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Project title

Methods of economic and environmental assessment of the on-site impacts of soil erosion and conservation - a case study of smallholder agriculture in Sri Lanka

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NRSP Production System

Hillsides & Socio-economic Methodologies

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Executive Summary

Hillsides are extremely vulnerable to soil erosion. Many projects have sought to address this degradation through soil conservation measures that have conspicuously failed or have been ignored by local people. This research project has sought to develop methods of economic and environmental assessment of the on-site impacts of erosion and conservation that will ensure that the costs of erosion are adequately assessed, and the benefits of conservation are fully calculated - both from the particular perspective of farmers.

Based on a detailed investigation with poor households in the hill lands of Sri Lanka (Malulla Village, Hanguranketha District), field biophysical techniques of erosion were developed which are easy to apply by local professionals. Techniques included assessment of erosion rates from field indicators such as soil pedestals, tree root exposures and armour layers, and of conservation by reductions in erosion and volumes of soils retained by structures. With farmers, in-field yield assessments were made to support with- and without-conservation scenarios. After testing alternative forms of economic assessment, an 'investment appraisal' technique was developed, which best reflects the impact on household livelihood. The appropriateness of this form of economic analysis to the understanding of how poor households make investment decisions in conservation technologies was tested using the common practice of *Gliricidia* contour hedgerows. It was possible to distinguish between which physical field circumstances and which households this conservation measure would be appropriate for promotion. This prediction largely corresponds to actual uptake of the technology. The research has also tested and validated these biophysical and farmer-perspective assessment techniques with groups of local professionals. Both with the primary target institution in Sri Lanka (the Mahaweli Authority) along with staff in 5 other institutions, and with staff of 15 institutions co-operating in a DFID-funded programme in Bolivia, training courses were conducted. Participant evaluations were used to refine the techniques.

This project contributes to DFID's development goals by providing a set of generic tools for the assessment of erosion and conservation that have particular application to vulnerable hillside environments and the poor and marginal households that normally occupy these sites. For the first time, we have a validated set of techniques which successfully integrate a large number of biophysical variables and economic costs and benefits that determine the impact of erosion and the likelihood of uptake by farmers of specific conservation techniques. Local professionals involved with the project (11 in Sri Lanka; 22 in Bolivia) with little previous experience in these methods were able to apply the techniques and gain a much-enhanced understanding of the biophysical and economic factors at field and household level. If applied more widely, these techniques have significant potential in human resource development of developing country staff in working with poor rural households in degraded environments. Further development and application of these techniques, as well as wider dissemination is indicated.

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Background

Hillside production systems

Hillside production systems are extremely vulnerable to soil erosion and land degradation. Soil fertility becomes depleted quickly, and the capacity of the land to support hillside agro-ecosystems is substantially reduced. These biophysical processes have significant implications for the sustainability of hillside production systems and for the poor, marginal households which populate these areas. Such hillsides in many parts of the world (e.g. Rif Mountains in Morocco; highland Mexico; upland Java) have been the sources of large populations that have migrated in search of better living in urban areas. Yet, hillside environments can, where appropriate land use techniques are applied, be used sustainably and productively. In Sri Lanka, the Kandy home gardens are renowned for their multi-storey cropping and intensive production, sustained over many centuries. Searching for appropriate measures, and matching the characteristics of households with the performance of conservation techniques in supporting those same households, is a major challenge which, prior to this project, has been largely unresolved except by *ad hoc* guesswork by experienced natural resource managers.

The ingredients for sustainable production on hillsides are location-specific and dependent on complex socio-economic criteria. Smallholder farmers cultivate hillsides. They are mainly dependent on household labour for agricultural production; they often lack security in land tenure; have limited access to the factors of production, land, labour and capital; undertake multiple income-generating activities; their land use activities are carried out for a variety of purposes and with an extraordinarily large range of techniques and management styles. These complex circumstances need to be taken into account. Alongside these, the biophysical circumstances are also difficult, rendering land use activities vulnerable to short-term declines in production. With a declining natural resource base, farmers have to undertake other activities that either further undermine resources or put pressures on the economy elsewhere.

Previous work in Sri Lanka and demand for a project

In the particular context of Sri Lanka, aid projects in the hill lands have been contributory to some of the problems of smallholder farmers. The construction in the 1970s of major reservoirs, including the Victoria Dam financed by the United Kingdom, for the provision of irrigation water to the Mahaweli Scheme and for hydro-electric power, displaced many farmers and attracted many others for the economic opportunities offered by these investments. A massive expansion of cultivation, much of it illegal, occurred in the hill lands and catchments to the reservoirs. The evidence of erosion was abundant. The Principal Investigator of R6525 worked first for FAO in Sri Lanka in the early 1980s and then for the DFID Forlump (Forest and Land Use Mapping Project, predecessor to ENDEV) project, based in Kandy. A review of erosion research in Sri Lanka and many in-field assessments of land use in relation to degradation revealed that erosion rates are not only very high in the hill lands but have been exacerbated by changes in land use, not only cultivation but also forestry. For this reason, the Mahaweli Authority of Sri Lanka (in effect, the regional development agency with the status of a Ministry in the GoSL) instituted the Environment and Forest Conservation Division in order to address conservation. This research project was originally proposed by EFCD's Director, Dr Herath Manthritilake, who hosted R6525's Research Associate during her tenure of an APOS award for the ENDEV project.

Study area in Sri Lanka

The main institutional collaborator for the project, the MASL/EFCD, suggested a suitable study area site, where hillside production systems were typical of much of the hill lands and where there had been no substantial past project interventions.

The field-based part of the project was in the village of Malulla (80º48'E 7º12'S), near Hanguranketha in the Central Province. The area is defined as part of the Intermediate agro-ecological zone of Sri Lanka, typical of much steep-slope marginal rainfed farming undertaken in the country. It is at an elevation of 750 metres above sea level and receives a mean annual rainfall of 900 mm (minimum 75% expectancy value), most of which falls between October and January. Traditionally, hill land was used to produce crops such as sesame and millet under a system of shifting cultivation. This ceased when the Ceylon Tobacco Company introduced tobacco cultivation to the area, though the local tobacco depot has since closed and tobacco cultivation is less common than previously. For the last decade, farmers have concentrated on cultivating the hill land with vegetables, such as carrots, Japanese radish, pole beans, kohlrabi, and cabbages, for one growing season a year. Some bush fallowing is practised, but in the better, less eroded and more protected, pockets of soils, cultivation is continuous from season to season.

Hill land under vegetable cultivation is privately owned and cultivated by the owner or by a tenant. Leases run for a period of one growing season, with rent paid in cash. The land is cultivated entirely by hand, with little or no addition of organic matter and intensive use of agrochemicals. Crops are produced using household, exchange and hired labour and are sold to merchants who transport the vegetables to markets in urban areas. Some households also cultivate paddy land, producing one crop of rice and one crop of vegetables a year. Other sources of household income included produce from home gardens, work as hired farm labour, builders or carpenters. Few households keep livestock.

Soils in the area are red yellow podzols, which have low natural fertility. These are not inherently erodible but have a tendency to cap and become compacted, resulting in high rates of overland flow. The land is steeply sloping. Cultivation is practised on slopes of up to 70%, although the more productive and better-protected fields are typically on slopes of 40 to 60%. Different soil conservation technologies have been adopted in response to adapted practice (local knowledge) and previous soil and water conservation campaigns. Most owner-cultivators employ permanent conservation technologies such as lock and spill drains, stone walls, *Gliricidia* contour hedgerows and *Vetiver* grass strips. On rented land, if permanent conservation technologies are not present, tenant farmers construct graded drains.

The case study area was ideal for the project, in that there was a range of technologies available for research monitoring, and a community of land users that allowed ready access to the site and who participated freely. One of the two growing seasons in the project monitoring suffered considerable drought. This limited the availability of some land users, since they had to seek work elsewhere. However, the drought was useful for the research in revealing those conservation technologies that provided best for plant-available water and production in a difficult year.

Training Workshop background information

Two training workshops were planned as part of the project in which local professional participants would test, validate and suggest modifications to the tools and techniques developed by the project. In this sub-section, their field location and situation are described.

Training Workshop held in Sri Lanka

The workshop was held at the at the TREE (Training, Research, Education, Extension) Centre of the Sri Lankan Wildlife Trust. The Centre is located in the Victoria-Randenigala-Rantembe Wildlife Sanctuary, close to the Randenigala Dam. The field site was located nearby in Kirthibandarapura (80º55'E 7º9'S), which is in the administrative district of Hanguranketha, in the Central Province and Intermediate agro-ecological zone of Sri Lanka. The characteristics of the field site are similar to those of Malulla. Typical slopes that are cultivated range from 40 to 70% and soils are red-yellow podzols.

The main distinguishing feature of the site where field training was undertaken was the crops grown. Cultivation of tobacco was still being undertaken in Kirthibandarapura. This was accompanied by the production of low input vegetable crops, such as bitter gourd, aubergine, beans, chilli and cassava.

The fieldwork was accompanied by heavy rainfall, which enabled participants to see the erosion processes. The majority of participants had never before been in the field in the rain, and great excitement ensued. This, along with good co-operation from local people, made the Training Workshop effective and very well evaluated by participants – see later under Activities.

Training Workshop held in Bolivia

The workshop was held at Toralapa Experiment Station (65°40'W 17°31'S) in the Transition Zone in Tiraque Province, Cochabamba Department, Bolivia. It is at an altitude of over 3430 masl and receives mean annual precipitation of 530 mm (Toralapa Experiment Station), most falling from December to March. Frost can completely destroy the crops, which are also subject to considerable damage from hail. The land under cultivation is steeply sloping (up to 85 %) and is moderately to very stony. Erodible Andosols predominate and this erodibility, combined with the rapid down-cutting of local rivers, explains the widespread occurrence of gullies and sheet erosion. Some farmers control erosion rates within fields to some extent by contour cultivation and the construction of stone boundary bunds.

The most important crop produced in the area is potatoes, either irrigated or rainfed, cultivated in rotation with *faba* beans, barley and oats (for forage) and fallow. The majority of land is cultivated by households that are owner-occupiers and is ploughed using oxen. Cattle manure, artificial fertilisers and pesticides are applied only to potatoes and not to other crops in the rotation. Crop production is undertaken using household, hired labour and reciprocal labour. Produce is used for household consumption and sold at local markets. Most households keep livestock, including oxen, cows, sheep, pigs and chickens. Agricultural production is insufficient to fulfil the consumption requirements of many households and as a result individuals travel to Santa Cruz, Chapare and cities in Argentina to earn additional income.

Participants were able to walk from the Station to the field site. The closeness had the advantage of enabling maximum time to be spent in the field, but the disadvantage that the area was already very well visited by other projects. 'Project fatigue' meant that participation by local people was disappointing. The biophysical techniques that depended only on keen observation were very well received, but the techniques (especially those deriving financial information) needing interaction with farmers were not so successful.

Project design and timing

This project was designed to develop methods for the economic analysis of erosion and conservation in the context of the household. This would be achieved broadly through:

- a case study involving participatory appraisal of hillside production systems;
- analysis of major biophysical effects of erosion and conservation;
- modelling of the interactions of erosion and conservation with the household;
- and comparative assessment of different approaches for the economic analysis of erosion and conservation.

Each stage of the analysis was planned to be widely disseminated within the immediate target community of farmers, with staff of the target institution and to policy-makers and researchers more widely through talks, presentations, publications, posters and other media. In-country training of local professionals as a means of both validating and disseminating the

biophysical and economic methods developed by the project was to be a strong feature. At the request of the then DFID/SRI management of the Hillsides component of NRSP, the findings were also to be validated in another focus country (Bolivia) – see Project Logical Framework.

The project commenced on 1st April 1996. Contracted activities (but not all dissemination outputs) were completed within the three years to 31st March 1999. The former NRSP managers approved a 2-month extension to 31st May 1999 to enable dissemination of project findings in Sri Lanka.

Project Purpose

The project's purpose was to support two outputs (one in each production system – Hillsides and SEM) in the former RNRRS/NRSP. These outputs were (1) the development of cost-effective methods of needs assessment that can be used to identify development opportunities and problems and (2) the packaging and promotion of economically viable land, soil and water management techniques. (Socio-Economic Methodologies Output 1 & Hillsides Output 1). The identified development constraint was the inability of local professionals adequately to assess the costs of erosion and the benefits of conservation, and hence their lack of capacity to promote technologies that would provide benefits to farmers and to target these to particular groups of people.

Specifically, therefore, methods of economic and environmental assessment of erosion and conservation technologies that can be used in the field by developing country professionals were to be evaluated and validated for their appropriateness to smallholder farming situations. This purpose was in support of the RNNRS goals of employing socio-economic methodologies, applicable across all RNR systems, to improve the effectiveness of RNR research and to facilitate the control of soil erosion.

Project Outputs

The project had four principal Outputs, plus a fifth specified as "dissemination of the findings" – see Project Logical Framework (page 16). This last Output is verified by the reports of the project, training workshop reports, journal papers, conference papers and posters – see Appendix 2.

Output 1: Systems analysis framework for examining soil erosion and conservation in the context of the household:

A preliminary systems analysis framework was developed that examined interactions of soil erosion and conservation with smallholder farming households. In the form of cobweb diagrams, this provided visualisations of inter-linkages between different aspects of smallholder households (see Appendix 2F report [Appendix V, third page] for an example from the project's Bolivian training workshop). The diagrams presented possible impacts of erosion and conservation on households and resultant knock-on effects within the household, with their ultimate effects on the well-being of members of the household. The preliminary framework was employed to investigate these impacts for smallholder households in the project's study area.

Use of the systems analysis framework was incorporated into the training workshops held in Sri Lanka and Bolivia. The participants found the themes of the framework to be useful prompts in semi-structured interviews with farmers. Through this they identified some interactions of erosion and conservation with households, but the scope for doing this was limited. It became apparent that use of the framework was reliant on the investigator pursuing the necessary issues during interviews with farmers. It was concluded that the systems analysis framework was useful as a tool for raising awareness about potential interactions, but not for identifying the interactions in the field.

In response to the findings of the training workshops, the use of qualitative analysis techniques was explored. The techniques were employed to examine interactions of erosion and conservation with smallholder households in the study area in Sri Lanka. Compared with prior investigations based on the systems analysis framework, the qualitative techniques readily yielded rich data on interactions of erosion and conservation with households. The techniques prompted farmers to identify and discuss the opportunities and constraints for adoption of different soil conservation technologies and impacts of the technologies on the household. Because analysis was performed by the farmer, the scope and ease of identifying interactions was increased. Although field professionals have not tested the qualitative techniques, the experience of the project suggests that they should provide useful tools for examining soil erosion and conservation in the context of smallholder farming households. Details of this work will be presented in a forthcoming paper, to be submitted for publication by December 2000.

Systems analysis was also undertaken through a published review of methodologies for economic analysis of soil erosion and conservation (Appendix 2A). This presented different valuation approaches that have been used for the biophysical variables that change with erosion and conservation. These approaches were assessed in terms of how far they represent the smallholder farmer's perspective. The systems analysis framework made an initial estimate as to the type of evaluation analysis that might best capture the investment decisions of these farmers. The published framework was the first time that a clear distinction was drawn between "resource-value" approaches (i.e. valuation of the depletion of nutrients and/or other measures of soil quality by erosion), "production-value" approaches (i.e. loss in yield with erosion, or gain through conservation), or "livelihoods-value" (i.e. contribution to household livelihoods). Full results of this comparison of valuation approaches are being prepared for publication, but have been delayed until the project's RA has completed a PhD thesis (expected December 2000).

Output 1 has not, therefore, been fully realised in the sense that was originally envisaged. A systems analysis framework that combines the components of erosion and conservation with those of the household, using diagrammatic techniques, achieved the purpose of sensitising local professionals to the issues involved. The participant evaluations of the two Training Workshops, supported by actual practice during the Workshop field exercises, revealed that qualitative analytical techniques were more useful for field use. Assembling the results of these field techniques into a systems framework for choosing the most appropriate valuation approach was more successful. Conceptually and methodologically, the project has made a major advance, enabling assessors to choose which approach (resource-value, production-value, or livelihoods-value) would best serve local needs.

Output 2: Guide to data sources for rapid assessment of the biophysical impacts of erosion and conservation:

The major biophysical effects of erosion and conservation were assessed in the study area in Sri Lanka. This was carried out using secondary data, a physical model and novel field techniques. The two Training Workshops included these techniques of rapid assessment.

The publication at Appendix 2E contains a preliminary guide to data sources for rapid field assessment listing (on p.196) the observation and field measurement of a number of aspects, including erosion, sedimentation, physical performance of conservation technologies, biological performance and effect on production, and longer term effects on soil quality. Appendix 2B is an example of the application of the field techniques to a situation in Bolivia.

During the course of the project it was, however, realised from the evaluations of local professional participants that any 'guide' would need to be much more practical as well as systematic. Local professionals often do not perceive the level of detail required to make the necessary rapid assessments, and they also need tested and validated worksheets upon which to record the information. These findings parallel the experience of another much larger project (*People, Land Management and Environmental Change – PLEC* funded by the Global Environment Facility, Washington DC, and executed by the United Nations University, Tokyo, with field sites in Papua New Guinea, Thailand, China, Kenya, Uganda, Tanzania, Ghana, Guinea, Peru, Brazil, Mexico and Jamaica, and over 200 collaborating scientists) in which the present PI is Scientific Co-ordinator. To develop the materials needed to achieve this Output in a form effective enough for our in-country collaborators was outside the scope and budget of R6525.

The PI applied to UNEP in March 2000 for funds to support a six month project (June-December 2000) to produce a *Guidelines for the Field Assessment of Land Degradation* that would meet the needs of both PLEC and the Output 2 of R6525. The scope of the *Guidelines* includes the identification of indicators of biophysical change consequent upon land use, the measurement of these indicators, and the combining of the results with a household livelihood perspective. Participatory techniques are described in detail, and the results are put into a DFID-style Capital Assets Framework. Through trust funds provided by the Government of Norway through UNEP, this additional project produced a draft *Guidelines* in 60 copies of 120 pages by September 2000. These copies are out for review to leading practitioners and academics (including the Chairman of NRSP/PAC).

The draft *Guidelines* contain at Chapter 4, 14 techniques to measure indicators of soil loss – including rills, gullies, pedestals, armour layer, plant/tree root exposure, tree mounds, build up against barriers, enrichment ratios etc. At Chapter 5, it describes 4 techniques to assess impacts on production – such as crop yield monitoring, crop growth characteristics and nutrient deficiencies. At the time of writing this FTR, reviews of the draft have been received from ICIMOD (Nepal), Free University (Amsterdam), a Peruvian University, IBSRAM (Bangkok), University of Bern and about 5 others.

The next revision will be concluded by 9 October and will be posted on the UNU web-site at **http://www.unu.edu/env/plec** by the end of October 2000. Funding will be sought from NRSP for an additional 6 weeks of Research Associate time to get this substantial publication into a final form and disseminated to DFID collaborators. Earthscan Publications has given initial interest in publishing a paper copy of the *Guidelines*.

This Output 2 has, therefore, not been realised in the way originally envisaged, as a result of experiences during this project and in another related project. The uptake pathway for this Output has, however, been very substantially widened to an exceptionally large number of developing country institutions and international agencies through the PLEC network. The contribution of DFID/NRSP is, of course, prominently acknowledged in the drafts produced so far and the version to be posted on the UNU web-site.

Output 3: Comparative assessment of different approaches for economic analysis of soil erosion and conservation

A number of different approaches have been used for the valuation of soil erosion (and the benefits of soil conservation). The project examined the replacement cost approach, the impact on returns to crop production, the impact on fallowing, contingent valuation and a novel approach described as the impact on livelihood. Comparison was made between these approaches in terms of (1) the principles on which they are based and (2) the effects of these on the cost of erosion and financial viability of conservation technologies. The latter was undertaken by using each valuation approach to undertake financial analysis of two conservation technologies (graded drains and stone walls) employed in the study area in Sri Lanka. The analyses employed field data (including biophysical impacts of erosion and conservation) collected by the project.

Results of the financial appraisals were assessed against the practices actually employed by farmers in the study area. Where possible, adaptations were made to the valuation approaches to ensure that they represented the situation for the smallholder farmers. The impact on livelihood was found to best reflect conservation decisions made by farmers in the study area. This was also employed to assess the viability of other conservation technologies employed by some farmers in the study area (lock and spill drains, *Gliricidia* hedgerows, *Vetiver* grass strips).

The Working Paper at Appendix 2A is a review of methodologies for economic analysis. The papers at Appendices 2C and 2D describe the various economic valuation approaches, comparing their benefits in the context of soil erosion and conservation assessment (OVI 3.1 in the Project Logframe). The OVIs 3.2 and 3.3 have been undertaken through the Training Workshop reports (e.g. Appendix 2F). However, further dissemination is warranted and details of this work are planned for presentation in a forthcoming paper, to be submitted for publication by December 2000.

Output 3 has been accomplished and specific recommendations have been made for the most appropriate approach for economic analysis of soil erosion and conservation – a financial investment appraisal approach assessing impact on livelihoods.

Output 4: The findings of the project tested and evaluated in another environment

The findings of the project, which focused on methodological issues, were: (a) techniques for examining soil erosion and conservation in the context of the household (b) techniques for rapid field assessment of the biophysical impacts of erosion and conservation (c) approaches for the investment appraisal of soil erosion and conservation from the perspective of smallholder households. These findings were based on a case study in Sri Lanka. They were then extended to another hill land site in Sri Lanka and to another DFID/NRSP focus country, Bolivia via training workshops with local professionals.

Training workshops held in Sri Lanka and Bolivia were used to test findings (a) and (b). The findings were tested and evaluated based on the following criteria: extent to which the techniques were transferred to field officers through an intensive training workshop; ease of use of the techniques by field officers; usefulness of the data collected using the techniques, as perceived by the field officers. Evaluations of the workshops by the participants and the co-ordinators indicated that the techniques developed for biophysical assessment (finding (b)) largely fulfilled these criteria. The systems analysis framework developed under finding (a) had shortfalls, discussed under Output 1 (see above). Testing of the qualitative methods developed in response to this was not possible within the time frame and budget of the project. Although the workshops provided training in investment appraisal, insufficient data were collected during the workshops to enable testing of finding (c). In the Bolivian case, the researchers remained in the field area with local collaborators that had been involved in the Training Workshop. The objective was to gain the needed data – the publication at Appendix 2B is one example of the achievement of OVI 4.

Output 4 has been satisfactorily achieved in the way originally intended.

Research Activities

Activities (1) to (5) below were the contracted research activities for R6525. All were addressed and delivered during the course of the project.

(1) Modelling of the interactions of erosion and conservation with the activities and resources of smallholder farmer households and identification of the opportunities and constraints within the household that act to promote or reduce soil erosion rates.

Preliminary models were developed in the UK based on data from earlier fieldwork conducted in Sri Lanka and from relevant information in the literature. Although this fieldwork was in another part of the hill lands, it indicated key criteria that affect decision-making by resource-poor households in their land use activities. The models were constructed using flowcharts. They addressed the interactions of erosion and conservation with the activities and resources of the household and identified the opportunities and constraints within the household that act to promote or reduce soil erosion rates. The preliminary models were validated and modified using data collected through the participatory appraisal of hillside production systems in the field area in Hanguranketha. The final output of this phase of the research was a system analysis framework for examining soil erosion and conservation in the context of smallholder farmer households. The framework was enacted for use in the field through the drawing of 'cobweb diagrams' to enable participants (both local professionals and land users) to appreciate the linkages and interactions.

The field work was carried out in the village of Mallula, in the Hanguranketha District, Sri Lanka, which is an area that had already been identified by the Mahaweli Authority as being of particular interest for this study. Programmes of soil conservation had been attempted, and the local communities were attempting to adapt to a declining resource base, either by changing crops (e.g. to tobacco which is particularly hazardous for erosion) or investing in technologies such as *Gliricidia* contour hedgerows. The land is mostly used to cultivate vegetables; it is steeply sloping and a number of different soil conservation technologies are employed with a range of standards of construction and maintenance. The conservation

technologies include: contour drains, lock and spill drains, stone terraces, terraces with scraped earth risers, and single and double row *Gliricidia* contour hedges. Several different schemes promoting and subsidising the construction and maintenance of soil conservation technologies have operated in the area in the past.

Preliminary fieldwork had also already been carried out in the immediate study area and some of the data required had been collected from a sample of twenty farmers. This showed the feasibility of the participatory approach adopted. The project collected data from all farmers in Malulla Village. Discussions were held with individuals and with groups of farmers in order to collect data on erosion, conservation, and their interactions with the household and farming system. Individuals assisted with information and data collection on their own plot, while community groups provided the opportunity for focus groups discussions. The information collected included: estimates of erosion rates, estimates of nutrient depletion, the impact of erosion on crop yields, the effects of adopting different conservation technologies and the inputs required to construct and maintain them, farmers' perceptions of soil erosion and of different conservation technologies and the factors limiting their adoption. Also of importance was information on the multiple livelihood roles played by conservation technologies, including such aspects as provision of additional fodder, growth of beanpoles, places to put weeds and firewood. These items of information were documented, organised and fitted into the systems framework; they feature in the unpublished reports and published output of the project.

(2) Assessment of the major biophysical effects of erosion and conservation using field and secondary data and physical models.

A review was carried out of secondary data sources and physical models and data to be extracted on the biophysical effects of erosion and different conservation technologies in the field area. This built on the previous experience of the FAO and DFID-funded projects in the hill lands, and aided the refinement of the techniques for potential use by developing country field staff and professionals. Field data were particularly collected on the biophysical effects of erosion and conservation in the field area. This included farmers' assessments of yield differences in their fields (i.e. between eroded and non-eroded parts of the field, and between sites with and without conservation), simple measures of nutrient depletion and of reduction in topsoil thickness. The final output of this phase was a review of the sources of data on the biophysical effects of erosion and conservation and also the data required in order to carry out the economic analysis of erosion and conservation in the field area.

(3) Comparative assessment, for the purposes of economic analysis, of the different approaches for valuing the on-site effects of erosion and conservation.

This was carried out from a practitioner's perspective and the preliminary assessment drew widely on the literature. A review of methodologies for the economic analysis was undertaken and published as a widely-circulated Working Paper of the ESRC Centre for Social and Economic Research on the Global Environment. Comments on the analysis were obtained from several sources, including leading environmental economists in the UK and international institutions. The review concluded that the primary problem with economic analysis was not necessarily the specific analytical techniques adopted (though these do give widely differing results), but the lack of good quality data on the impacts of erosion and conservation. To be good and appropriate, the data should ideally present the information from a farmer's perspective and represent the circumstances of resource-poor households. The different approaches were demonstrated by carrying out economic analysis of erosion and conservation using data for the field area. Modifications were made to the approaches

where necessary. The full analysis included a critique of the strengths and weaknesses, especially of 'replacement cost' (which uses primarily the value of the nutrients depleted, in terms of how much it would cost to replace these artificially) and 'production value' (loss in yield and additional farming costs) approaches. A new 'investment appraisal' approach was developed which centres primarily on the impact of erosion and conservation on household livelihoods. A simplified technique of this approach has been published, which uses as a key criterion the number of years above the poverty line for a poor household engaging either in conservation or no conservation. This last approach would seem to have particular application in the new DFID agenda of Sustainable Rural Livelihoods for the poor.

(4) Application of the findings of the project in another Hillsides System focus country.
After negotiation with the Hillsides Production System Leader at SRI, it was decided that this research activity should be accomplished in Bolivia in conjunction with Proyecto LADERAS, based at the University of San Simon, Cochabamba. Two specific activities were planned: (1) a Workshop on the Biohysical and Economic Assessment of Erosion and Conservation, held 23-28 November 1998 at the PROINPA Research Station, Torolapa; (2) a detailed study of the common practice of stone walls in comparison with piling stones in mid-field. These two activities enabled the findings of the project to be tested and evaluated in a situation with different social and environmental conditions to those in the field area in Sri Lanka.

The Training Workshop had 22 participants from 15 different institutions. The PI and RA were assisted by an experienced South American researcher, Guadalupe Duron. Most of the working materials were provided in Spanish and a full Workshop report and volume of documentation is available. In addition to gathering data on stone walls, two other working groups examined irrigated potatoes compared with rainfed potatoes, and irrigated barley and oats. Participants evaluated the methods and the Whole Workshop. Most found the techniques easy to understand and to apply. Several commented on the benefits and new insights obtained from rapid field estimations - for most this was entirely new. Being technical specialists often with decades of actual field experience, some participants were clearly happier giving their opinions to farmers than learning from farmers. This conceptual barrier will have to be explicitly tackled in future projects.

The detailed study on stonewalls (more exactly, boundary stone bunds) showed how existing practices employed by farmers provide a potentially valuable source of information for the introduction of soil and water conservation measures. The farmer-oriented approach adopted enabled a god understanding of farmers' objectives to 'habilitate' the land for crop production purposes, ease of ploughing and implementation of furrow irrigation. Boundary bunds, although better at reducing erosion rates than mid-field piles of stones, are however rejected by some farmers because of the labour involved and the loss of cropped area. Significant differences in farmer circumstance could be related to decisions by farmers on whether to build boundary bunds or pile stones in the field.

(5) Dissemination of the findings of the project.
The project has adopted an active dissemination policy with many papers, posters, talks at meetings and conferences, and published output – see Publications and Dissemination Listing. In Sri Lanka, a local language (Sinhala) booklet was produced with many photographs for the local people who had co-operated with the research.. This served the dual purpose of validating findings about the farming practices and disseminating the research findings to the community. In Bolivia, a Spanish version of the training manual and

workshop report was produced for all participants and local institutions. Project findings have also been disseminated widely in talks, meetings, conferences, poster papers, reports and journal papers. DFID has used illustrative material from this project for two annual reports and an information pack for NRSP printed in 1998.

Type of Publication	Count
Journal Papers – refereed	3
Published monographs & working papers	1
Book chapters – refereed	1
Workshop Reports (including one in Spanish)	2
Written versions of oral papers	6
Oral presentations	5
Poster papers	3
Published photographs from project in other media	5
Vernacular publication – in Sinhala	1

A final output is currently in hand to develop the field biophysical techniques into a comprehensive document that will have truly generic application – see further details above under Output 2

Contribution of Outputs

The outputs of the project have largely been achieved. Some of the tangible outputs have inevitably been delayed because only well into the project was it perceived that that they deserved greater attention. Biophysical techniques and socio-economic methodologies for the assessment of soil erosion and conservation have been developed, tested, validated and applied to two target countries – Sri Lanka and Bolivia. The systems analysis framework - now largely involving qualitative analysis - enables developing country professionals to grasp the complexity and diversity of variables involved as well as the need to access a farmer's perspective. Data sources are now clearly indicated, including most importantly data that can be collected easily by local professionals themselves. From our collaborators and the evaluations of our two training workshops, we have been told that the range of techniques developed enable field staff to "see" erosion and conservation in a new, more farmer-perspective way. Difficulties remain, not least in the somewhat conventional and stereotypical view of many field professionals, which prevent more immediate uptake by all staff. Nevertheless, the outputs form part of the process of change that has become very evident in Sri Lanka especially. The project has received enthusiastic support from its principal target institution (Mahaweli Authority of Sri Lanka). The Director of its Environment and Forest Conservation Division, as well as many staff, have played an active role, including testing out techniques, co-authoring papers, evaluating results, providing logistical support and attending meetings. DFID bilaterally-supported projects have also been involved, and SEADD (Bangkok) provided additional funds for the Sri Lankan workshop. A brief follow-up in Sri Lanka in August 1999 revealed that other institutions, notably the Tea Research Institute, have applied some of the project's techniques in its own work. Findings have been disseminated to Bolivia as an integral part of the project. Although the involvement in Bolivia was relatively short, it gave rise to many requests (alas unfulfilled

because of funding constraints) for more training and application to other areas and institutions.

The findings are, however, of generic application and wider significance for research and development in natural resource management, giving for the first time a set of co-ordinated and integrated biophysical and economic techniques applicable at the field level. These techniques contribute to the RNRRS (and its 1998 successor RNRKS, and, from November 1999, DFID's strategy for renewable natural resources) goal by providing tools for the more accurate and farmer-relevant assessment of the impact of erosion and the potential benefits of soil conservation measures. There has also been evidence that the wider international community has seen value in the methods developed by this project. After an oral presentation by the PI at the Second International Land Degradation Conference (attendance funded by the United Nations University), approaches were made by USAID and UNEP to develop the techniques further and disseminate them in a formal *Guideline* publication. UNEP gave written approval for a project proposal for 6 months assistance to be funded, using field data and photographs from this project in Sri Lanka and Bolivia, as well as field sites of other projects. A proposal is also in process of submission to the Global Environment Facility to integrate these field techniques into policy development in Ghana, The Gambia and Guinea – this will lead to what the GEF call a PDF-A, and a full project in 2001 of up to US$750,000, if approved.

The key lessons to arise from this project are:

- Biophysical assessment techniques for rapid assessments of erosion are widely applicable in hillside environments to assess rates of erosion, change in soil quality and effects on yields.
- Field biophysical assessment techniques can assess a range of important erosion and productivity change processes, including rainsplash, depletion of topsoils, reduction in soil depth, exposure of roots, enrichment of sediments, and in-field sedimentation.
- "Investment appraisal" is a useful and accessible means of assessing the economic viability of a conservation technology as an investment by the farmer. It manages to bring together the variables that are of greatest importance to the land user, especially labour costs and yield impacts.
- Training of field staff is necessary in order for them to become familiar with the techniques and overcome scepticism that they are too "quick-and-dirty".
- The approach has engaged a number of stakeholders (including farmers, field staff and local professionals) and shows that participatory approaches develop techniques, which are better at capturing a farmer-perspective.
- The approach is flexible and potentially applicable to other soil and land resource management issues.

Project Logical Framework

METHODS OF ECONOMIC AND ENVIRONMENTAL ASSESSMENT OF THE ON-SITE EFFECTS OF SOIL EROSION AND CONSERVATION - A CASE STUDY OF SMALLHOLDER AGRICULTURE IN SRI LANKA

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
GOAL			
Employ socio-economic methodologies, applicable across all RNR systems, to improve the effectiveness of RNR research and facilitate the control of soil erosion and deforestation processes. (SEM & HS Purposes)	By 2005 implementation of two or more new methods by client institutions in the NARS of at least six priority countries. A new method validated and applied in 50% of RNRRS programmes by 2005. (SEM Log Framework) Improved land use/land management practices implemented by 2000 in target areas. By 2000 in target areas: - soil erosion reduced by 25%, - rate of deforestation reduced by 25%, - biomass off take increased by 10%. (HS Log Framework)	RNRRS programme manager's reports. Reports of target institutions. Evaluation of NRSP. (SEM Log Frame) National production statistics. Reports of target institutions. Research programme reports. Evaluation of NRSP. Monitoring against base line data. (HS Log Framework)	Research results taken up through uptake pathways. Enabling environment (policies, institutions, markets, incentives) for widespread adoption of new technologies exist. (SEM Log Framework) Enabling environment (policies, institutions, markets, incentives) for widespread adoption of new technologies and strategies exists. Climatic conditions are favourable. (HS Log Framework)
PURPOSE			
The development of cost-effective methods of needs assessment that can be used to identify development opportunities and problems and enable the packaging and promotion of economically viable land, soil and water management techniques. (SEM Output 1 & HS Output 1)	At least one refereed publication by 2000. At least one methodology validated by 2000. (SEM Log Framework) Field testing of techniques demonstrates capacity to reduce erosion by half. 76% of precipitation infiltrates soil or is otherwise effectively retained. Field capacity of soil maintained for at least 50% of the year. (HS Log Framework)	Annual research reports of programmes. Annual reports on promotion of research products and their impact. (SEM Log Framework) Research programme reports. (HS Log Framework)	Target institutions integrate new socio-economic methods into research programmes. Practical and affordable methods developed. New methods effectively disseminated to research programme managers. (SEM Log Framework) Target institutions invest in the uptake and application of research technology. (HS Log Framework)
OUTPUTS			
(1) A systems analysis framework for examining soil erosion and conservation in the context of the household. (2) Guide to data sources from which information can be obtained rapidly on the biophysical effects of erosion and conservation.	(1.1) Preliminary models of the interactions of erosion and conservation with smallholder households completed by June 1996. (1.2) Collection of field data completed by February 1997. (1.3) Modifications to household models completed by August 1997. (2.1) Assessment of the major biophysical effects of erosion and conservation using secondary data sources and physical models completed by May 1998. (2.2) Assessment using field data completed by February 1997.	(1) Research project reports. (2) Research project reports.	Collaborating institutions and farmers participate in the research activities. Politically stable environment for carrying out fieldwork.

(3) Comparative assessment of different approaches for the economic analysis of soil erosion and conservation, to include recommendations of measures that may be adopted in order to incorporate the perspective of smallholder farmers. (4) The findings of the project tested and evaluated in another environment. (5) Dissemination of the findings of the project.	(3.1) Comparative assessment of the different approaches for valuing the on-site effects of erosion and conservation completed by December 1997. (3.2) Demonstration of the different approaches completed by December 1997 (3.3) Development of recommendations completed by June 1998. (4) Application of the findings of the project in another Hillsides System focus country completed by January 1999 (5.1) Distribution of reports to appropriate agencies completed by March 1999. At least two papers submitted to refereed journals and one paper submitted for presentation at an international conference by March 1999. (5.2) Project workshop held in Sri Lanka by November 1998.	(3) Research project reports. (4) Research project reports and one refereed paper. (5.1) Research project reports. At least two refereed publications and work presented at an international conference. (5.2) Research project reports.	

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
ACTIVITIES			
(1.1) Preliminary models developed of the interactions of erosion and conservation with the activities and resources of smallholder households. Constructed in flow diagram format based on data from preliminary field work and relevant literature. (1.2) Collection of field data through the participatory appraisal of hillside production systems in the field area. (1.3) Validation and modification of preliminary models using field data. (2.1) Review of secondary data sources and physical models and extraction of data on the biophysical effects of soil erosion and different conservation technologies in the field area. (2.2) Field data collection on the biophysical effects of erosion and conservation in the field area using simple visual and measurement techniques (3.1) Review and comparison of the different approaches for valuing the on-site effects of erosion and conservation, drawing widely on the literature. (3.2) Demonstration of the different approaches by carrying out economic analysis of erosion and conservation using data from the field area. (3.3) Recommendations made of measures that may be adopted in order to incorporate the perspective of smallholder farmers into economic analysis. (4) Application of the findings of the project in another Hillsides System focus country. (5.1) Distribution of reports and published output to appropriate agencies eg: ODI. IIED, national EPAs and presentation at an international conference. (5.2) Project workshop held in Sri Lanka.	Total Project Budget: Staff costs £ 64,148 Overheads £ 38,489 Equipment £ 2,529 Overseas travel £ 20,322 Miscellaneous £ 2,718 Total costs £128,206	(1.1) Research project reports. (1.2) Research project reports. (1.3) Research project reports. (2.1) Research project reports. (2.2) Research project reports. (3.1) Research project reports. (3.2) Research project reports. (3.3) Research project reports. (4)Research project reports. (5.1) Research project reports. (5.2) Research project reports.	Collaborating institutions and farmers participate in the research activities. Politically stable environment for carrying out field work.

Publications

A. Published or Accepted for Publication

Clark, R. 1996. Methodologies for the Economic Analysis of Soil Erosion and Conservation. *Working Paper GEC 96-13*. Norwich, UK: Centre for Social and Economic Research on the Global Environment

Clark, R. 2000 (forthcoming). A policy-oriented assessment of valuation approaches for the on-site impacts of soil erosion and conservation. *Paper accepted for publication in Ecological Economics* (revision in progress)

Clark, R., Durón, G, Quispe, G. and Stocking, M. 1999. Boundary bunds or piles of stones? Using farmers' practices in Bolivia to aid soil conservation. *Mountain Research and Development* 19(3): 235-240

Clark, R., Manthrithilake, H., White, R. and Stocking, M. 1998. Economic valuation of soil erosion and conservation - a case study of Perawella, Sri Lanka, pp 879-888. In: H.-P. Blume *et al* (eds) *Towards Sustainable Development - Furthering Cooperation between People and Institutions*. Selected papers of the Ninth Conference of the International Soil Conservation Organisation, Bonn, August 1996. Advances in Geoecology 31, Resiskirchen, Germany: Catena Verlag.

Stocking, M. and Clark, R. 1999. Soil productivity and erosion: biophysical and farmer-perspective assessment for hillslopes. *Mountain Research and Development* 19(3): 191-202

B. Internal Reports and Working Papers:

Copies may be obtained from the Principal Investigator, Professor Michael Stocking, ODG, UEA, Norwich NR4 7TJ, United Kingdom (m.stocking@uea.ac.uk; fax +44 1603 505262)

Clark, R. 1997. *High land farming and soil conservation in Malulla, Nuwara Eliya District, Sri Lanka.* Norwich, UK: University of East Anglia (language: Sinhala) [unpublished report]. This was distributed to farmers involved in the project's case study. The report served two purposes: (1) validation of data collected from farmers - draft copies of the report were distributed to key informants and their feedback incorporated into the final copy; (2) the report provided a mechanism for "handing back" the research to the farmers.

Clark, R. & Stocking, M. 1996 *Project R6525: Economic and Environmental Assessment of Soil Erosion and Conservation*. Paper presented at the Hillsides Systems Workshop, Silsoe Research Institute, 15th October 1996. Norwich, UK: University of East Anglia [unpublished]

Clark, R, Durón, G and Stocking, M. 1998. *Evaluación biofísica y económica de la erosión y conservación del suelo, Biophysical and economic assessment of soil erosion and conservation, Evaluation workshop: Bolivia 23-27 November 1998, Workshop Report and Documents.* Norwich, UK: University of East Anglia (language: Spanish and English) [unpublished report]

Clark, R. & Stocking, M. 1998. *A policy-oriented assessment of valuation approaches for the on-site impacts of soil erosion and conservation.* Paper presented at the Fifth Biennial Meeting of the International Society for Ecological Economics Santiago, Chile, 15-19 November 1998. Norwich, UK: University of East Anglia [unpublished].

Stocking, M. and Clark, R 1997. *Economic and biophysical assessment of soil erosion and conservation. Training Workshop: Sri Lanka 24-28 November 1997. Workshhop Report and documents.* Norwich, UK: University of East Anglia [unpublished report]

Stocking, M. and Clark, R. 1997. *The biophysical assessment of soil conservation technologies: the case of Gliricidia contour hedgerows in the Hill Country of Sri Lanka.* Paper presented at the Hillsides Workshop, Silsoe Research Institute, Silsoe Bedfordshire 16-17 December 1997. Norwich, UK: University of East Anglia [unpublished]

Stocking, M. and Murnaghan, N. 2000. ***Guidelines for the Field Assessment of Land Degradation.*** Working Paper (draft of UNU web-site paper and book to be published by Earthscan). Norwich, UK: University of East Anglia, in co-operation with Tokyo: United Nations University. 120pp

C. Other Dissemination of Project Outputs:

Clark, R. 1998 Economics of soil erosion. Oral presentation at the Natural Resources Systems Programme Workshop on socio-economic methodologies for natural resources research. DFID, London. 24 February 1998.

Clark, R. 1999. *Economic assessment of soil erosion and conservation.* Oral presentation to DFID Natural Resource Advisors attending "The Economics of Development" short course at the University of East Anglia, Norwich, 29 July, 1999.

Clark, R., Duron, G., Quispe, G. & Stocking, M. 1999. *Boundary walls and piles of stones- A case study of farming practices in the Transition Zone, Bolivia.* Poster presented at the Conference on Poverty, rural livelihoods and land husbandry in hillside environments, Silsoe, 6-8 January 1999.

Clark, R., Manthrithilake, H., White, R. & Stocking, M. 1996. *Economic Valuation of Soil Erosion and Conservation - A Case Study of Perawella, Sri Lanka*. Oral presentation at the Ninth Conference of the International Soil Conservation Organisation, Bonn, Germany, 26-30 August 1996.

Clark, R. & Stocking, M. 1998. *A policy-oriented assessment of valuation approaches for the on-site impacts of soil erosion and conservation.* Paper presented at the Fifth Biennial Meeting of the International Society for Ecological Economics Santiago, Chile, 15-19 November 1998.

Clark, R. & Stocking, M. 1998. *Economic and Environmental Assessment of Soil Erosion and Conservation*. Oral presentation to the Environment Conservation Division of the Mahaweli Authority of Sri Lanka, Polgolla, Sri Lanka, 1 July 1999.

Clark, R. & Stocking, M. 1999. *A policy-oriented assessment of valuation approaches for the on-site impacts of soil erosion and conservation.* Poster presented at the Conference on Poverty, rural livelihoods and land husbandry in hillside environments, Silsoe, 6-8 January 1999.

Stocking, M. 1999. ***Land Degradation, Food Security and Biodiversity: Examining an Old Problem in a New Way.*** United Nations Forum on Sustainable Use and Conservation of Agricultural Diversity for Food Security. United Nations University, Tokyo, 12 February 1999. This was attended by policy-makers, diplomatic representatives and academics, and was the keynote address of the Forum. It showed how the techniques of biophysical assessment developed by the project can be used for global issues such as food security.

Stocking, M. and Clark, R. 1997. *Economic & Environmental Assessment of Soil Erosion & Conservation.* Poster describing the project, displayed at the Development Studies Association Annual Conference, 11-13th September, University of East Anglia, now on general display at UEA; copy also on display in the colaborator's offices in Sri Lanka.

Stocking, M. & Clark, R. 1999. *Soil productivity and erosion: biophysical and farmer-perspective assessment for hillslopes*. Oral presentation at the Conference on Poverty, rural livelihoods and land husbandry in hillside environments, Silsoe, 6-8 January 1999.

Stocking, M. & Tengberg, A. 1999. *Land Degradation and Food Security: Farmer-based Assessments*. Keynote presentation to 2nd International Land Degradation Conference, Khon Kaen, Thailand, 28 January 1999. [this will be published by Oxford & IBH, New Delhi, in a book specifically targeted at developing country professionals. Submitted and accepted – publication likely in mid-2000]

Photographs produced by the project used to illustrate the DFID Natural Resources Systems Programme Annual Report for 1996/97, 1997/98 and the cover of the information pack produced by DFID for the Natural Resources Systems Programme.

Residential Training Workshop on Biophysical and Economic Assessment of Soil Conservation Technologies held at the TREE Centre, Randenigala, Sri Lanka, 24-28 November, funded by TC funds through SEADD (DFID) (under contract to NRI). This workshop demonstrated market demand and uptake of the research and transfer of methods developed by the project to senior professionals and field officers involved in natural resource management in Sri Lanka. It also facilitated field testing by Sri Lankans of methods developed by the project. Fifteen individuals from eight institutions participated over five days. The workshop focused on field techniques for biophysical assessment of soil erosion and soil conservation technologies, rapid rural appraisal methods, and investment appraisal of soil conservation technologies.

Residential Training Workshop on Biophysical and Economic Assessment of Soil Erosion and Conservation held at the PROINPA (Promoción e Investigación de Productos Andinos) Toralapa Research Station, Bolivia, 23-27 November. The purpose of the exercise in Bolivia was to fulfil the Hillsides System's requirement that the project's findings (a set of field-based techniques developed in Sri Lanka) are also applied in another Hillsides System focus country. To provide added value, the project designed the exercise as a training workshop, enabling transfer of the techniques developed in Sri Lanka to local professional staff in Bolivia. The workshop focused on field techniques for biophysical assessment of soil erosion and soil conservation practices, rapid rural appraisal methods, and investment appraisal of soil conservation technologies. Eighteen participants commenced the Workshop, more joined during the course and at the end 22 certificates of participation were presented to participants from 15 institutions in Bolivia.
The participants' evaluation of the methods and of the Workshop itself was mixed. Most found the techniques easy to use and commented on the benefits of rapid measurements, but some had problems with the approximations and assumptions that have to be made. The biophysical and economic assessments produced by the participants at the end of the Workshop (see Workshop Report) are informative and useful, showing not only substantial learning by participants, but also a basis for undertaking a new form of biophysical and economic assessment of soil erosion and conservation pioneered by this research project.

APPENDICES

APPENDIX 1. Final Project Inventory

APPENDIX 2. Project Publications

[Other workshop reports, most conference papers and posters are not included here – but copies are available from the Principal Investigator]

2A. Clark, R. 1996. Methodologies for the Economic Analysis of Soil Erosion and Conservation. *Working Paper GEC 96-13*. Norwich, UK: Centre for Social and Economic Research on the Global Environment **[NB Submitted separately bound as copy of original Working paper]**

2B. Clark, R., Durón, G, Quispe, G. and Stocking, M. 1999. Boundary bunds or piles of stones? Using farmers' practices in Bolivia to aid soil conservation. *Mountain Research and Development* 19(3): 235-240

2C. Clark, R., Manthrithilake, H., White, R. and Stocking, M. 1998. Economic valuation of soil erosion and conservation - a case study of Perawella, Sri Lanka, pp 879-888. In: H.-P. Blume *et al* (eds) *Towards Sustainable Development - Furthering Cooperation between People and Institutions*. Selected papers of the Ninth Conference of the International Soil Conservation Organisation, Bonn, August 1996. Advances in Geoecology 31, Resiskirchen, Germany: Catena Verlag.

2D. Clark, R. & Stocking, M. 1998. *A policy-oriented assessment of valuation approaches for the on-site impacts of soil erosion and conservation.* Paper presented at the Fifth Biennial Meeting of the International Society for Ecological Economics Santiago, Chile, 15-19 November 1998. Norwich, UK: University of East Anglia. A longer version will shortly be published: **Clark, R. 2000.** A policy-oriented assessment of valuation approaches for the on-site impacts of soil erosion and conservation. *Paper accepted for publication in Ecological Economics* (revision in progress)

2E. Stocking, M. and Clark, R. 1999. Soil productivity and erosion: biophysical and farmer-perspective assessment for hillslopes. *Mountain Research and Development* 19(3): 191-202

2F. Clark, R, Durón, G and Stocking, M. 1998. *Evaluación biofísica y económica de la erosión y conservación del suelo, Biophysical and economic assessment of soil erosion and conservation, Evaluation workshop: Bolivia 23-27 November 1998, Workshop Report and Documents.* Norwich, UK: University of East Anglia (language: Spanish and English) [unpublished report]

APPENDICES

APPENDIX 1 Final Project Inventory

Project: R6525 Economic & Environmental Assessment of Soil Erosion & Conservation
RNRRS Production System: Hillsides/ Socio-Economic Methodologies

Model Inventory Sheet - 1998 / 1999

Item	Make & Model	Serial No*	Date Received	Purchase Price	Location	Disposal		
						To	Date	Authorised
Laptop Computer	Toshiba Satellite 100 CS	05625218E 0953	6 / 96	£ 1762.50	UEA, Norwich & Sri Lanka	Use of developing country professionals visiting ODG	10/99	NRSP/HTS
Desktop Computer	Compuadd P 120	Base unit: 0903775	2 / 97	£ 1338.33	UEA, Norwich	- ditto -	10/99	NRSP/HTS
		Monitor: FS6611651						
		Keyboard: 41160696						

* This column must always be completed. The number may be the manufacturer's serial number or one generated by the inventory holder's own sequential numbering system. In the case of the latter, the number must be clearly marked on the item itself.