on project's results.

4.2.5 Soil water status

A first attempt to monitor soil moisture in the context of precipitation, run-off, infiltration and water retention by soil conserving structures such as contour ridges or grass barriers has been made in the erosion plots at Santander de Quilichao and Mondomo by Ruppenthal (1995). However, data remained inconclusive since neutron probe measurements were influenced by high organic matter content of top soils and Fe and Mn minerals in sub-soils leading to obviously erroneous results. Therefore, water balance aspects need further attention. Also, monitoring the water conservation aspect of soil conservation practices is required to give a complete picture of different conservation practices. Infiltration rates and water runoff for example are affected by land use. In hillside regions with dry seasons this affects continuous supply of drinking water from wells and creeks and potential crop yield (Elwell, 1985; Troeh et al., 1991).

As a rule, implementation of soil conservation methods has a positive influence on soil water retention and will reduce runoff and downslope sedimentation of a watershed's drainage system (Pimentel et al., 1995). However, it is unknown which soil conservation strategy (contour ridges, grass barriers, legume cover, etc.) will be most advantageous. For better characterization of conservation practices, water status will be monitored in the erosion plots already established at Santander de Quilichao and Mondomo by measuring runoff, sediment load of runoff and infiltration rates routinely with the already existing experimental infrastructure. In addition, soil moisture retention will be measured with a TDR (Time-Domaine-Reflectometry) equipment which will be made available by the Institute of Plant Production in the Tropics and Subtropics of the University of Hohenheim. Measurements will be made three times during each rainy season (beginning, middle and end) and at the peak of each dry season in all cropping systems under study. Starting with the current year, the systems to be evaluated are bare fallow and crop rotation plots according to treatments already outlined in chapter 4.1 (Table 1).

TDR measurements will be located at specific sites within each plot as indicated below:

Treatments 1 through 5: in the centre of each plot

Treatment 6: in the centre of the plot, within the vetiver grass barrier, up-slope and down-slope between the grass barrier and the next two maize (cassava) rows, giving a total of 6 points in this treatment

Treatment 7: between maize (cassava) and legume rows in the centre of each plot.

Previous studies on root patterns and root growth dynamics in cassava with grass barriers and cassava with undersown legumes have shown that it will suffice to do measurements at the following depths only: 10 cm, 30 cm, 60 cm and 90 cm (Tscherning et al., 1995; Muhr et al., 1995a).

The soil moisture availability information will be complemented by measurements to estimate plant-water-status. This will be done both by measurement of stomatal conductance with a porometer and by direct transpiration measurements with a portable photosynthesis measurement equipment. The project itself will not be involved in these measurements which will be carried out by the cassava physiology section of CIAT. However, this complementary plant water status information will be extremely useful to assess the overall impact, different soil conservation systems have on soil moisture availability and plant water consumption. The information on incoming rain, runoff, sediment load of runoff, infiltration, soil moisture retention and plant water use will provide a fairly complete picture on a given cropping system's impact on water use and water losses.

4.3 Soil erosion and crop productivity

To determine the impact of soil erosion on crop productivity the following analysis and observations have been carried out from 1993 to 1995 on naturally eroded plots with a known erosion history and on artificially scalped plots:

- chemical soil analysis: organic matter, pH, total N, different fractions of P (organic P, inorganic P, Bray II), K, Ca, Mg, S, Al, Zn, Cu, Mn, B
- physical soil analysis: aggregate stability and size, bulk density, pore volume, texture, soil moisture characteristics
- plant measurements: phenological observations, yield, tissue analysis.

Relating these data to the soil losses occurred in the different treatments allows the researchers to determine how soil characteristics are influenced by erosion and how this affects crop productivity. Using multiple regression analysis, model equations will be designed during the extension phase of the project in order to describe the actual productivity status of the soil by a few key parameters and predict changes in productivity with progressing erosion.

These equations will be combined with the USLE in order to obtain a simple model that estimates erosion hazard and probable productivity loss with time and under selected management practices.

The results obtained with the model will be compared with outputs of other, more sophisticated simulation models like EPIC or PERFECT (Littleboy, M. et al., 1989), which were developed to estimate the long term effects of soil erosion on productivity. These models require a lot of data which often are not available and limit their application, but they provide a useful tool to validate the model equations.

The economic impact of soil erosion will be calculated using the method of Van Kooten et al., 1989. In this concept, the soil is considered as a non-renewable natural resource when calculating the marginal cost of utilization. Costs and benefits of soil degrading management practices are related to costs and benefits of more sustainable techniques. These calculations will be done on a short term and on a long term perspective.

The crop sequence under investigation has been sorghum, peanut and cassava. After harvesting cassava in June 1995, sorghum is repeated in order to assess the effects of 2 year intensive cropping and high fertilizer input (in the fertilizer treatment) on the restoration of productivity of the differently degraded treatments.

4.4 Further development of soil conservation technology

The project itself will phase out its present field research on soil conservation system components development but will actively assist CIAT's interprogram project to continue in this endeavor as well as take a guiding role in the applied technology development efforts by our partners CETEC, FIDAR and CVC.

The areas in which the project will assist these programs and institutions are:

- evaluation of low competing soil covers to widen the spectrum of options available for different environments. Special emphasis will be given to the better characterization of the most promising Chamaecrista germplasm in agronomical, morphological and physiological terms to identify useful traits and principles for selection of germplasm.

- further development of live barriers and hedgerows for soil conservation with emphasis on new conservation components to be developed on the basis of identified market opportunities and on sown-barriers using pearl millet, sorghum, upland rice or panicum. Some of these materials could also be tested as potential crops for rotation with cassava, leading to soil conserving minimum tillage systems.

- collaborative funds are also requested to assist the above mentioned institutions (CETEC, FIDAR, CVC) in their soil conservation technology development and adaptation activities at the local level.

4.5 Improving farmer adoption by linking market opportunities to conservation technology

During the current project phase the project has developed a working relationship with the Hillsides Program's agricultural economist. Besides the already ongoing farm level analysis of identified conservation components, the basic idea is to investigate whether adoption of soil conservation technologies can be induced by linking market opportunities to erosion control technologies.

Farm level literature on erosion control technologies in tropical countries is dominated by one theme: disappointing levels of adoption (Laing and Ashby, 1992, Kaimovitz, 1992). Given the farmer's circumstances, soil depletion, in many cases, is rational from the farmer's point of view (Ashby, 1985, Anderson and Thampapillai, 1990). At early stages of soil depletion the net returns without soil conservation exceed the net returns with conservation. Over time as soil degrades further, the gap declines, until eventually, net returns with conservation are higher than those without. Adoption is unlikely to occur until this point in time is reached, which one study calculates to be at least 40 to 60 years after degradation begins, depending on soil type, and the discount rate used (Seitz et al., 1979). Thus, there is a conflict between the farmer's economic logic and ecological considerations (Barbier, 1990).

These problems with adoption imply that farmers will have to be offered incentives to induce the timely adoption of soil conservation practices. Incentives have commonly taken the form of subsidies or regulations. The former are costly and in many cases induce distortions. The latter are difficult to enforce. The approach proposed here is to link identified income earning opportunities to soil conservation practices.

The idea is to increase the net returns to conservation, so that they exceed the net returns without conservation at an earlier point of time. In terms of Barbier's classification, the approach proposed here would increase the relative profitability of systems with low or moderate erodibility, thus providing more technological options that contribute to both income and erosion control. Adoption is expected to occur because of the opportunity to increase income, with soil conservation occurring as a byproduct. This approach derives support from the fact that in the few cases of successful adoption that have occurred, soil conservation practices permitted the introduction of high value crops, or supported the introduction of livestock, or was associated with value-added processes (Tiffen et al, 1993, Nimlos and Savage 1991).

Linking the market opportunity to conservation practices is, however, vital. The literature is replete with cases where income generating opportunities without links to conservation have exacerbated resource degradation (Thrupp, 1993).

Since its start in 1993, the project has aimed at the generation of economically attractive soil conservation components for small scale farmers in the Andean midaltitude hillsides, by selecting multi-use components such as forage grasses or legumes as soil conservation elements. However, an attempt to first identify market opportunities and then develop soil conservation technologies out of them, has not been made, so far.

Besides the economic analysis of conservation technology already developed in the project including technologies such as undersown forages in cassava, the following activities have been started in 1995 together with the CIAT Hillsides Program and the interprogram team and will be finalized during the extension phase of the project:

1. Market research and farmer interviews to identify market opportunities.

2. Evaluation of their potential for erosion control

3. Identification of appropriate production technologies

4. Preliminary evaluation of their viability through partial budget analysis

5. Evaluation of historical experience in the study area of institutional marketing arrangements.

6. Design and implementation of institutional arrangements for identified market opportunities with erosion control potential (to be carried out by the local consortium CIPASLA).

7. Ex-ante evaluation of adoptability using a farm household model that integrates biophysical and socioeconomic information with feedback for technology developers and policy makers.

8. Ex-post adoption study (to be carried out by the CIAT Hillside Program at a later point in time)

The farm household model will allow the researchers to compare the current farm situation with scenarios including new technologies and restrictions for soil losses as well as critical levels of income and needs for price subsidies.

Data from project trials will be used to quantify the resources required for the new technological options (labor, material inputs, management), as well as to quantify the impact on soil erosion.

Ongoing activities deal with the evaluation of technological options identified in advance of the investigation of market opportunities. In the extension phase, work will concentrate on technological options resulting from the identification of market opportunities. Collaboration from experienced project staff is required to translate market opportunities into conservation technology. First, prototype components will be established in the field and institutional arrangements for exploiting linked market opportunities will have started by the end of the current phase of the project. A preliminary assessment of adoption will, therefore, be possible within the duration of the extension phase. For execution of modelling activities and a possible adoption study in the extension phase a Masters student from a Colombian university is proposed.

An indicator that this output has been achieved is the availability of economic parameters and technical coefficients for farm level modelling of economic sustainability.

4.6 Data management

With increasing time of project duration, information collected from erosion plots is becoming more and more and more important for applications which go beyond the thesis work they had been collected for initially. Potential applications cover areas such as modeling exercises, model validation and monitoring of long-term trends etc. Looking at the data in this way can highly increase its value and offers new opportunities in developing strategies for sustainable soil resources management based on long-term datasets which seldom are available in the tropics.

4.6.1 Creation of a GIS mega database on project results

Application of accumulated project results to larger spatial units and for purposes mentioned above are only feasible, if the data are put in a transparent and user friendly format. Collaboration with CIAT's GIS unit is therefore proposed to generate a consistent database and to carry out a pilot application mapping areas in the watershed with similar characteristics to the plot level data.

During the extension phase of the project, the aim is to prepare a quality controlled, comprehensive database of the results obtained since 1987 of field plot experiments using the Universal Soil Loss Equation (USLE) in the Cauca region.

These data will then be used as input to a geographic information system (ESRI's ARC/INFO) which will be programmed to model soil erosion potential under different land use scenarios and slopes in the Rio Ovejas watershed, Cauca Department. Staff from the Cauca Department Government will be involved at CIAT in all steps of this process to make sure that the end product can be accessed by the local planning and political decision sector.

Specific work plan to generate erosion risk map

1. Existing erosion data from field plot experiments in the Cauca Valley that used the USLE will be subjected to extensive quality control as they have been collected by a variety of scientists over a long period. All data will be geocoded.

2. A common database will be designed to accommodate all the different data and data formats and the database will be loaded.

3. A land cover/land use map and digital terrain models of the region around the experimental sites will be prepared and values for slopes will be calculated.

4. These data will be incorporated into an existing geographic information system of the area along with more detailed data on precipitation.

5. Models will be run to calculate the soil erosion potential under inceptisols (all the experimental data were collected under inceptisols), different land uses and slopes (i.e. cassava-, bean-, maize-cropping systems, improved pasture and fallow systems, - with and without specific conservation technologies).

A GIS data base analyst-modeler with a M.Sc. in GIS is requested for a twelve month period to accomplish this project activity.

An indicator that this output has been achieved will be the availability of databases for applying crop production models, e.g., DSSAT compatible databases across the 100,000 ha Rio Ovejas watershed. The assumption is that data is available from outputs 1, 2 and 3, and on-going research undertaken by the Hillsides Program.

5.0 Training and dissemination of information

5.1 Training of Colombian and international scientists

Doctoral Thesis

- J.A. Castillo F.: Validation of indicators of management related changes in soil's resistance against water erosion with special emphasis on the influence of cropping and tillage on soil biology and soil physics.

- Mr. Castillo has been employed by the project since 1993 and has finished his M.Sc. degree on erodibility of Andean Inceptisols in October, 1994. Due to his outstanding performance during his M.Sc. research, he was selected to continue with doctoral degree research within the new "Soils and Water Management" Ph.D. program of the Universidad Nacional de Colombia.

M.Sc. thesis

- N.N.: Technology adoption: Linking market opportunities to conservation technology.

- The Tropical Lowland/Hillside Program economist, Dr. J. Smith, will name the candidate for this graduate research assistant position and supervise the thesis work.

Graduate thesis

- N.N. : Assessment of the potential of Citronella oil as an agent to control major bean pests in the Valle del Cauca Department.

Postgraduate course

- A postgraduate course entitled "Soil Degradation and Conservation in the Tropics" is offered annually by the University of Hohenheim, Stuttgart and a participation of one scientist/extensionist from collaborating institutions for 1996 and 1997 is planned and budgeted in the project.

5.2 Training of German scientists

Postdoctoral fellow

- Postdoctoral training of Dr. Karl Müller-Sämann is on-going. The long-term engagement by the German postdoctoral fellow will allow him to gain broad-based experience and collect and publish scientific data in resource management, specifically soil conservation research. This will enable him to seek an international scientist position, e.g., within the CGIAR system or pursue further academic qualifications with a German university (Habilitation).

Doctoral thesis

- Felicitas Flörchinger: Soil degradation-crop productivity relationships in Andean hillside farming. Field research is ongoing and will be finalized by the end of 1995. For data evaluation and comparative model calculations, an additional 12 MM is requested for the extension phase of the project, so that this thesis can be finalized well before the end of the project.

Doctoral thesis

- Christian Cloppmann: Rainfall erosivity and water balance studies in the Andean region of Northern South America. Candidate is presently employed on University of Hohenheim funds and doing literature research and methodology studies on his subject, based on preparatory work done by previous Colombian and German thesis students. Once the extension phase of the project is approved, field research can start immediately.

Diploma thesis

- Anna Haering: Residual effects of management practices on structural stability of Andean inceptisols with special reference to organic soil-binding substances. Field research for this thesis is being carried out during the current 1995 cropping season. Data evaluation and writing of thesis will be concluded in 1996. Ms. Haering is funded through Eiselen-Foundation.

5.3 Publications and workshops

A soil conservation manual and a regional workshop on soil conservation were planned for the current project phase (1995). However, the continuous flow of research results from the project's different initiatives as well as regional and international partners strongly suggest that these two activities be postponed into the extension phase of the project (1997). Also, whilst these two items were proposed in the initial project no budget line items were identified for these activities. Since both require special financial support, they will be included in the budget of the extension phase of the project. The manual will be provided both in English and Spanish.

6.0 Expected patentable research results

CIAT and the collaborating German institution, the Institute for Plant Production in the Tropics and Subtropics of the University of Hohenheim, Stuttgart, F.R.G., support and abide by the concept of complete access to research results.

All generated information and viable technologies achieved by the projects will be disseminated and made available to targets groups without restriction. In this kind of project, none of the expected outputs would be patentable.

7.0 Budget

General Remarks

The proposed extension of the project brings to an end more than ten years of field research on the causes of soil degradation and strategies for soil conservation in Andean cropping systems of southern Colombia. The scientific community working in this field agrees that only a sustained long-term research effort provides the basis for an in-depth analysis of problems and a sufficiently solid ground for the development of conservation strategies. It is only at the end of such a prolonged research endeavour that full advantage can be taken of the entire scope of scientific results and practical products such a program generates.

During the three years ahead of the program (including year 1995 belonging to the current project phase) an attempt is made to make the most comprehensive use of all scientific elements and products the project has been accumulating over the last years. This has resulted in the intense working program contained in the present extension proposal. Since many different lines of research have to be brought to a productive conclusion the cost of this extension proposal is higher than that of an average two-year research program. Special attention is, therefore, given to justifying individual budget components in detail to make sure that the scientific relevance and importance of each budget item is well understood by our donors.

The proposed budget for the two year extension phase is outlined in Table 3.

Table 3

Centro Internacional de Agricultura Tropical – CIAT

BMZE – Soil Degradation And Crop Productivity Research For Conservation Technology Development in Andean Hillside Farming

Proposed Budget (In US$ dollars)

LINE ITEM	Year 1	Year 2	Total
CIAT COMPONENT			
1.0 PERSONNEL			
Graduate Research Assistant (3 first year – 2 second year)	75,000	55,500	130,500
Field technician (1)	15,500	17,250	32,750
Field worker (3)	28,700	31,900	60,600
Bilingual Secretary (1/2)	9,600	10,700	20,300
Total personnel	128,800	115,350	244,150
2.0 TRAVEL			
National	4,500	5,000	9,500
International	3,000	5,000	8,000
Total travel	7,500	10,000	17,500
3.0 RESEARCH AND OPERATIONS			
Small equipment, supplies, consumables	12,000	8,000	20,000
Services : Laboratory analysis	12,000	10,000	22,000
Vehicle : Operation and maintenance	6,000	7,000	13,000
Total research and operations	30,000	25,000	55,000
4.0 TRAINING AND INTERINSTITUTIONAL COOPERATION			
Training graduate Research Assistant	2,500	2,500	5,000
Training Scientist Colombian institutions	5,000	5,500	10,500
Cooperative funds	9,600	7,200	16,800
Regional workshops	–	18,750	18,750
Soil conservation manual	1,000	5,000	6,000
Total training and interinstitutional cooperation	18,100	38,950	57,050
5.0 INDIRECT COSTS (0.20)	35,680	36,460	72,140
TOTAL CIAT COMPONENT	220,080	225,760	445,840
HOHENHEIM COMPONENT			
1.0 PERSONNEL			
Post – doctoral 24 MM	76,375	80,850	157,225
Pre – doctoral (Soil degrad. & Crop Product.) 12 MM	29,250	–	29,250
Pre – doctoral (Rainfall Erosivity) 24 MM	29,250	31,590	60,840
Total personnel	134,875	112,440	247,315
2.0 TRAVEL			
Post – doctoral + family	5,000	5,500	10,500
Pre – doctoral	3,000	1,500	4,500
Supervisor (ticket + sojourn)	4,800	5,000	9,800
Airfreight pre – and post – doctorals	2,500	4,000	6,500
Total travel	15,300	16,000	31,300
3.0 RESEARCH AND OPERATIONS			
Small equipment, supplies, consumables	3,500	3,500	7,000
Services : Literature, translations, publications, copies	3,500	5,000	8,500
Student helper	4,500	4,750	9,250
Total research and operations	11,500	13,250	24,750
TOTAL HOHENHEIM COMPONENT	161,675	141,690	303,365
GRAND TOTAL	381,755	367,450	749,205

Juan Garafulic

JUAN A. GARAFULIC
Financial Controller

7.1 Budget Rationale (CIAT component)

7.1.1 Personnel

7.1.1.1 Graduate research assistant (Ph.D. candidate, 24 MM)

This research assistant (J. Castillo) is already employed by the project. His research program started in 1995. He is doing research on management induced changes in soil susceptibility to erosion and on related soil biological indicators. Field work will be concluded in 1997 so that sufficient time is available for data evaluation and thesis writing at the end of the project.

7.1.1.2 Graduate research assistant (M.Sc. candidate, 24 MM)

This research assistant (N.N.) will be appointed by the Tropical Lowlands/Hillsides Program and will be employed by the project. He/she will do research on socio-economic ex-ante adaptability evaluation of conservation technology. The work will be based on biophysical data and cultivation practices provided by the project and identified market opportunities.

7.1.1.3 Graduate research assistant (12 MM)

This research assistant (N.N.) will be named by the CIAT GIS-unit and will be employed by the project to work as a GIS analyst in the construction and quality control of the project data base. He/she will geocode the data using a GPS-equipment and prepare the digital orto-photos, DTM's and slope maps as well as the land use/ cover maps of the watershed where the erosion data were taken by the project. He/she will further program a system to run the relevant models and present the results. This person needs an Master's degree in GIS with at least one year of experience to accomplish these tasks efficiently.

7.1.1.4 Field technician and labourers

The field technician and labourers are needed to continue to operate the long-term research plots at Santander de Quilichao and Mondomo until 1997. They assist the pre-doctoral fellows in their research on soil degradation/crop productivity, on rainfall erosivity and water conservation and on management-related changes of soil erodibility. This staff is also needed to support the transfer of knowledge on soil conservation technology to national institutions who will carry on with adaptive research. They will train and assist corresponding personnel of institutions and farmer's groups to plant barriers, establish legumes, construct soil collection ditches and other practical tasks.

7.1.1.5 Secretarial assistance

It has to be emphasized that a project with the size and complexity as it has existed for several years and is outlined in the present proposal cannot operate without secretarial assistance. A half-time secretary which has assisted the program over the last years is, therefore, necessary to continue to cover the correspondence, communications, material ordering and travel preparation support. Additional tasks for the extension phase of the project will be the typing of the soil conservation manual, assistance with the workshop organization and other administrative support. A full-time secretary has been shared with the cassava program in the past, an arrangement which should be continued so that the project only needs to cover 50% of the cost of secretarial services.

7.1.1.6 Annual increase in personnel cost

The budget shows an annual increase in personnel cost of 11% which is based on experience from the last two years. Steep raises in salaries on the one hand and an actual revaluation of the Colombian Peso against the US dollar has led to an annual increase in real terms of 12% in personnel costs over the last two years against 5% budgeted in the current project. Therefore, a percentage of cost increase more reflecting reality has been used in this budget.

7.1.2 Travel

7.1.2.1 Local travel

Local travel funds are needed to cover frequent travel to erosion plots in Quilichao and Mondomo, visits to inter-program trials in the Rio Ovejas watershed and contacts and activities with local partners. Also, the GIS modeler requires limited local travelling funds. Project staff will attend national meetings on soil erosion/crop management as needed.

7.1.2.2 International travel

International travel costs originate from contacts with partners in Ecuador and Brazil and from participation of project staff in regular meetings on soil conservation. For the supervisor of the GIS-activity, Dr. William Bell, one trip from CIAT to Hohenheim is needed to link this part of the project with the Hohenheim-based GIS group.

7.1.3 Research and operations

7.1.3.1 Small equipment, supplies, consumables

These funds are needed for maintenance of the erosion/run-off plots in Quilichao and Mondomo and for the purchase of seeds, fertilizers and pesticides. Also, the cost and maintenance of small equipment and field operations has to be covered with these funds. The acquisition and scanning of aerial photos is also included in this line item.

7.1.3.2 Laboratory analysis

Approximately half of the funds will be used to continue soil analyses on the long-term erosion plots in Quilichao and Mondomo where soil samples from bare plots, crop plots and sediment will be routinely taken until 1997. Also, the sampling of research plots in the Rio Ovejas watershed is envisaged in the context of testing the applicability of soil stability indicators to larger areas in the region. A total of 480 samples for 1996 and 400 samples for 1997 at an individual sample cost of US $25 is envisaged for the extension phase of the project.

7.1.3.3 Vehicle operation and maintenance

The project has two vehicles for which operation and maintenance cost has to be covered. The amount requested includes gasoline and lubricants, tires, car repairs and short-term renting of additional cars from the CIAT motor-pool when one of the project cars is in the workshop.

7.1.4 Training and interinstitutional co-operation

7.1.4.1 Degree Training of Colombian Scientists

Costs related to the Ph.D. and M.Sc. degree studies of the graduate research assistants and graduate students will be covered by the project according to CIAT standards, which requires modest funding during the extension phase.

7.1.4.2 Scientists from collaborating institutions

Scientists and/or Extensionists from collaborating institutions will be given the opportunity to participate in the Hohenheim short course on "Soil Degradation and Conservation in the Tropics" for which funds to cover travel,subsistence, as well as teaching materials and literature are requested.

7.1.4.3 Co-operative Funds

These funds will be used to support collaborating institutions such as CETEC, FIDAR and CVC to carry out on-farm research and demonstration activities and thus disseminate the project technology throughout the region and transfer results to farming communities.

7.1.4.4 Regional workshop

The workshop on SOIL CONSERVATION which will be offered by the project at CIAT during 1997 will cover the costs of 25 participants from Latin America with an estimated need of US $500 per participant to cover travel costs and US $250 to cover the cost of a 5-day-stay at CIAT (room and board) giving a total of US $750 per participant.

7.1.4.5 Soil conservation manual

The soil conservation manual will be produced during 1996/97. Preparatory work will be done in the first year of the extension phase whereas the final production and printing of the manual will be done in 1997 for which funds in the amount of US $1,000 and US $5,000, respectively are requested. A version will be made available in Spanish for use by NARS and NGO extensionists.

7.2 Budget rationale (University of Hohenheim component)

7.2.1 Personnel

7.2.1.1 Postdoctoral fellow (Dr. Karl Mathias Müller-Sämann)

The *Postdoctoral Fellow* is required to assume responsibilities for overall co-ordination of the project on site, to ensure continuity on the long-term research plots at Quilichao and Mondomo and to liaise effectively among participating programs within CIAT and between the project and local institutions. The postdoctoral fellow earns a standard BAT IIa salary.

7.2.1.2 Predoctoral fellow (Ms. Felicitas Floerchinger)

The *Predoctoral Fellow*, Ms. Felicitas Flörchinger, who is presently advancing field research on the relationships between soil degradation and crop productivity will require the year 1995 to finalize her field research. An additional 12 MM is requested in the extension phase to cover the period of data evaluation, model development/calibration and thesis writing.

7.2.1.3 Predoctoral fellow (Mr. Christian Kloppmann)

The predoctoral fellow has been working on this project since January 1995, being supported by the University of Hohenheim funds. His research on rainfall erosivity and water conservation is to be continued and finalized during the extension phase of the project. Financial support is requested for 1996 and 1997 covering 24 MM which will allow him to finalize field research, evaluate data and write his thesis.

7.2.2 Travel

7.2.2.1 Postdoctoral and family

Budgeted funds cover one trip of the postdoctoral fellow and family from Germany to Colombia in 1996 and one trip back from Colombia to Germany in 1998.

7.2.2.2 Predoctoral fellows

There will be one trip back from Colombia to Germany (F. Floerchinger) and one trip from Germany to Colombia (C. Kloppmann) in 1996. In late 1997 or early 1998 there will be one trip back from Colombia to Germany (C. Kloppmann).

7.2.2.3 Supervisor Travel

A project of this size and complexity is only manageable if regular interdisciplinary consultations between all partners concerned are carried out.One single supervisory trip for the scientist with overall responsibility for the project during the whole extension phase of the project would thus be totally inadequate. Over the last three years, the responsible scientist has been carrying out 2-3 supervising trips to Colombia per year, responding in this way to the co-ordinating, contact and supervisory needs of this project. Most of these trips were paid for by other than project funds.

It is envisaged that during 1996 and 1997 at least two supervisory trips per year will be necessary to provide the project with the necessary guidance, scientific supervision and co-ordinating support. It is again anticipated that one trip per year can be financed by other sources. Therefore, funds for only one trip per year are requested in the proposed budget.

7.2.3 Research and operations

7.2.3.1 Small equipment, supplies, consumables

This includes small items necessary for field and laboratory research not available in Colombia such as splash cups, extension cable for distrometer, pluviograph registration paper, special reagents and chemicals necessary for laboratory analyses and repair or replacement of existing field and laboratory equipment.

7.2.3.2 Literature, translations, publications etc.

This line item covers the purchase of expensive literature and software related to erosion research and modelling, occasional translations from Spanish documents into English (Colombian graduate thesis, publications originally written in Spanish etc.). The publication costs of scientific articles and editions of scientific texts appearing in the Hohenheim Tropical Agricultural Series. Copies and tele-communication is also covered under this line item.

7.2.3.3 Student helper

The *Student Helper* is requested for logistic and operational support of the project at the University of Hohenheim. Funds for his employment are requested for five months at a rate of 83 h per month. The student helper is employed to support the project with current information on new literature and he will assist in data analysis and report preparation.

8.0 References

Allison, W.D. 1947. Soil erosion studies. Part II. Soil detachment hazard by rain drop splash. Agricultural engineering 28: 197-201.

American Society of Agricultural Engineers (ASEA) 1985. Erosion and Soil Productivity. Proceedings of the National Symposium on Erosion and Soil Productivity. ASAE Publ. No. 8-85, St. Joseph, Mich., 1985. 287 pp.

Anderson, J. R. and Thampapillai, J. 1990. Soil conservation in developing countries: project and policy intervention. Policy and Research Series 8. The World Bank, Washington D.C.

Ashby, J.A. 1985. The social ecology of soil erosion in a Colombian farming system. Rural Sociology, 50 (3):377-396.

Baldock, J. A.; Kay, B.D. and Schnitzer, M. 1987. Influence of cropping treatments on the monosaccharide content of the hydrolysates of a soil and its aggregate fractions. Can.J.Soil Sci. 67:489-499.

Barbier, E.B. 1990. The farm-level economics of soil conservation: the uplands of Java. Land Economics 66(2):199-211.

Bronzoni, G. and Villalobos, F. 1989. Cambios en el uso de la tierra y su relación con los fenómenos erosivos: Análisis técnico de un caso en tierra blanca de Cartago. Investigación Agrícola (San Jose, Costa Rica 3(2): 19-29.

Burgos, A. 1987. El manejo inadecuado de la ganadería como factor de erosión en los suelos de ladera. Suelos Ecuatoriales XVIII (2): 257-260.

Carcamo, J.A. Alwang, J., and Norton, G.W. 1994. On-site economic evaluation of soil conservation practices in Honduras, Agricultural Economics, 11:257-269.

Castillo, J.A. 1994. Determinación del índice de erodabilidad (K) en dos suelos del departamento del Cauca, Colombia. Universidad Nacional de Colombia, Palmira. Posgrado suelos y Aguas. Thesis M.Sc., 206 p.

Castillo F., J.A., A. González M. and K.M. Müller-Sämann, 1995. Determinación del índice de erodabilidad (K) en dos suelos del Departamento del Cauca, Colombia. Suelos Ecuatoriales (paper accepted).

Centro Internacional de Agricultura Tropical (CIAT). 1992. Annual Report for 1991. Cassava Program.

Centro Internacional de Agricultura Tropical (CIAT). 1993. Annual Report for 1992. Cassava Program.

Centro Internacional de Agricultura Tropical (CIAT). 1995. Annual Report for 1994. Cassava Program. In press.

Elwell, H.A. 1985. Zimbabwe Science News 19:27; cited in Pimentel et al. 1995

FAO, 1982. Potential population supporting capacitites of lands in the developing world. Report FPA/INT/513, FAO, Rome, Italy.

Flörchinger, F. and K.M. Müller-Sämann, 1995. Efecto de la remoción del horizonte superficial (erosión simulada) en la productividad del suelo. Suelos Ecuatoriales (paper accepted)

Gómez A., A. 1988. La zona andina Colombiana, erosión y conservación de suelos. Suelos Ecuatoriales XVIII (2) : 27-39.

Haynes, R.J. and Francis G.S. 1994. Influence of crop species on microbial biomass and soil aggregation. Transactions 15th world congress of soil science. Volume 4B. Acapulco, Mexico, July 1994.

Haynes, R.J. and Swift, R.S. 1990. Stability of soil aggregates in relation to organic constituents and soil water content. J. of Soil Science 41:73-83.

Hudson, N. 1991. A study of the reasons for success or failure of soil conservation projects. FAO Soils Bulletin No.64. 65p.

Hudson, N.W. 1965. The influence of rainfall on the mechanics of soil erosion with particular reference to northern Rhodesia. M. Sc. thesis. University of Capetown, Capetown, South Africa.

Imeson, A.C. and Vis, M. 1982. Factors influencing the erodibility of soils in natural and semi-natural ecosystems at different altitudes in the Central Cordillera of Colombia. Z. fuer Geomorphologie, Supplementband. No. 44: 91-105.

Kaimovitz, D. 1992. La experiencia de Centro America y la Republica Dominicana con proyectos de inversión que buscan sostenibilidad en las laderas. Documento para el seminario sobre agricultura sostenible en America Latina del BID y IICA. Washington DC, 9-10 Septiembre.

Kowal, J.M. and A.H. Kassam. 1976. Energy and instantaneous intensity of rainstorms at Samaru, northern Nigeria. Tropical Agriculture 53: 185-198.

Lal, R. and W. Elliot. 1994. Erodibility and erosivity. In: Soil erosion research methods. 2nd Edition. R. Lal, Ed. Soil and Water Conservation Society and St. Lucie Press, Angkeny, IA and Delray Beach, FL, USA. 340 p.

Laing, D.L. and Ashby, J.A. 1992. Adoption of natural resource management practices by resource-poor farmers. In Zobisch, M.A. (ed). Acceptance of soil and water conservation strategies and technologies. DITSL, Witzenhausen.

Langdale, G.W. and W.D. Shrader, 1982. Soil erosion effects on soil productivity of cultivated cropland. In: Determinants of Soil Loss Tolerance. Am. Soc. of Agron., Madison, ASA Publication No.45:41-51.

Littleboy, M., Silburn, D.M., Freebairn, D.M., Woodruff, D.R. and Hammer, G.L., 1989. Perfect. Productivity erosion runoff functions to evaluate conservation techniques. Queensland Government 1989, 1993. Department of Primary Industries, Brisbane. 119 pp.

Muhr, L., D.E. Leihner, T.H. Hilger, and K. M. Müller-Sämann. 1995a. Intercropping of cassava with herbaceous legumes. I. Rooting patterns and their potential importance for below ground competition. Angew. Bot. 69, in press.

Muhr, L., D.E. Leihner, T.H. Hilger and K. M. Müller-Sämann. 1995b. Intercropping of cassava with herbaceous legumes. II. Yields as effected by below ground competition. Angew. Bot. 69, in press.

Müller-Sämann, K.M., M. Ruppenthal and J.A. Castillo F. 1994. Conservación de suelos en yuca. In: Memorias de la Primera Reunión de Agricultura Sostenible en San Gil (Santander, Colombia). CIAT/ CORPOICA, Cali, Documento de Trabajo No. 135:195-226.

Nimlos, T. and Savage, R.F. 1991. Successful conservation in the equatorial highlands. Journal of Soil and Water Conservation, 46(5):341-343.

Oldeman, L.R.; Hakkeling, R.T.A.; Sombroek, Wim G. 1990. World map of the status of human-induced soil degradation: an explanatory note. Wageningen, The Netherlands: United Nations Environment Program; International Soil Reference and Information Center, 1990. 27p. ilus. En.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Christ, L. Shpritz, L. Fitton, R. Saffouri and R. Blair. 1995. Environmental and economic cost of soil erosion and conservation benefits. Science 267:1117-1123.

Rasiah, V. and B.T. Kay 1994. Characterizing changes in aggregate stability subsequent to introduction of forages. Soil Sci. Soc. Am. J. 58:935-942.

Reining, L. 1992. Erosion in Andean Hillside Farming. Hohenheim Tropical Agricultural Series. Nr. 1. Ed. Dietrich E. Leihner. Josef Margraf Scientific Books. Weikersheim, Germany. 219 p.

Ruppenthal, M., 1994. Soil erosion and crop productivity in conventional and forage-legume based cassava cropping systems in the south Colombian Andes. Doctoral thesis. 96.

Ruppenthal, M. 1995. Soil Conservation in Andean Cropping Systems. Hohenheim Tropical Agricultural Series. Nr. 3. Ed. Dietrich E. Leihner. Josef Margraf Scientific Books. Weikersheim, Germany. 125p.

Seitz, W.D., Taylor, C.R., Spitze, R.G.F., Osteen, C. and Nelson, M.C. 1979. Economic impacts of soil erosion control. Land Economics, 55(1):28-42.

Singh, I., Squire, L. and Strauss, J. (eds). 1986. Agricultural Household Models: Extensions, Applications and Policy. Johns Hopkins University Press, Baltimore. The World Bank.

Statistisches Bundesamt. 1988. Statistik des Auslandes - Laenderbericht Kolumbien.1988. Wiesbaden. 83 p.

Thrupp, L.A. 1992. Challenges in Latin America's Recent Agroexport Boom. Development. WRI, New York.

Tiffen, M., Mortimore, M. and Gichuki, F. 1993. More People, Less Erosion: Environmental Recovery in Kenya.John Wiley & Sons Ltd, Chichester.

Tisdall, J.M. and Oades, J.M. 1982. Organic matter and water stable aggregates in soils. J. Soil Sci. 33:141-163.

Troeh, F.R., J.A. Hobbs and R.L. Donahue 1991. Soil and Water Conservation. Prentice Hall, Eaglewood Cliff.

Tscherning, K., D.E. Leihner, T.H. Hilger, K. M. Müller-Sämann and M. El Sharkawy. 1995. Grass barriers in cassava hillside cultivation - Rooting patterns and root growth dynamics. Field Crops Research (accepted for publication).

United States Department of Agriculture(USDA). 1983. EPIC - Erosion/Productivity Impact Calculator. 1. Model Documentation. Agricultural Research Service. Technical Bulletin No. 1768. Washington D.C.

Van Kooten, G.C., Weisensel, W.P. and De Jong, E., 1989. Estimating the costs of soil erosion in Saskatchewan. Canadian Journal of Agricultural Economics, 37: 63-75.

Vuuren, W.E. van. 1982. Prediction of sediment yield for mountainous basins in Colombia, South America. IAHS - Publication No. 137: 313-325.

Wischmeier, W.H., and Smith, D.D. 1958. Rainfall energy and its relationship to soil loss. Transactions, American Geophysical Union 39: 285-291.

Wischmeier, W.H. and Smith, D.D. 1978. Predicting rainfall erosion losses - a guide to conservation planning. U.S. Department of Agriculture, Agriculture Handbook No. 537. Washington D.C.

Appendix A

Project Implementation Schedule of Activities by Quarter

Activities	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
IMPROVED PREDICTABILITY OF SOIL EROSION								
finalize research on rainfall factor								
validate indicators for modifiable soil erodibility								
mega-data-base and model develop								
IMPROVED KNOWLEDGE OF IMPACT OF SOIL DEGRADATION ON CROP PRODUCTIVITY								
evaluation of field data and model calculation								
economic cost appraisal								
study aspects of water conservation								
SOIL CONSERVATION TECHNOLOGY DEVELOPED AND TESTED								
measure effects of conservation on crop production								
economic evaluation of technology options								
ex ante validation of technology adoption linking conservation components to market opportunities								
collaborate with national institutions & farmer groups for technology testing & development								
INFORMATION MADE AVAILABLE AND SCIENTISTS TRAINED								
elaborate a consolidated data base on project results								
publish CIAT manual on soil conservation								
offer regional workshop on soil conservation								
publish technical articles								
supervise thesis work								
PROJECT MANAGEMENT								
revise project design based on donor suggestions and finalize contract with donor								
prepare and submit progress reports								
participate in end of project evaluation								
submit end of project report to donor agency								

C E T E C
Corporación para Estudios
Interdisciplinarios y Asesoría Técnica

APPENDIX B:

Confirmation Partner Letters

Cali, Junio 21 de 1995

Doctor
Robert Havener
Director General
Ciat - Palmira

Durante 4 años (1991 - 1995) La Corporación para Estudios Interdisciplinarios y Asesoría Técnica - CETEC - ha mantenido una estrecha colaboración con el proyecto de conservación de suelos en yuca, dirigido por el Doctor Karl Muller Samán y en este lapso hemos desarrollado algunos ensayos de campo en técnicas de control de erosión para suelos de ladera, en 2 veredas de la zona de intervención de CETEC en el norte del Cauca (San Antonio, Cascajero).

Esta colaboración nos ha permitido mejorar sustancialmente las propuestas técnicas que la institución ha implementado con los agricultores que participan en los proyectos y al mismo tiempo se han disminuido los efectos erosivos en las parcelas de los productores.

Sería muy importante para CETEC seguir contando con la colaboración del proyecto de conservación de suelos en yuca, para adelantar nuevos ensayos que permitan mejorar cada día las propuestas que la institución impulsa en las comunidades del Norte del Cauca.

Cordialmente,

MA Eugenia Morales

MARIA EUGENIA MORALES
Coordinadora Administrativa
C E T E C

Calle 4B No. 38-35 Teléfonos: 557 70 18 - 558 24 87 FAX: 556 04 96 A.A. 26279 Cali - Colombia

CVC CORPORACION AUTONOMA REGIONAL DEL VALLE DEL CAUCA

Santiago de Cali, junio 9 de 1995
ST.EN.BS.1518

16 JUN. 1995

Doctor
ROBERT HAVENER
Director General
CIAT
Palmira.

Apreciado doctor:

Conocedores de la importancia de los resultados obtenidos en el desarrollo del Convenio CIAT-FIDAR-CVC durante tres (3) años, en el manejo y conservación de suelos de ladera para el cultivo de yuca en las veredas de Pescador, El Pital, La Balsa, en el departamento del Cauca, en donde se realizaron trabajos de transferencia de tecnología a la comunidad en aspectos agronómicos y culturales de este cultivo, tendientes a disminuir la erosión causada por la escorrentía como consecuencia del mal manejo de suelos. De otra parte la ley 99 de 1994, reestructuró las corporaciones del pais, ésto conllevó a la salida de la CVC del departamento del Cauca.

Por lo anterior creo necesario el prolongar este convenio para operar en el área jurisdiccional actual de la CVC.

Atentamente,

HERNAN RAUL LARA A.
Subdirector Técnico

Copia a: Doctor Karl Muller Samann, Proyecto Conservación de Suelos Yuca.

Doctora María Elvira Vega A., División Estudios y Normas

Fidar
Fundación para la investigación y el desarrollo agrícola
Personería Jurídica No. 1410 del 11 de Dic. de 1989 NIT: 8000963972

Santiago de Cali, mayo 30 de 1995 C-068-95

Doctor
Robert Havener
Director General
Centro Internacional de Agricultura Tropical

Estimado señor Havener.

La Fundación para la Investigación y el Desarrollo Agrícola - FIDAR, es una institución privada sin ánimo de lucro cuyo propósito principal es el trabajo con pequeños productores agrícolas; con el fin de contribuir a mejorar su calidad de vida.
Sus principales líneas de acción se encuentran orientadas hacia los siguientes aspectos:

- Investigación, validación y transferencia de tecnologías para apoyar el establecimiento de sistemas agrícolas sostenibles.

- Capacitación y fomento de agroindustria rural con grupos comunitarios (especialmente jóvenes y mujeres) con el fin de mejorar el ingreso familiar.

- Actividades educativas dirigidas a fomentar procesos de organización comunitaria.

Desde hace más de cuatro años nuestra institución ha recibido apoyo y capacitación de diferentes programas de CIAT, los cuales nos han servido para fortalecer y consolidar los conocimientos técnicos de nuestros funcionarios y de poder ofrecer a los agricultores con los cuales trabajamos, germoplasma de buena calidad de fríjol, yuca y gramíneas forrajeras.

Calle 1B No. 60-12 Tel: 520514 FAX: 57-23-520514 A.A. 25687 Cali-Colombia.

Fidar
Fundación para la investigación y el desarrollo agrícola
Pesonería Jurídica No. 1410 del 11 de Dic. de 1989 NIT: 8000963972

Consideramos importante también, mencionar que FIDAR en colaboración con el Programa de Conservación de Suelos Yuca de CIAT en asocio con la GTZ de Alemania y la Corporación Autónoma Regional del Valle del Cauca (CVC) hemos mantenido un convenio por espacio de tres años con el fin lograr mejores resultados de trabajo en equipo, especialmente en lo referente a la adopción de prácticas de conservación de suelos por parte de los agricultores.

Para FIDAR sería de mucho provecho seguir contando con la colaboración y asesoría del proyecto de Conservación de Suelos Yuca por un período de tiempo mayor, con el fin de darle continuidad a las actividades mencionadas y disponer de información más precisa sobre las investigaciones de coberturas vegetales de leguminosas, y manejo de labranza mínima de suelos de ladera.

Quedamos muy agradecidos por la atención que se sirva prestar a nuestra solicitud.

Cordialmente,

José Restrepo M.
Coordinador de Investigación y Capacitación
FIDAR

NUEVA DIRECCION: CRA 41 No.5C-116 TELEFAX.553 64 89 A.A. 25687 CALI COLOMBIA.

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