Assessment of Soil Organic Carbon Stocks and Change at National Scale

GF/2328-2740-4381

Terminal Evaluation Report

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October 2005

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List of acronyms and abbreviations

ABRACOS	Brazilian Amazonian Climate Observation Study
ACZ	agro-climatic zone
AESRs	Agro-Ecological Sub-Regions
AFOLU	Agriculture, Forestry and Other Land Use
ASB	Alternatives to Slash and Burn
CAMREX	Carbon in the Amazon River Experiment
CENA	Centro de Energia Nuclear na Agric (Brazil)
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CNPq	Conselho Nacional de Desenvolvimento Científico e Tecnológico
COP	Conference of the Parties
DFID	Department for International Development (UK)
DGEF	Division of Global Environment Facility Coordination
DWD	Deutscher Wetterdienset
FAO	Food and Agriculture Organisation of the United Nations
GEF	Global Environment Facility
GHG	Greenhouse gas
GIS	Geographic Information System
GRID	Global Resource Information Database
GUI	Graphical User Interface
GWP	Global Warming Potential
HCST	Higher Council for Science and Technology (Jordan)
ICAR	Indian Council of Agricultural Research
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICRAF	International Centre for Research in Agroforestry (World Agroforestry Centre)
IGP	Indo-Gangetic Plain
IIASA	International Institute for Applied Systems Analysis
IPCC	Inter-governmental Panel on Climate Change
IRD	Institut de Recherche de Developpement
IRRI	International Rice Research Institute
ISRIC	International Soil and Reference Information Centre
KSS	Kenya Soil Survey
LADA	Land Degradation Assessment in Dry-lands
LBA	Large Scale Biosphere-Atmosphere Experiment in Amazonia
LUCID	Land Use Change, Impacts and Dynamics
MCT	Ministry of Science and Technology
NASA	National Aeronautical and Space Administration
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NERC	Natural Environmental Research Council (UK)
NREL	Natural Resource Ecology Laboratory
OP	Operational Program
PSC	Project Steering Committee
QUEST	Quantifying and Understanding the Earth System
RWC	Rice-Wheat Consortium
SOC	Soil organic carbon
SOTER	Soil and Terrain

START	System for Analysis Research and Training
UNEP	United Nations Environment Programme
UNFCCC	United National Framework Convention on Climate Change
USAID	US Agency for International Development

Executive summary

1. "Assessment of Soil Organic Carbon Stocks and Change at National Scale" is a medium-sized, targeted research project that relates to carbon sequestration and is aimed at the Global Environmental Facility (GEF) Operational Programme (OP) No. 12: Integrated Ecosystem Management.

2. The project was specifically designed to improve national assessment methodologies relating to land use options and the United Nations Framework Convention on Climate Change (UNFCCC) requirements, and to support core activities of the GEF Integrated Ecosystem Management Operational Programme and the Inter-governmental Panel on Climate Change (IPCC), by developing and demonstrating generic tools for quantifying the impact of land management options and climate scenarios on carbon sequestration in soils.

3. The objectives of the project include: the identification and use of long-term experimental datasets to systematically evaluate and refine modelling techniques that allows the estimation of carbon sequestration in tropical soils; the collation and formatting of national-scale soils, climate and land-use datasets and to use them in the development of coupled modelling-Geographic Information System (GIS) tools to estimate soil carbon stocks; the demonstration of these tools by estimating current soil organic carbon (SOC) stocks at country-scale (using India, Jordan, Kenya and Amazon-Brazil as case studies) and to compare these estimates with the existing techniques of combining soil mapping units and interpolating point data; and to quantify the impact of defined changes in land use on carbon sequestration in soils with a view to assisting in the formulation of improved policies to optimise resource use in the four case-study countries.

4. The objective of this terminal evaluation is to establish project impact (with respect to objectives and outcomes), project performance, and review and evaluate the implementation of planned project activities and outputs against actual results.

5. Project implementation occurred in five stages, which addressed the stated project objectives. Stage 1 of the project involved evaluation and refinement of the two SOC models chosen for the project - RothC and Century. Stage 2 involved the collation and formatting of national and regional scale soils, climate and land use data sets suitable for use as input data for the GEFSOC Modelling System. Stage 3 involved development, implementation and testing of the GEFSOC Modelling System in each of the four case study countries. These activities were coordinated by the NREL in Colorado, USA, in conjunction with Rothamsted Research, UK. Stage 4 assessed current SOC stocks (1990 and 2000) for each case study area using the GEFSOC Modelling System. Stage 5 assessed likely changes in SOC stocks in each of the case study countries under a range of land use change scenarios for the target year 2030.

6. The project has been successful in meeting or exceeding all stated objectives and outputs as required in the project documentation.

7. The project is an excellent example of team work between developed and developing-world institutions in delivering objectives and outcomes which have national and international benefit with respect to carbon management and the influence of land management and climate change. Much of the success of this project is due to the enthusiasm of the team members, who in the majority of cases have worked beyond the bounds placed by the funds made available to the project.

8. On-going support for deployment and training in the use of the GEFSOC Modelling System must be considered a high priority by the GEF. This is a unique piece of software that will greatly assist national governments in improving their greenhouse gas inventories under UNFCCC requirements

9. The only obvious deficiency in this project which may have impacted on implementation of the project was the non-inclusion of collaborating institutions aligned with the CGIAR. A closer association with the Centres of the CGIAR may have circumvented some of the problems which hampered the project with respect to acquisition and accessing datasets.

10. The Technical Report provided an excellent document for assessment of project objectives and outcomes. The report however does lack some detail. Some modifications to improve clarity and transparency of the methodology have been outlined as recommendations within this evaluation.

11. The application of the GEFSOC Modelling System as a decision support tool for quantitative assessments of SOC change in response to soil, management and climate depends heavily on the ability of the individual models to accurately predict SOC change. In future, greater emphasis should be placed on model validation, particularly when national level simulations are being performed.

12. Acquisition of more datasets is critical in meeting this objective, and this could be enhanced by a closer relationship with the CGIAR, who are already in close contact and collaborating with national research institutions in the developing world.

13. Provision of more information with respect to the development of future land use scenarios in all of the case study countries will enhance the applicability of project outcomes. In particular, the methodology described in the development of land management scenarios for the implementation Stages 4 and 5 should be more clearly defined to ensure replication in future projects.

14. In future projects, explore the possibility of including estimates of associated greenhouse gases (i.e. nitrous oxide and methane) in the provision of a Global Warming Potential (GWP) estimates of farming systems and land use management. With the increased use of these predictive modelling products in the developing world, all greenhouse gases (not just CO_2) must be

accommodated to ensure realistic assessments of emissions (in terms of carbon equivalents) are made in the development of projects which are designed to produce carbon credits.

15. In future projects, explore the need, scope and availability of socio-economic data associated with decision making at farm, regional and national level which may influence the actual selection of land management practices in both space and time, and their impact on SOC accumulation. Data presented in this current project only provides estimates of "potential" changes in SOC and must be supplemented in future to include over-arching socio-economic drivers of sustainable production in the developing world.

16. There is a great need to sustain the momentum built up within this project, especially with respect to the further development and maintenance of the GEFSOC Modelling System, country specific databases and training of more scientists in the use of the System and acquisition of more data. The CGIAR may provide the avenue for sustaining the project until a new project is developed and implemented.

17. A natural extension of this project would be to increase the potential of the GEFSOC Modelling System by incorporating a standardised global climate database.

I. Project identifiers

Project title: Assessment of Soil Organic Carbon Stocks and Change at National Scale
Project no.: GF/2328-2740-4381 PMS GF/1030-02-01
Duration: 39 months - originally January 2002 to March 2005 but implementation started six months late, hence the project ended in July 2005.

II. Introduction

A. Background

18. "Assessment of Soil Organic Carbon Stocks and Change at National Scale" is a medium-sized, targeted research project that relates to carbon sequestration and is aimed at the Global Environmental Facility (GEF) Operational Programme (OP) No. 12: Integrated Ecosystem Management.

19. The project was specifically designed to improve national assessment methodologies relating to land use options and United Nations Framework Convention on Climate Change (UNFCCC) requirements, and to support core activities of the GEF Integrated Ecosystem Management Operational Programme and the Inter-governmental Panel on Climate Change (IPCC), by developing and demonstrating generic tools for quantifying the impact of land management options and climate scenarios on carbon sequestration in soils.

20. The stated research objectives of the project include:
    a. The identification and use of long-term experimental datasets to systematically evaluate and refine modelling techniques that allows the estimation of carbon sequestration in tropical soils.
    b. The definition, collation and formatting of national-scale soils, climate and land-use datasets and to use them in the development of coupled modelling-Geographic Information System (GIS) tools to estimate soil carbon stocks.
    c. The demonstration of these tools by estimating current soil organic carbon (SOC) stocks at country-scale (using India, Jordan, Kenya and Amazon-Brazil as case studies) and to compare these estimates with the existing techniques of combining soil mapping units and interpolating point data; and
    d. To quantify the impact of defined changes in land use on carbon sequestration in soils with a view to assisting in the formulation of improved policies to optimise resource use in the four case-study countries.

21. From a national perspective, the project was developed to improve assessment methodologies in relation to UNFCCC requirements for estimating carbon emissions from land systems; assist national agencies to analyse the impact of land management scenarios for biodiversity conservation, as related

to carbon sequestration, as well provide quantitative estimates of carbon sequestration potential for use in international negotiations.

22. From an international perspective, the stated project outcomes were developed to provide GEF with tools for assessing consequences of land management interventions on carbon sequestration, as an aid in developing projects which conserve and improve biodiversity (in soils); and be complementary to the IPCC process; as well as facilitate international collaboration for capacity building and analysis relevant to carbon sequestration research.

23. The stated outcomes from this targeted research project include:

a. Data from national data sources of variables relating to the control of carbon stocks in Brazilian, Indian, Jordanian and Kenyan soils systematically collated and formatted in standardised GIS formats and fed into national greenhouse gas (GHG) inventories.
b. Regional-/national-scale quantities of carbon stored in Amazon-Brazilian, Indian, Jordanian and Kenyan soils estimated and critically compared with soil mapping methodologies, and maps of land-use and carbon density derived.
c. Capacity building in the use of GIS-model interfaces and SOC stock assessment.
d. Generic tools designed to help formulate national and sub-national level policy by (i) quantifying current SOC stocks at national and sub-national level; and (ii) analysing the impacts of land management options on carbon storage, GHG emissions and sequestration possibilities.
e. Tools developed to help GEF identify and select possible national carbon sequestration projects, and guide their development and implementation.

24. The project was executed by the University of Reading, UK on behalf of an international consortium comprising scientific agencies in Brazil (Centro de Energia Nuclear na Agric, Universidade de Sao Paulo and Ministry of Science and Technology); India (National Bureau of Soil Survey and Land Use Planning); Jordan (Higher Council for Science and Technology/Badia Research and Development Programme) and Kenya (Kenya Soil Survey) together with representatives from scientific collaboration groups in the US (Natural Resources Ecology Laboratory, Colorado State University), UK (Rothamsted Experimental Station), the Netherlands (International Soil Reference and Information Centre), Austria (International Institute for Applied Systems Analysis, IIASA) and France (Institut de Recherche de Developpement, IRD).

25. All activities were managed and coordinated on a day-to-day basis by the International Coordinator (from University of Reading), in consultation with United Nations Environment Programme (UNEP)/Division of Global Environment Facility Coordination (DGEF). The Project Steering Committee (PSC) was composed of representatives from the University of Reading, as the

executing agency, the international consortium comprising scientific agencies in the participating countries and the scientific collaboration groups.

26. The total budget of the proposal was US$2,002,000 with US$978,000 funded by the GEF Trust Fund and US$1,024,000 pledged as counterpart contributions, of which one third (US$370,000) to be directly from grants and two-thirds from in-kind contributions.

B. Evaluation Objectives and Scope

27. The objective of this terminal evaluation is to establish project impact (with respect to objectives and outcomes), project performance, and review and evaluate the implementation of planned project activities and outputs against actual results.

28. The evaluation has focused on four main questions:
    a. To what extent has the development and demonstration of the methodology (generic tools) for assessing SOC stocks helped national agencies improve their capacity for analysis of land use options in the context of the UNFCCC?
    b. Are the tools developed timely and relevant to the work of the Intergovernmental Panel on climate Change, IPCC?
    c. Are the modalities for international collaboration on land management scenarios generation, capacity building and analysis developed by this project functional, sustainable and replicable?
    d. To what extent does this project contribute to the objectives of OP12 on integrated ecosystem management?

29. The evaluation has assessed:
    a. Delivered outputs, i.e. an assessment of the project's success in producing each of the programmed outputs, both in quantity and quality as well as usefulness and timeliness.
    b. Project outcomes and impact, i.e. evaluation of the project's success in achieving its outcomes and likelihood of impact.
    c. Sustainability of the project.
    d. Execution performance, i.e. A determination of effectiveness and efficiency of project management and supervision of project activities.

30. The evaluation was commissioned by the Evaluation and Oversight Unit of UNEP and undertaken by an independent, external evaluator.

C. Evaluation Methodology

31. The evaluation was undertaken from 25 August to 20 October, 2005.

32. The findings of the evaluation are based on:
    - A desk review of the Project Document, the Terminal Report, and the associated Technical Report, Project Steering Committee (PSC) reports, the Project website (www.rdg.ac.uk/GEFSOC) and links,

and selected materials based on citations within the abovementioned documents.

- A technical review in Piricicaba, Brazil (29th August – 7 September, 2005) undertaken by the external evaluator, including demonstration of project specific software.
- Phone interviews by the external evaluator with the International Project Coordinator, Dr Eleanor Milne (formerly of the University of Reading, now Natural Resource Ecology Laboratory (NREL), Colorado, USA); Dr Mark Easter, collaborator from NREL and; Mr Mohamed Sessay, UNEP/GEF Task Manager from Nairobi, Kenya.
- Email correspondence with the International Project Coordinator and project collaborators.
- Responses to questionnaires, distributed by the external evaluator, to individuals and stakeholders directly associated with, or exposed to the project during its development and implementation. This included collaborating groups and core team members in the USA, UK, Netherlands, France and Austria as well as members of the PSC.
- Comments sought from members of the international scientific community (not related to the project) on the merits of the project with respect to its stated outcomes and outputs and their relevance to climate change, specifically carbon sequestration, issues.

D. Limitations of the Evaluation

33. The evaluation was limited by the fact the external evaluator was only requested to visit one of the four countries in which the project was implemented.

34. Some key individuals in collaborating institutions did not respond to the questionnaires.

35. The project's relevance to wider international scientific efforts in climate change and carbon sequestration research could not be fully assessed due to limitations on information that could be transmitted to individuals not associated with the project prior to the evaluation being completed.

III. Project Activities

36. Project implementation occurred in five stages, which addressed the stated project objectives. Many of activities were carried out concurrently.

37. Stage 1 of the project involved evaluation and refinement of the two SOC models chosen for the project - RothC and Century. This was considered necessary as these models have, in the main, been developed and tested with only temperate ecosystems in mind.

38. This stage involved two major activities. First, case study country post-doctoral scientists received training in the use of the two models at a training

workshop in the UK, at the University of Reading. Second, in order to carry out model evaluation and testing within their own country, time series data sets which include SOC, crop yield, climate and soil physical property (e.g. bulk density, texture) information, were collated in each of the case study regions. These included long-term experimental data sets from local research institutes and land use chronosequences similar in terms of soil type and climate. As many of the crops grown in the case study areas had not been modelled before using these particular models, the scientists had to develop parameters to ensure accurate prediction of biomass production over time.

39. Stage 2 involved the collation and formatting of national and regional scale soils, climate and land use data sets suitable for use as input data for the GEFSOC Modelling System (refer Stage 3). This data were required for "up-scaling" changes in SOC in response to agronomic management and land use change to either national and/or regional levels. The data were organised into a standardised format by the case study scientists to ensure comparable inputs and outputs, consistent with the aims of a generic data handling and simulation system that has general application across many environments.

40. For soils input, the Soil and Terrain (SOTER) database format was chosen, as it was generally applicable in the case study countries (except India) and its coverage is practically global, and therefore likely to be of use in similar studies in the future. Gaps in the spatial data and attributes (e.g. bulk density) were identified and filled by case study country scientists in conjunction with the International Soil and Reference Information Centre (ISRIC), Netherlands, who developed a taxo-transfer, rule-based approach for filling data gaps. In the case of the Indo-Gangetic Plains (IGP) of India, no prior SOTER database existed and a training session was organised by ISRIC with the National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) to compile a SOTER for the IGP.

41. The climate data required for input into the GEFSOC Modelling Systems (mean monthly rainfall, maximum and minimum temperature and evapo-transpiration) was collated and formatted as GIS 'coverages' by case study country scientists. Data sources included grid-based global data sets and point-based national networks of meteorological stations and previous research projects.

42. Land use and land use history data were assembled by case study country scientists from government statistical bulletins, research reports and global data sets. Much of this data was in paper form and had to be converted to an electronic format. In addition, information on land management was collated. Land management information came from in-country expert knowledge, research reports and farmer interviews.

43. Stage 3 involved development, implementation and testing of the GEFSOC Modelling System in each of the four case study countries. Their activities were coordinated by the NREL in Colorado, USA, in conjunction with Rothamsted Research, UK. The GEFSOC Modelling System was

developed, based on a similar architecture to a system already developed at NREL for regional and continental simulations of SOC change in the USA.

44. The RothC and Century simulation models were linked to a spatial database using a GIS system as was the more empirical IPCC method for estimating SOC stocks. A set of program modules to run the three approaches calculating SOC were developed, as was a graphical user interface (GUI) that allows users to interact with the GEFSOC Modelling System.

45. As part of Stage 3, NREL scientists visited each of the case study countries to provide training on use of the GEFSOC Modelling System and 'test case' it in each country. During these visits, case study country scientists made modifications and amendments to the modelling system as part of its development process.

46. Stage 4 assessed current SOC stocks for each case study area using the GEFSOC Modelling System. Both current and historical (pre-current) land use and management information was assembled by each of the case study countries. Global level information (e.g. population, terrain, soils, climate, land cover, transportation infrastructure and agro-ecological zone suitability information) provided by IIASA, Austria, was amalgamated and down-scaled to the landscape level to provide compatibility as inputs into the GEFSOC Modelling System.

47. Management information at both site and regional scales was collated by the case study country researchers and reviewed through a workshop. Historical and current land use and land management information (such as crop type, rotation, and management) were assembled into sequences of management change over time. Model outputs were then generated for both 1990 and 2000, the former to correspond to the baseline year outlined in the Kyoto Protocol and the latter to act as a more recent base year representing current SOC stocks.

48. Stage 5 assessed likely changes in SOC stocks in each of the case study countries under a range of land use change scenarios for the target year 2030. Scientists from each of the case study countries spent 1 month at IIASA, funded by the System for Analysis Research and Training (START) Visiting Scientist Programme and developed land use change scenarios for the case study areas. The process involved determining the proportion of land that would change land use or land management between 2000 to 2030, in effect extending the work carried out in Stage 4.

49. Inferences about possible land use and management change were made from extrapolation of current trends and plans/policies outlined in government documents and the FAO cropping change predictions. Changes in SOC stocks were predicted using the GEFSOC Modelling Systems from 7000 years before human settlement to 1990, 2000 and 2030.

50. During the course of the project, seven workshops and three PSC meetings were held (Table 1). A number of exchange visits were carried out,

with the primary aim of providing expertise and building capacity in the use of GIS-model interfaces and SOC stock assessment.

Table 1. Details of workshops held during the GEFSOC Project[1]

Workshop	Purpose	Date	Location
1	Model training, data management and content definition	December 2002	UK
2	Spatial data review, plot scale data review	April 2003	Brazil
2.5	Further model and data management training	July 2003	USA
3	Model evaluation at plot scale	October 2003	Kenya
4	Initial regional model evaluation + mid term review	May 2004	Jordan
5	Scenario formulation	September 2004	Austria
5.5	Pre-final presentation workshop	April 2005	UK
6	Final project presentation	May 2005	Kenya

[1]Table reproduced from Terminal Report

IV. Evaluation of the Project

A. Attainment of stated objectives

51. The objectives have been specifically designed to ensure the progressive development of datasets and decision support software to determine current SOC stocks within the case study countries and quantify the impact of defined changes in land use on SOC as an aid in the development of policies to optimise resource use into the future, at the landscape level.

Objective a. The identification and use of long-term experimental datasets to systematically evaluate and refine modelling techniques that allows the estimation of carbon sequestration in tropical soils.

52. Both of the soil carbon models (RothC and Century) used in the project were subject to evaluation and refinement using in-country data sets derived for each of the case studies. The project gave the first systematic evaluation of RothC and Century for conditions in the Brazilian Amazon, Jordan, Kenya and the IGP. As part of the model refinement process, new options were developed within the forestry and crop sub-models of Century for all of the case study countries.

53. The project identified long-term datasets of SOC change in Kenya and the IGP of India which could be used in modelling calibration (if required) and validation. In the case of Brazil, long-term chronosequences from deforested regions of the Amazon where pasture systems had been established were used as surrogates for traditional long-term trial data. In the case of Jordan, no long-term trial data existed.

54. For the Brazilian Amazon case study, both RothC and Century models were extensively evaluated using data from 11 forest-to-pasture chronosequences from across this region. In addition, evaluation of actual versus modelled microbial biomass (for both RothC and Century) and $\delta^{13}C$ values were made for Century for some of the Brazilian Amazon data sets, thus providing greater insight into SOC cycling in this region.

55. In the IGP, crop, soil and climatic information was collated from 48 long-term fertiliser trials, however most of these trials lacked detailed SOC data, therefore the data was mainly utilised to assess the accuracy of crop production in the Century model. At only two sites, Barrackpore (West Bengal) and Ludhiana (Punjab), were there sufficient SOC data available for use in the validation of the models ability to estimate changes in SOC over time. No model validation work was completed for the RothC model in the IGP treatments and work is on-going to complete this exercise.

56. The project team in the IGP emphasised the fact that the ability of the Century model to predict SOC depends largely on the plant productivity sub-models and placed significant resources into the validation of the crop production sub-models. Whilst this is a necessary exercise, the emphasis should have been placed on accessing data from other trials across the IGP which may have provided SOC data, allowing greater focus on SOC prediction.

57. The IGP itself has the broadest mix of soils, climate and land management systems of all the case studies and therefore should have been the most extensively validated. The Ludhiana trial itself is based in a very sandy region of the IGP which is useful for testing SOC at a relatively extreme end of the spectrum. Many long-term trials with SOC data exist across this region, including studies at Pantnagar and a comprehensive listing can be found in Abrol et al. (2000) - Long-term soil fertility experiments in rice-wheat cropping systems, published by the Rice-Wheat Consortium (RWC) for the IGP.

58. The Century model has proven to be the model of choice for simulating SOC in aerobic ecosystems worldwide. There is insufficient detail in the Technical Report with respect to the validation of the Century model with respect to simulation of SOC dynamics in flooded rice-based systems, which dominate the IGP, particularly long-term (double and triple cropped rice). There is evidence in the published literature (Olk) of a change in the quality of SOC in systems which are prone to extended periods of anaerobiosis.

59. In Kenya, data from two long-term trials were available for validating the Century and RothC models. One from a long-term fertility trial near Nairobi, and the other at Machanga (13 years) in the semi-arid zone of the country. With no long-term data in existence for the humid and arid zones of Kenya, the two sites may be considered representative of contrasting climatic conditions; however increased effort in identifying additional sites would have

provided a more robust test of the models' ability to estimate SOC change in this environment.

60. In Jordan, an extensive, but unsuccessful search of national agencies was undertaken to acquire the long-term SOC data necessary for validating the Century and RothC models. Regional data was found at the International Centre for Agricultural Research in the Dry Areas (ICARDA) for Aleppo in Syria, but was not considered suitable for testing the model in a Jordanian environment.

61. The lack of long-term data for Jordan therefore prevented evaluation of the models using standard methods, however, a survey of 200 soil samples was undertaken throughout the country and in combination with yield and management data, both Century and RothC were reportedly able to replicate existing SOC levels.

62. Less of an effort appears to have been invested in the application of the RothC model throughout the case study countries. For example, the method for determining the plant carbon inputs for this model varied across the case studies and lack compatibility e.g. in Kenya, the use of inverse modelling and measured SOC values does not provide an effective evaluation of the model's ability to simulate SOC change.

63. Objective 'a' was achieved, and in fact surpassed by the project (e.g. by broadening the options with respect to the applicability of the Century model to tropical and arid regions). An exemplary effort was made by the Brazilian case study in providing comprehensive testing of the models, particularly in an area of increasing international significance with respect to its influence on the global cycle (i.e. the Amazon).

64. The efforts in the IGP, Kenya and Jordan could possibly have been improved through utilization of more detailed datasets, especially those with SOC information, through projects within the Consultative Group on International Agricultural Research (CGIAR) e.g. RWC of the IGP coordinated by Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) and the International Rice Research Institute (IRRI) and the Alternatives to Slash and Burn (ASB) associated with the International Centre for Research in Agroforestry (ICRAF), and data from ICARDA.

Objective b. The definition, collation and formatting of national-scale soils, climate and land-use datasets and to use them in the development of coupled modelling-GIS tools to estimate soil carbon stocks.

65. National and global data sources were used to compile national and sub-national data sets of soils, climate, land use and land use history information for the four case studies. In the case of soils data, four SOTER (soil and terrain) databases were created. Whilst Jordan, Kenya and Brazil already had national scale SOTER databases, a SOTER database was created for the IGP. Climate data were collated for all case studies from various

sources, including grid-based global data sets, point-based data national networks of meteorological stations and previous research projects, and formatted as GIS coverages.

66. Land-use and land-use history data were compiled for all case studies, using government statistical bulletins, research reports and global data sets. Information on land management was also collated, e.g. case study specific crop, forestry and pasture management practices. Land management information also was acquired from in-country expert knowledge, research reports and farmer interviews.

67. For the Brazilian Amazon, national weather service records and the Anglo-Brazilian Amazonian Climate Observation Study (ABRACOS), Carbon in the Amazon River Experiment (CAMREX) and Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) projects. Rainfall data from over 1,000 sites were also collated.

68. Digital datasets of potential native vegetation and land cover of the Brazilian Amazon were acquired for the project, as was the SOTER database. An ancillary soils database was also manually digitised by the Brazilian project members using 23 bulletins, originally produced by the RADAMBRASIL Project, with over 2500 soil profiles for the Brazilian Amazon. Data from 170 Agricultural Census bulletins were also converted from hardcopy to digital form. Land use data are now available at decadal intervals from 1940-1995 for the entire Brazilian Amazon.

69. The IGP case study scientists, in cooperation with the NBSS&LUP prepared six datasets for this region. These are detailed in a series of reports, and include: a Natural Resource Atlas; a Benchmark Soil Series; a SOTER database; Soils, land use and climatic data for use in models. Much of this information is reportedly detailed in a Special Publication for Assessment of Soil Organic Stocks and Changes at the National Scale.

70. Whilst the IGP represents 14 Agro-Ecological Sub-Regions (AESRs) on the basis of bioclimatic systems, the fact that many of these are similar in terms of bioclimatology and land management, has made it possible to identify 3 representative AESRs, thus providing a more efficient and less complex data input system. Land management, rotation and crop management have been constructed for the representative AESRs of the IGP.

71. Digital historical vegetation and land-use information was assembled for Kenya, and overlaid with an agro-climatic zone (ACZ) map of the country (containing mean monthly climatic data), producing a combined temperature-zone map. Historical land-use data for Kenya was compiled from selected Kenyan government annual agricultural reports ranging from 1909-2002, as well as land-use and population census data. The Food and Agriculture Organisation (FAO) Africover database was also utilised to provide apportioning of urban, rain-fed and irrigated agriculture. Soil texture information, an essential model input, was extracted from the SOTER database and reclassified into 24 classes.

72. For Jordan, GIS maps have been produced in the development of model inputs in estimating SOC stocks and changes. These include natural and current land use, SOTER data, and ecological zones. Crop, animal, fertiliser and irrigation statistics from 1994-2002 were also assembled from the Jordan Department of Statistics.

73. The GEFSOC Modelling System was specifically developed by the project team to provide spatially explicit estimations of soil carbon stock changes at the national and sub-national level. The System is based on a decision support framework developed by NREL for use in the USA, however in this project it links GIS-based data input structures to two simulation models (Century and RothC) and the empirical IPCC method.

74. The GEFSOC Modelling Systems provides direct comparisons of predicted SOC stocks and change in response to land management activities. Within this modelling system, carbon inputs and tillage data simulated by the Century model are generally used as inputs to the RothC model unless otherwise specified. Land use management is classified according to IPCC guidelines and these classifications are used to drive the IPCC method.

Objective c. The demonstration of these tools by estimating current soil organic carbon (SOC) stocks at country-scale (using India, Jordan, Kenya and Amazon-Brazil as case studies) and to compare these estimates with the existing techniques of combining soil mapping units and interpolating point data.

75. Spatially explicit soil carbon stocks were determined using the GEFSOC Modelling System for the years 1990 (to comply with the baseline specified within the Kyoto Protocol) and 2000 (to represent the current situation) for all of the case studies. The GEFSOC Modelling System is capable of running the IPCC method (0-30 cm) at the same time as RothC and Century (both 0-20 cm) and gave plausible estimates of SOC stocks using three different methods.

76. Estimates of the current mean SOC density in the top 20 cm from RothC and Century using the GEFSOC Modelling System are within the range of SOC values presented in previous quantitative studies for the Brazilian Amazon.

77. Estimates of the current SOC stocks in the IGP using both Century and IPCC approaches are within the range of quantitative estimates developed in association with this project. Current estimates using the RothC approach exceed the quantitative estimates for the IGP by a factor of 2 and further work is being undertaken to check this result.

78. IGP case study scientists have identified a number of options for narrowing the range of current estimates for SOC, including additional direct measurements, increased validation and improving quality of data inputs relevant to land management.

79. The Century, RothC and IPCC approaches are in general agreement with respect to current SOC estimates for Kenya and align with the quantitative estimates developed using SOTER information.

80. The relatively large size of the agro-ecological zones used to aggregate climate and vegetation characteristics in Kenya resulted in rather ill-defined SOC changes across the landscape and case study scientists have identified the need for higher resolution data for representing the gradients in variability in SOC normally seen across a region.

81. For Jordan, the RothC and Century approaches (especially the latter) are in general agreement and align with the quantitative estimates developed using the SOTER databases. The IPCC method produced an estimate of current stocks 2-3 times greater than the other estimates. The reasons for this discrepancy are not defined and require further investigation and definition.

Objective d. To quantify the impact of defined changes in land use on carbon sequestration in soils with a view to assisting in the formulation of improved policies to optimise resource use in the four case-study countries.

82. Changes in SOC stocks over a 30-year period in the future as simulated using the GEFSOC Modelling System were based on land-use scenarios for each of the case study areas. Plausible land-use change scenarios were determined for each of the case study areas by analysing current and historical trends in land-use change, plans and policies outlined in government documents, and the FAO projections of how cropped area and cropping intensity may change in the future.

83. Both the Terminal and Technical Reports provide little if any concise information on the development of future land-use change scenarios, even though model outputs are presented for future scenarios. The delivery of policy-relevant resource planning material can only be fulfilled if a comprehensive data preparation, simulation and land-use change framework (as outlined in this project) is developed and implemented.

84. Without a methodology detailing the development of future land-use change scenarios, the project is restricted to a data and model coupling exercise with product-orientated outcomes which, by themselves, reduce the full potential of this project and its future application. This task was carried out in close cooperation with IIASA, however, it is difficult to assess what activities and methodology were actually used.

85. Overall, the stated objectives of this project have been either met or, in some instances, exceeded. The development of the climate, soil and land-use databases have in all cases been beneficial for both natural resource management and development of more accurate and refined greenhouse gas inventories relevant to reporting structures designed by the UNFCCC.

86. The final objective, the quantification of future land changes on SOC storage was completed, but the methodological details of this aspect of the project are unsatisfactory for assessment purposes.

87. The application of the generic GEFSOC Modelling System should not be restricted to the case study countries outlined in this project as the framework has been comprehensively developed with other countries and projects in mind.

88. The GEFSOC Modelling System itself is not restricted in terms of geographical resolution i.e. the framework could accommodate climate, soil and land use data at sub-regional, watershed and community levels for developing natural resource management plans for sustainable development.

89. An examination of the full listing of projects funded under the OP 12 portfolio suggests the outcomes realised by this current project could have benefit in the delivery of the objectives of at least twenty projects within the current portfolio. The outputs provide information on likely impacts on soil fertility, soil water holding capacity, erodibility and below ground biodiversity.

B. Achievement of stated outputs

90. The project has developed highly applicable, practical outputs, in the form of simulation software and linked digital climate, soil and land-use databases for four regions of the world which have not previously had the opportunity for such a detailed assessment. The quality and integrity of these outputs is exceptionally high as the underlying principals in their development have been tested and reviewed by peers from around the globe.

91. The principal international collaborating scientists involved in project implementation (NREL, Rothamsted Research and ISRIC) are widely regarded as experts in their field and are currently providing high quality information to the IPCC and the wider climate change community, particularly in relation to SOC stock assessment and the impact of land use change and land management changes. The project has benefited greatly by their inclusion and willingness to work in close association with case study country scientists.

92. The project team have developed a methodology which utilises widely applicable software products for data compilation and analysis, including GIS platforms. The paucity of datasets in some circumstances was taken into account in delivery of stated outputs for the four case studies.

Output a. Data from national data sources of variables relating to the control of carbon stocks in Brazilian, Indian, Jordanian and Kenyan soils systematically collated and formatted in standardised GIS formats and fed into national greenhouse gas inventories.

93. National data sets of soils, climate and land use data are now available for the Brazilian Amazon, the IGP of India, Jordan and Kenya, in standardised GIS format that can be utilised by case study countries into national greenhouse gas inventories. The SOTER database in particular will provide a basis for more detailed greenhouse gas inventories.

94. The formulation and collation of these datasets provide evidence that with adequate funding, significant advancements can be made in the development of tools to support sustainable development of agricultural systems in the developing world.

Output b. Regional-/national-scale quantities of carbon stored in Amazon-Brazilian, IGP, Jordanian and Kenyan soils estimated and critically compared with soil mapping methodologies, and maps of land-use and carbon density derived.

95. The GEFSOC Modelling System has been used to estimate SOC stocks in the Brazilian Amazon, the IGP of India, Jordan and Kenya. Estimates have been provided using approaches based on two process-based modelling systems, RothC and Century and an empirical accounting method developed by the IPCC.

96. Estimates using the three approaches have been compared to a mapping-based approach using SOTER databases for each case study. Carbon stocks for the years 1990 and 2000 have been mapped, and the simulation approaches provide good correlation with standard mapping estimates.

Output c. Capacity building in the use of GIS-model interfaces and SOC stock assessment.

97. One of the major achievements of this project has been training of 10 scientists in case study countries in the development of simulation modelling and GIS capacity as an aid in the construction of SOC inventories and assessment of the impact of land management strategies and climate change on SOC stocks into the future. An additional 6 scientists were also present (from the IGP) for SOTER training.

98. The capacity building activity has included extended exchange visits by case study countries to advanced research institutions associated with the project as well as collaborating scientists visiting the national institutions. Scientists at NREL, where the GEFSOC Modelling System was developed, Rothamsted Research, and ISRIC, have provided exceptional input into the capacity building exercise.

Output d. Generic tools designed to help formulate national and sub-national level policy by (i) quantifying current SOC stocks at national and sub-national level; and (ii) analysing the impacts of land management options on carbon storage, GHG emissions and sequestration possibilities.

99. The project has developed a decision support system that allows users to generate estimates of SOC stocks and stock changes, simultaneously, using three different predictive approaches. The system allows quantification of current SOC stocks for complex systems and land use transitions in space and time. This can be at national or sub-national level or at any scale where a high degree of complexity is involved.

100. The GEFSOC Modelling System can also analyse the impacts of land use and land management options on carbon storage, which provides information on GHG emissions and sequestration possibilities. It allows users to build spatially explicit land use and management scenarios that vary over time for highly complex systems.

101. The GEFSOC Modelling System also has the capacity to accept new datasets in the future with higher resolution climate, soil and land use information. This capacity will greatly enhance the application of the System in the future in the development of greenhouse gas inventories, and development and assessment of sustainable land use management strategies.

Output e. Tools developed to help GEF identify and select possible national carbon sequestration projects, and guide their development and implementation.

102. The project was developed under GEF OP12, which focuses on integrated ecosystem management. The GEFSOC Modelling System will allow the GEF to estimate the impacts of proposed projects (from all of the operational programs, but with most relevance to OP12 and OP15 on future SOC stocks.

103. To date, here has been no direct application of the GEFSOC Modelling System to assist in the identification of possible carbon sequestration projects, but a number of projects have been selected for possible inclusion in a testing phase.

C. Cost-effectiveness

104. This project was co-financed under Operational Programme (OP) 12, Integrated Ecosystem Management of The Global Environment Facility to the value of US$0.98M. Whilst a total amount of US$1.09M was pledged by cooperating organisations and governments, including the international donor community, $0.92M was actually received in the form of grants or in-kind contributions (Table 2).

Table 2. Co-financing of the GEFSOC project

Organisation	Cash $US	In-kind $US
KSS		52,850
CENA & CNPq, Brazil		37,340
IRD		125,232
ICAR, India	20,000	20,000
HCST, Jordan		61,836
U.S. Agencies	150,000	130,000
U.K. Agencies		79,000
Netherlands Agencies	103,519	
Austrian Agencies		75,000
NERC & DFID	45,000	
START		15,400
Total	333,919	581,258

105. The shortfall in pledged funds did not significantly affect the delivery of objectives and outcomes as stated in the project document. All deliverables were met within the required time frame. It is noted that the shortfall in funds from non-GEF sources (mainly attributed to U.K. Agencies) could have been much larger and may have impacted on outputs except for increased contributions from other members of the international community.

106. The GEFSOC Modelling System and SOTER databases associated with this project are actually modifications and enhancements of structures and data which had been collected over many years and in other projects. GEF has made a good strategic decision in being the first agency to leverage and transform this weight of information into a product of global significance. It is conservatively estimated that the preparatory work undertaken in the pre-development stages, prior to project approval and implementation would be well in excess of US$5M.

D. Impact

107. As a result of this project, institutions in Brazil, India, Jordan and Kenya now have significant capacity in the use of GIS model interfaces and SOC stock assessment, having been instrumental in the development of the GEFSOC Modelling System. This places these institutions in a unique position globally as they have co-developed the only generically applicable system for making processes based estimations of SOC stock changes, built on data from developing countries.

108. Whilst it is still too early to fully assess whether these datasets will be utilised in the refinement of greenhouse gas inventories for case study countries, there are solid indications arising from survey information that the project datasets will be a welcome addition in developing inventories.

109. The project has provided significant impacts in the development of IPCC methods for carbon emissions from soils. Data from long-term experiments and chronosequences collected by project scientists have been included in the global data sets used to revise soil stock change factors in the IPCC Tier 1 (default) method[1].

110. The global data sets have been incorporated into the 2003 Good Practice Guidance for Land Use, Land Use Change and Forestry greenhouse gas inventories and are currently being incorporated into the IPCC 2006 Guidelines for National Greenhouse Gas Inventories – Volume 4: Agriculture, Forestry and Other Land Use (AFOLU).

111. The GEFSOC Modelling System will shortly be publicly available and downloadable from the web, thus providing the opportunity for developing countries to use an advanced (Tier 3) inventory methodology, using the two most widely used SOC simulation models available (Century and RothC), to improve their estimates of land-use-related carbon emissions. A Tier 1 methodology is also incorporated into the software, and if country-specific stock change and emission factors are available, these can be entered into the GEFSOC Modelling System database to construct a Tier 2 inventory

112. Using the GEFSOC Modelling System, countries can readily identify which land use activities and/or geographic areas within their country are potentially of most importance as carbon sources or sinks.

113. The methodology outlined in the delivery of the project, including the GEFSOC Modelling System and associated data structures, addresses activities of high to critical significance and relevance to the IPCC Fourth Assessment Report (AR4) Chapter on Agricultural Greenhouse Gas Mitigation Options and has a direct global impact. This statement is supported by a survey of expert scientists not associated with the project but working on greenhouse gas assessments for national governments in the developed world.

114. The project has produced 9 papers in peer reviewed scientific journals to date. In addition, a special issue has been agreed with Agriculture Ecosystems and Environment, which will present the project findings in 13 peer reviewed papers. During the project, presentations of interim project results were made at 14 different conferences in India, Denmark, Brazil, Russia, Germany, the UK and the USA.

[1]The Tier 1 methodology uses default parameters as provided by the IPCC to enable countries with limited data resources to estimate emissions; Tier 2 approaches require at least some country-specific information, which may be obtained through local literature or experiments; and for the Tier 3 method, all parameters should be country-specific and more accurate than the default values, and may include locally calibrated and validated simulation models.

E. Sustainability

115. Sustainability of the GEFSOC Modelling System and associated databases has been highlighted as a critical issue by the PSC. Scientists from case study countries have been trained in the use of the GEFSOC Modelling System, but they have expressed some concern regarding the on-going need for additional training. The major concern is that whilst the international community have provided excellent support and in-country training in preparing datasets and running the models, much of this activity is still heavily reliant on input from specialty staff from NREL or Rothamsted Research.

116. To date, no major planning exercise has been undertaken with respect to sustainability of the model products and enhancement of data for improving the quality and accuracy of outputs. USAID have provided funding for one year to allow this exercise to be undertaken by staff at NREL through the continued employment of the International Project Coordinator.

117. All of the case study scientists have reported that there will be on-going use and maintenance of the products (i.e. models and databases) within their countries, including short training courses to expose the products to other scientists and national agencies. The products will normally be utilised in development of refined estimates of greenhouse gas estimates as required by UNFCCC and considerable interest also exists with natural resource managers in all countries.

118. Exposure of the GEFSOC Modelling System to the international climate change and sustainable development community may provide the necessary impetus for other countries to invest in the implementation of the System within their own environment.

119. The CGIAR would be an obvious home for sustained activity and growth of the GEFSOC Modelling System, including its development as a major resource and decision-support tool across the developing world.

F. Stakeholder participation

120. The major stakeholders, case study countries and international collaborating institutions were all engaged in project development, and once approved, in the PSC and workshops held on a regular basis throughout the life of the project.

121. The International Project Coordinator also provided regular updates, and visits, to stakeholders, and scientists from both the case study countries and international collaborating institutions, and ensured engagement was maintained with all participants.

122. NREL, Rothamsted Research, ISRIC and IRD provided exceptional interaction with stakeholders and case study scientists, however, the participation of IIASA was not as evident and impacted on some of the final

outputs with respect to the development of future land use change scenarios and their adequate documentation.

G. Country ownership

123. The project was successful in developing databases and modelling tools for both greenhouse gas inventories and sustainable development in relation to land use management in four case study countries. In all countries, the level of ownership has been maximised by close cooperation between international collaborating institutions and the national institutions.

124. Project implementation was facilitated by the fact that national institutions provided an environment and in many cases additional resources to ensuring project outputs were delivered.

125. Case study country scientists are now trained in the use of the GEFSOC Modelling System, associated models such as Century and Roth C, and the IPCC approach, and the development of soil, climate and land use databases to ensure simulations can be performed.

126. All case study countries have indicated a willingness to promote, use and maintain the GEFSOC Modelling System, however provision of additional resources, including regular training updates from international institutions, would ensure country ownership is maximised.

H. Implementation approach (including monitoring and evaluation)

127. A preliminary monitoring and evaluation (M&E) plan was outlined in the original project proposal. This included the necessary M&E procedures and was consistent with the requirements of the implementing agency.

128. A comprehensive M&E plan was developed at the first meeting of the PSC which included provisions and timelines for, the collection and reporting of data relevant to the performance indicators identified for the project; the scheduling of workshops and PSC meetings for self-evaluation and assessment thus ensuring timely delivery of stated outcomes; descriptions of the roles and deliverables required by case-study countries, partner organisations and stakeholders (where necessary); the identification of additional resources, especially those required for M&E; and the final composition of the PSC and their specific role in M&E and project delivery.

129. PSC meetings were held at regular intervals and discussions and were both fluid and decisive, providing a clear path at all times to meeting objectives and project outcomes within the project time frame. All of the international collaborating institutions and representatives from the project team within the four case study countries were represented within the PSC and all were comfortable with the level of support provided by the PSC.

130. The project was designed and implemented as a series of interlinked Stages (Table 3). The performance indicators included a series of

interdisciplinary workshops specifically designed to assess progress and gain targeted feedback from acknowledged experts in preparation for the next stage. In total, three PSC meeting, and seven workshops were held, and each included activities consistent with M&E compliance as required by the implementing agency.

Table 3. Logframe of stages and performance indicators (workshops) held during the GEFSOC Project.

Quarter[1] / **Stage**[2]	1	2	3	4	5	6	7	8	9	10	11	12	13
Format long-term datasets & evaluate SOC models.		S W	S										
Define necessary spatial databases of SOC controlling variables.				S W	S W	S	S	S	S				
Develop methods to couple models with GIS.				S	S	S W	S						
Quantify current SOC stocks using modelling/GIS methodology.								S W	S	S	S		
Develop environmental and land-management change scenarios.									W	S	S		
Estimate change in SOC stocks & implementing of methodology.												S W	S

[1]Logframe based on three month intervals, with project commencing in July 2002 (Quarter 1)
[2]S = Scheduled Time Frame for each Stage as outlined in the Project Proposal; W = Workshop completed.

131. Comprehensive quarterly reports were supplied to UNEP by the International Project Coordinator which tracked progress against the logframe.

132. The project team produced a detailed Technical Report to supplement the required Terminal Report, which was of great benefit in the Terminal Evaluation of the project.

133. The International Project Coordinator of this project (from the University of Reading) provided excellent logistical, technical, monitoring and overall coordinating support to the project team. Her efforts were applauded by all team members and it is recognised that without this exemplary effort, under, at times, some difficult circumstances, the project may have erred.

134. The UNEP Project Task Manager provided excellent support to the International Project Coordinator and the project team.

135. The main assumption outlined in the project document was that the models (initially developed in the temperate US and UK) would be equally applicable to tropical regions. The use of long-term SOC data for model evaluation was successful and modifications to crop, forestry and pasture components of the Century model (in particular) were incorporated and

successfully tested, and applicable to the tropical and arid land management systems explored in this project.

136. The availability of data suitable for model evaluation also provided a major risk, however the validation procedure varied for each case study country and problems with accessibility to data was generally resolved within each country.

137. The potential for technical difficulties in relation to computer hardware and specific software in implementing the project was clearly outlined in the original project documentation. This was moreso the case with the GEFSOC Modelling System as it was originally designed with the assumption that there was sufficient local expertise in soils, land use, climate, and native ecosystems among the team of users for a specific case study country to build the necessary datasets and parameterise the model runs.

138. The international development team within the project recognized very early in the project that whereas there was generally good to excellent scientific knowledge in the four case study countries for assembling the necessary data, there was a lack of advanced skills in computer networking, GIS, and databases necessary for project implementation and meeting objectives within the stated time frames.

139. A comprehensive risk management strategy was outlined by the development team which minimized the need for technical expertise required to install the system, conduct data entry operations, run the models, and interpret the model output.

140. The risk management strategy included:

- Screen-by-screen tutorials for LINUX installation of the GEFSOC Modelling Systems so that users could run a companion PC, to guide them through the installation process.
- Automated GEFSOC system installation using the (reliable) LINUX operating system, which has the same look and feel of the Windows operating system with which the project members were more familiar.
- Simple instructions and training on how to use the less intuitive command-line terminal window, however, a simple Graphical User Interface (GUI) for the LINUX system is being developed that will bypasses the command-line entirely, allowing users to execute model runs with the push of a button. This should be completed prior to the end of 2005, before any new users would be in a position to begin model runs.
- Extensive expert training in the use of the Century and RothC models and the IPCC method for estimating SOC stocks and changes over time in response to land management. This also included provision of a large body of literature and tutorials to case study country scientists and first hand access to collaborating scientists who are internationally regarded as experts in the

development and use of Century and RothC models as well as the IPCC method.

- An easy-to-use system for constructing input datasets, and interpreting model output. These tasks are probably the most time-consuming and intricate. A system was designed so that users with basic skills in Microsoft Excel and GIS software would be able to create and manipulate datasets.
- An easy-to-use methodology for obtaining the system, specifically construction of a web page to allow downloading of the entire GEFSOC Modelling System, including an online user manual. Alternate access to the System is by contacting NREL directly, who will mail CD's directly to the user.

141. The proposal document also stated the risk that the newly-developed tool (now the GEFSOC Modelling System) may not be adopted by end users (i.e. national agencies in planning exercises and GEF in project selection) due to the contentious nature of land use management and the fact it may be used to help identify land management options which are socio-economically unacceptable to local communities.

142. To minimise this risk, land use scenarios were developed by the project team that were as realistic as possible, using current trends in land use. Whilst socio-economic considerations in this project are missing, it is recognised that socio-economic studies were outside the remit of this project. Funding is currently being sought to implement the GEFSOC Modelling System at a variety of scales with associated socio-economic information.

143. To further enhance the on-going use of the GEFSOC Modelling Systems, case study lead institutions were already part of, or had strong links with, national government departments and senior representatives were invited to participate in workshops.

144. To minimise the risk of the GEFSOC Modelling System not being used by the GEF in future projects, the project team has been informing existing GEF projects, such as Land Use Change, Impacts and Dynamics (LUCID) of their activities, including involvement in workshops, and a presentation at the Conference of Parties (COP) meeting in October, 2005.

145. The major constraint to the project in delivering outputs was the long delay in project approval which in turn resulted in the need for new project agreements to be signed with the Indian government and associated institutions. This effectively reduced the project duration in this case study by a year, but the national institutions provided the necessary additional man-power to ensure data was processed for completion of the tasks as originally contracted.

I. Replicability

146. The project has a high potential for replication across the developing world due to its well-ordered design, and the utilisation of generic data

structures of global significance (e.g. SOTER) that are compatible with a widely applicable decision-support environment i.e. GEFSOC Modelling System. It will be of particular use in the development of greenhouse gas inventories as required by the UNFCCC and in developing land management strategies for sustainable development.

147. There are plans to use the GEFSOC Modelling System in the GEF Land Degradation Assessment in Dry-lands (LADA) Project, which aims to build national, regional and international capacity to design and implement interventions to mitigate land degradation and establish sustainable land use and management practices. Part of the remit of LADA is also to consider impacts on carbon storage. The LADA project involves 6 countries Argentina, China, Cuba, Senegal, South Africa and Tunisia.

148. Model outputs from the GEFSOC Project Kenyan Case study will be used by the 'Agricultural Productivity and Sustainable Land Management' Project in Kenya (approved as a GEF full-sized project under OP #15).

149. The Brazilian Ministry of Science and Technology (MCT) plans to use outputs of this project as part of the Second National Communication to be submitted to the UNFCCC.

150. The GEFSOC Modelling System will be used in the National Aeronautical and Space Administration (NASA)-LBA proposal "Land-atmosphere exchanges of carbon dioxide and nitrous oxide associated with agricultural expansion in the Brazilian Amazon"

151. The site scale and national scale data sets for all of the GEFSOC case study countries will be used in the Quantifying and Understanding the Earth System (QUEST) Project in the UK, to calibrate soil components of a number of Digital Global Vegetation Models.

V. Conclusions and rating

152. The project has been successful in meeting or exceeding all stated objectives and outputs as required in the project documentation.

153. The project is an excellent example of team work between developed and developing-world institutions in delivering objectives and outcomes which have national and international benefit with respect to carbon management and the influence of land management and climate change.

154. Much of the success of this project is due to the enthusiasm of the team members, who, in the majority of cases, have worked beyond the bounds placed by the funds made available to this project. Only one international collaborating partner does not appear to have fully met its obligations, but the project team were able to work around this problem to ensure outcomes were delivered.

155. Special mention must be made of the International Project Coordinator. Her outstanding communication and coordination skills played a major part in the success of a rather complex, data intensive project across many countries.

156. On-going support for deployment and training in the use of the GEFSOC Modelling System must be considered a high priority by the GEF. This is a unique piece of software that will greatly assist national governments in improving their greenhouse gas inventories under UNFCCC requirements, as well as provision of a tool for improved land use management and sustaining or improving SOC stocks, a critical element for sustaining ecological productivity.

157. To this end, whilst a comprehensive risk management strategy was developed during the project, this must be re-visited in consultation with GEF and other donors to ensure longevity of the products or the significant investment made by GEF and its impact will be heavily discounted.

158. The only obvious deficiency in this project which may have impacted on implementation of the project was the non-inclusion of collaborating institutions aligned with the CGIAR. A closer association with the Centres within the CGIAR may have circumvented some of the problems which hampered the project with respect to acquisition and accessing of datasets. To this end, it is felt that whilst all objectives and outcomes were achieved, the validation of the models and access to data could have been significantly improved by access to other sources of information as provided by the CGIAR network.

159. Many of the international collaboration team were from developed world countries with little experience in developing world issues and interacting with respective national institutions and scientists. Some of these relationships take many years to build and without a direct line to the most appropriate national agencies and scientists, much activity is undertaken for little reward. This is a little surprising considering the relatively close association of some of the original proponents and promoters of this project to the CGIAR. Little, if any information has been forthcoming with respect to this lack of interaction with CGIAR Centres.

160. Collaboration with the CGIAR would also have provided a more structured and effective instrument for sustaining the project products and training necessary for continued maintenance and application. The CGIAR also have an on-going relationship with UNEP's GRID-Arendal, which could have played a significant role in this project. It is also not clear why GRID-Arendal were not part of this project.

161. The Technical Report provided an excellent document for assessment of project objectives and outcomes. The report however does lack some detail. Some modifications to improve clarity and transparency of the methodology have been outlined as recommendations within this evaluation.

162. The success of project implementation has been rated against categories determined by the UNEP Evaluation and Oversight Unit (Table 4).

Table 4. Rating[1] of GEF Project - Assessment of Soil Organic Carbon Stocks and Change at National Scale

Category	Comments	Rating
Attainment of objectives and planned results	All completed & detailed in reports	Highly Satisfactory
Achievement of outputs and activities	All completed and reported, incl. conferences	Highly Satisfactory
Cost effectiveness	Generous in-kind support	Highly Satisfactory
Impact	Potentially global	Highly Satisfactory
Sustainability	Funds required for training	Moderately Satisfactory
Stakeholders participation	Enthusiastic in the majority of cases	Satisfactory
Country ownership	Well supported & on-going	Satisfactory
Implementation approach	Structured and concise	Highly Satisfactory
Financial planning	Transparent and timely	Highly Satisfactory
Replicability	Generic methodology	Satisfactory
Monitoring and evaluation	Comprehensive planning	Satisfactory
Overall rating		Satisfactory

[1]The following rating system has been applied: Highly Satisfactory, Satisfactory, Moderately Satisfactory, Moderately Unsatisfactory, Unsatisfactory, and Highly Unsatisfactory.

VI. Lessons learned

163. The need for more detailed scoping of data availability and accessibility within developing world countries when a project is being developed.

164. The need for training of scientists through on-going GEF support – post project – to ensure sustainability and longevity of project products. This could be mandated as an essential element in project design and factored into project budgets.

165. The need for increased utilisation of experienced scientists from within the CGIAR, an organisation with close links to agricultural and natural resource management research in the developing world.

166. The need for increased utilisation of UNEP's own GIS and data warehousing facility e.g. GRID-Arendal in project implementation.

167. An examination of the GEF approval process is warranted, to ensure delays in project approval are significantly reduced thus avoiding problems associated with staff turnover and memoranda of understanding with respect to participation.

168. The need for increased accountability of collaborating institutions in providing support to ensure delivery of stated outcomes.

169. The need for a strong multidisciplinary project team, encompassing the relevant range of expertise with a willingness to collaborate, as demonstrated in this project, is essential

170. The need for a Project Coordinator with excellent team management, coordination and technical skills is essential for like projects across many countries where a large amount of technical data is required for completion of the project. This current project has provided an excellent example of such a person and the qualities required.

171. An examination of potential avenues available for GEF to directly fund collaborating institutions from the developed world. Funding from developed countries is becoming increasingly difficult to access as they have their own environmental problems to address. The inclusion of direct cash funds from GEF to support experts from the developed world must be examined more thoroughly or a situation will quickly arise where the best possible people are unavailable for these projects.

VII. Recommendations

172. The development of the Technical Report by the project team was an excellent means of conveying the technical aspects of a complex, data intensive project. The Technical Report, whilst not a requirement of the GEF reporting structure, could be significantly improved by provision of more detail on model evaluation for all the case studies.

173. It is noteworthy that a special issue is planned in a peer-reviewed journal to provide exposure of the project and the GEFSOC Modelling System to international scientific audiences. The provision of significantly more information in the Technical Report (as stated above) will greatly enhance the project's profile and credibility in the international climate change and land management community.

174. The application of the GEFSOC Modelling System as a decision support tool for quantitative assessments of SOC change in response to soil, management and climate depends heavily on the ability of the individual models to accurately predict SOC change. In future, greater emphasis should be placed on model validation, particularly when national level simulations are being performed. Acquisition of more datasets is critical in meeting this objective, and this could be enhanced by a closer relationship with the CGIAR, who are already in close contact and collaborating with national research institutions in the developing world.

175. It is unclear how the historical and current land management sequences for the IGP, as outlined within the Technical Report, were constructed (e.g. Section 6.4). Whilst there has been mention of datasets (section 6.1), what information existed within each, and how these were manipulated to provide sequences is unclear. Greater transparency in the representation of this methodology is required.

176. In future, for improved estimates of SOC stocks and change in Kenya, more emphasis must be placed on the acquisition of higher resolution climate, soil and land use data for this country.

177. Provision of more information with respect to the SOC outputs provided by both the RothC and IPCC methods for Jordan. The latter estimate provided through the GEFSOC Modelling System is 2-3 times greater than other estimates and requires investigation.

178. Provision of more information with respect to the development of future land use scenarios in all of the case study countries. It is recognised that support from IIASA was less than ideal and may have hampered development of these outputs, but little if any information is detailed in the Terminal and Technical Reports on how these future scenarios were developed.

179. In particular, the methodology described in the development of land management scenarios for the implementation Stages 4 and 5 is convoluted and lacks clarity. Replication of the information generated within these Stages would be extremely difficult based on the current description.

180. Whilst a methodology defining the development of future land use change scenarios is not mission-critical (as these scenarios can be ported from a variety of external sources), a methodology has already been developed and presented for estimating current stocks based on current land use estimates. It is highly desirable that a similar methodology be used for future land use scenarios to ensure compatibility and comparability in both space and time.

181. In future projects, explore the possibility of including estimates of associated greenhouse gases (i.e. nitrous oxide and methane) in the provision of a Global Warming Potential (GWP) estimates of farming systems and land use management. In many of the farming systems analysed in the current project, many of the components of the farming system (e.g. animals and rice), are significant contributors to the global methane (CH_4) budget and could potentially offset much of carbon sequestered in soils through improved land management. Both mineral and organic forms of nitrogenous fertiliser are also major sources of nitrous oxide (N_2O). With the increased use of these products in the developing world, this loss must also be accommodated to ensure realistic assessments of emissions (in terms of carbon equivalents) are made in the development of projects which are designed to produce carbon credits.

182. In future projects, explore the need, scope and availability of socio-economic data associated with decision making at farm, regional and national

level which may influence the actual selection of land management practices in both space and time, and their impact on SOC accumulation. Data presented in this current project only provides estimates of "potential" changes in SOC and must be supplemented in future to include over-arching socio-economic drivers of sustainable production in the developing world. Much of the farm level information is normally accessible through Economics Programs associated with Centres within the CGIAR.

183. There is a great need to sustain the momentum built up within this project, especially with respect to the further development and maintenance of the GEFSOC Modelling System, country-specific databases and training of more scientists in the use of the System and acquisition of more data. The CGIAR may provide the avenue for sustaining the initiative until a new project is developed and implemented.

184. The project team have developed a detailed risk management strategy for provision of software and training in the use of the GEFSOC Modelling System. On-going support for these activities and the complexity of the System does require detailed instruction which cannot be provided over the web. Whilst model architecture was modified to accommodate constraints in the developing world with respect to computer hardware and software, continued exposure and testing by developing world scientists must be undertaken as a priority to enhance useability and impact.

185. A natural extension of this project would be to increase the potential of the GEFSOC Modelling System by incorporating a standardised climate database, similar to the New_LocClim structure developed through collaboration between FAO and the German Weather Service (DWD), more specifically the Global Precipitation Climatology Centre.

ANNEX A. QUESTIONNAIRES USED IN THE EVALUATION

GEFSOC International Stakeholder Questionnaire

1. Was your organisation actively involved in any aspect of project development?
2. Did the project address activities and outcomes and products of low, high or critical significance to your organisation?
3. From your experience/exposure to this project to date, have these activities and outcomes been completed to your organisation's satisfaction?
4. Did your organisation actively participate during the project implementation phase?
5. Did your organisation participate in annual workshops or reporting activities, or have access to materials for comment during the life of the project? Please provide any relevant information.
6. Will the outputs (not products) contribute to others projects with your organisation?
7. Will the products (models/databases) contribute to others projects with your organisation?
8. Have any of the project outputs/products been conveyed or presented to policy officers within your (or related) organisation and have there been any responses/reactions?
9. Have any of the project outputs been conveyed or presented to the scientific community in relation to international agreements (e.g. IPCC)?

GEFSOC In-Country Stakeholder Questionnaire

1. Was your organisation actively involved in all levels of project development?
2. Where the financial and technical needs of your organisation adequately addressed in the project proposal?
3. Briefly outline how cash funds were expended? Dollar amounts are not required, activities only need to be specified.
4. Briefly outline how your own organisations in-kind funds were expended? Dollars amounts are not required, activities only need to be specified.
5. Did you organisation provide in-kind funds in addition to that specified in the project document & budget? Dollar amounts are not required, please express as a % of original contribution.
6. Did your organisation actively participate in activities which facilitated project implementation (e.g. Steering Committee consultation and/or other groups)?
7. Where all the needs of your organisation's project staff (as agreed with the GEFSOC Project Coordinator) met during the course of the project?
8. Where your project team members adequately trained to complete tasks by collaborating institutions? If, not, please provide more details.
9. Was the Project Coordinator effective in managing the project?
10. Was the Steering Committee effective in overseeing the project?
11. Will the outputs (not products) contribute to related projects within your country or region – either current or new? For example, refinement of IPCC Inventories, farming system sustainability etc.

12. Will the products (models/databases) contribute to related projects or within your country or region? For example, refinement of IPCC Inventories, farming system sustainability etc.
13. Are the products (models/databases) capable of being used in other organisations/regions of your country?
14. Will the on-going use of these products (models/databases) require specialist staff and on-going training from external partners?
15. Will it be possible for your own staff to provide training to other organisations in your country?
16. What is the likelihood of these products (models/databases) being maintained by your own organisation?
17. Has the Steering Committee provided a plan for future maintenance, use and updates of the products (models/databases)?
18. Has any of the project outputs been conveyed or presented to policy officers within your government and have there been any responses/reactions, particularly with respect to regional, national projects and international agreements?
19. Where there any unforeseen problems that hindered progress, from either internal or external sources?
20. How could your involvement in the project been improved (if at all)?
21. Did the project meet your organisation's expectations in terms of:
    a. It's own objectives for participating?
    b. Capacity building?
    c. Collaborative assistance?
    d. Finances received?
    e. Return on in-kind investment?
    f. On-going support?
    g. Flow-on effects – use of outputs & products for other projects etc?

    IN THIS LAST QUESTION, ONLY ELABORATE IF YOU HAVE ANSWERED "NO".

<u>GEFSOC Collaborating Institution Questionnaire</u>

1. Was your institution actively involved in any aspect of project development?
2. Where the financial and technical needs of your institution adequately addressed in the project proposal?
3. Briefly outline how cash funds were expended? Dollar amounts are not required, activities only need to be specified
4. Briefly outline how your institution's in-kind funds were expended? Dollars amounts are not required, activities only need to be specified.
5. Did your institution provide in-kind funds in addition to that specified in the project document & budget? Dollar amounts are not required, please express as a % of original contribution.
6. Did your institution actively participate in activities which facilitated project implementation (e.g. Steering Committee consultation and/or other groups)?
7. Where all the needs of your institution's project staff (as agreed in project documentation) met during the course of the project?

8. Will the outputs (not products) contribute to others projects with your institution.
10. Will the products (models/databases) contribute to others projects with your institution.
11. Will it be possible for your institution to provide some degree of on-going support to key collaborators in future? Will additional funding be required?
12. What is the likelihood of these products (models/databases) being maintained by your own institution?
13. Has the Steering Committee developed a workable and agreed plan for future maintenance, use and updates of the products (models/databases)?
14. Has any of the project outputs/products been conveyed or presented to policy officers within donor agencies with your country and have there been any responses/reactions?
15. Has any of the project outputs been conveyed or presented to the scientific community in relation to international agreements (e.g. IPCC).
16. Where there any unforeseen problems that hindered your progress, or ability to collaborate, from either internal or external sources?
17. How could your involvement in the project been improved (if at all)?
18. Did the project meet your institution's expectations in terms of:
    a. Its own objectives for being involved?
    b. Project coordination?
    c. Finances received?
    d. Return on in-kind investment?
    e. Flow-on effects – use of outputs & products for other projects etc?

    IN THIS LAST QUESTION, ONLY ELABORATE IF YOU HAVE ANSWERED "NO".

ANNEX B. PERSONS CONTACTED DURING THE EVALUATION

Brazil visit
Dr Carlos Cerri (CENA) and staff
Dr Carlos Eduardo Cerri (CENA)

Phone interviews
Mohamed Sessay (UNEP)
Mark Easter (NREL)
Eleanor Milne (now NREL, ex U. Reading)

Questionaires
This represents approx 50% of total requested.

Independents
W. Troy Baisden, Ph.D.
http://www.landcareresearch.co.nz/research/greenhouse/files/staff_profiles/p_troy_baisden.asp
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Dr. Louis V. Verchot
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International Centre for Research in Agroforestry
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Prof Olle Andren
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Charles W. Rice
Professor of Soil Microbiology
Director, CASMGS and Kansas EPA-EPSCoR Program
Kansas State University
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Stakeholders

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ICRAF

Patricia Garffer
p.garffer@usaid.gov

International collaborators

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NREL-CSU
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World Data Centre for Soils
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ANNEX C. TERMS OF REFERENCE FOR THE EVALUATION.

TERMS OF REFERENCE

Terminal Evaluation of the UNEP GEF "Assessment of Soil Organic Carbon Stocks and Change at National Scale" GF/2328-2740-4381 PMS GF/1030-02-01

1. BACKGROUND

Project rationale

"Assessment of Soil Organic Carbon Stocks and Change at National Scale" is a medium-sized, targeted research project that relates to carbon sequestration and is aimed at GEF Operational Programme no. 12: Integrated Ecosystem Management. The project is designed to improve national assessment methodologies relating to land use options and UNFCCC requirements, and to support core activities of the GEF Integrated Ecosystem Management Operational Programme and Inter-governmental Panel on Climate Change, IPCC, by developing and demonstrating generic tools for quantifying the impact of land management options and climate scenarios on carbon sequestration in soils.

The main research objectives include:

1. To identify and use long-term experimental datasets to systematically evaluate and refine modelling techniques that allows the estimation of carbon sequestration in tropical soils.
2. To define, collate and format national-scale soils, climate and land-use datasets and to use them in the development of coupled modelling-GIS tools to estimate soil carbon stocks.
3. To demonstrate these tools by estimating current soil organic carbon stocks at country-scale (using India, Jordan, Kenya and Amazon-Brazil as case studies) and to compare these estimates with the existing techniques of combining soil mapping units and interpolating point data.
4. To quantify the impact of defined changes in land use on carbon sequestration in soils with a view to assisting in the formulation of improved policies to optimise resource use in the four case-study countries.

The expected outcomes from this targeted research project include:

1. Data from national data sources of variables relating to the control of carbon stocks in Brazilian, Indian, Jordanian and Kenyan soils systematically collated and formatted in standardised GIS formats and fed into national greenhouse gas inventories.
2. Regional-/National-scale quantities of carbon stored in Amazon-Brazilian, Indian, Jordanian and Kenyan soils estimated and critically compared with soil mapping methodologies, and maps of land-use and carbon density derived.
3. Capacity building in the use of GIS-model interfaces and soil organic carbon stock assessment.
4. Generic tools designed to help formulate national and sub-national level policy by (i) quantifying current soil organic carbon stocks at national and sub-national level; and (ii) analysing the impacts of land management options on carbon storage, GHG emissions and sequestration possibilities.

5. Tools developed to help GEF identify and select possible national carbon sequestration projects, and guide their development and implementation.

Relevance to GEF Programmes

The project falls under GEF Operational Programme no. 12: Integrated Ecosystem Management and cross-cuts over to climate change, biodiversity and land degradation programmes thereby linking and adding value to all three.

Executing Arrangements

The project was executed by the University of Reading, UK on behalf of an international consortium comprising scientific agencies in Brazil (Centro de Energia Nuclear na Agric, Universidade de Sao Paulo and Ministry of Science and Technology); India (National Bureau of Soil Survey and Land Use Planning); Jordan (Higher Council for Science and Technology/Badia Research and Development Programme) and Kenya (Kenya Soil Survey) together with representatives from scientific collaboration groups in the US (Natural Resources Ecology Laboratory, Colorado State University), UK (Rothamsted Experimental Station), the Netherlands (International Soil Reference and Information Centre), Austria (International Institute for Applied Systems Analysis) and France (Istitut de Recherche de Developpement, IRD).

All activities were managed and coordinated on a day-to-day basis by the International Co-ordinator, in consultation with UNEP/DGEF. The Project Steering Committee was composed of The University of Reading, as the executing agency, the international consortium comprising scientific agencies in the participating countries and the scientific collaboration groups. The mandate of the Project Steering Committee was to decide on the scientific and technical direction of the project, as well as approve financial and work plans. During the project three annual steering committee meetings were held and members of the PSC also met at the projects workshops. Details of the PSC meetings can be found on the website at (http://www.reading.ac.uk/ GEFSOC/proj_com_meet.htm).

Project Activities

The initial project duration was 39 months, from January 2002 to March 2005 but implementation started six months late in June 2002; and hence the project will end in July 2005.

Implementation of project activities was planned in six steps:

1) Formatting long-term datasets and evaluating and refining SOC turnover models for India, Jordan, Kenya and Brazil
2) Defining necessary spatial databases of SOC controlling variables and collating and formatting national datasets.
3) Developing methods to couple models with GIS to assess current SOC stocks.
4) Quantifying current SOC stocks using modelling/GIS methodology and comparing with non-modelling methods.
5) Developing "realistic" environmental and land management change scenarios.
6) Estimating scenario-based change in SOC stocks and development of guidelines for implementing the methodology and national scale.

A workshop was planned for each step.

Budget
The total budget was US$ 2,002,000, with US$ 978,000 funded by the GEF Trust Fund, and US$ 1,024,000 as counterpart contributions of which one third (US$ 370,000) has been obtained from grants and two-thirds from in-kind contributions.

2. OBJECTIVE AND SCOPE OF THE EVALUATION

The objective of this terminal evaluation is to establish project impact (ref. objectives & outcomes), project performance, and review and evaluate the implementation of planned project activities and outputs against actual results. The focus will be on four main questions:

1) To what extent has the development and demonstration of the methodology (generic tools) for assessing soil organic carbon stocks helped national agencies improve their capacity for analysis of land use options in the context of the UNFCCC?

2) Are the tools developed timely and relevant to the work of the Intergovernmental Panel on Climate Change, IPCC?

3) Are the modalities for international collaboration on land management scenarios generation, capacity building and analysis developed by this project functional, sustainable and replicable?

4) To what extend does this project contribute to the objectives of OP12 on integrated ecosystem management?

The evaluation will assess, among other things;

- **Delivered outputs: Assessment of the project's success in producing each of the programmed outputs, both in quantity and quality as well as usefulness and timeliness.**
- **Project outcomes and impact. Evaluation of the project's success in achieving its outcomes and likelihood of impact.**
- **Sustainability**
- **Execution performance: Determination of effectiveness and efficiency of project management and supervision of project activities.**

The analysis of impact and outcomes achieved should include, *inter alia*, an assessment of the extent to which the project has (1) improved national assessment methodologies relating to land use options and UNFCCC requirements; and (2) supported core activities of the GEF Integrated Ecosystem Management Operational Programme.

The sustainability assessment should include the enabling environment, institutional and financial sustainability, stakeholder ownership and national institutional framework and governance and whether project was successful in identifying and engaging (leveraging co-finance) funding sources as a result of improved focusing and credibility of future interventions, realistic budgeting and in following good financial management practices.

The evaluator shall include an assessment of the quality and application of project monitoring and evaluation plans and tools, including an assessment of risk management based on the assumptions and risks identified in the project document.

The evaluator shall make recommendations that may contribute to the assessment and development of GEF's portfolio of projects, particularly with respect to OP12.

The evaluator will rate the overall implementation success of the project and provide individual ratings of implementation aspects as described in Section 3 of this TOR. The ratings will be presented in the format of a table with brief justifications based on the findings of the main analysis.

Furthermore, the evaluation should highlight lessons learned, both the positive as well as the negative, from the standpoint of the design and implementation of the project geared towards enhancing GEF programmatic planning.

The evaluation should also include a breakdown of final actual costs and co-financing for the project prepared in consultation with the relevant UNON/DGEF Fund Management Officer of the project (table attached in Annex 1 Co-financing and leveraged resources).

The scope of the evaluation is as specified in the "Global Environment Facility Guidelines for Implementing Agencies to conduct Terminal Evaluations, May 2003" to evaluate the activities supported by GEF through this project. The "achievement" indicators provided in the log frame of the project document should be used together with the evaluation parameters of appropriateness, effectiveness and efficiency, impact and sustainability.

3. TERMS OF REFERENCE

In particular but not restricted to, the evaluator shall do the following under the categories defined below;

1. Attainment of objectives and planned results:
    - Evaluate how, and to what extent, the stated project objectives have been met, taking into account the "achievement indicators". In particular, evaluate whether and to what extent the results of this project have informed national or international processes such as greenhouse gas inventories, the IPCC or others.
    - Ascertain the nature and significance of the contribution of the project outcomes to the wider portfolio of GEF Operational Programme no. 12: Integrated Ecosystem Management;

2. Achievement of outputs and activities:
    - Asses the scope, quality and usefulness of the project outputs in relation to its expected results.
    - Assess the soundness and effectiveness of the various methodologies developed as well as their relevance for assessing soil organic carbon stocks and change and the impact of land management options and climate scenarios on carbon sequestration in soils at national and sub-regional scale.
    - Assess to what extent project outputs produced have the weight of scientific authority necessary to influence policy makers, particularly the GEF and its Implementing Agencies.

3. Cost-effectiveness:

- Assess the cost-effectiveness the activities of the project which was funded by GEF and whether these activities achieved the goals and objectives within planned and/or reasonable time and budget
- Assess the contribution of cash and in-kind co-financing to project implementation and to what extend the project leveraged additional resources.
- Determine the extent to which external scientific and technical information and knowledge have been incorporated and have influenced the execution of the project activities.

4. Impact:
    - Evaluate the immediate impact of the project on scientific research and on policy development and decision making in the participating countries and other possible impacts.
    - As far as possible, also assess the potential longer-term impacts, considering that the evaluation is taking place upon completion of the project and that longer term impact is expected to be seen in a few years time.

5. Sustainability:
    - Ascertain to what extent the project outcomes will be sustained and enhanced over time.

6. Stakeholder participation:
    - Assess the mechanisms put in place by the project for identification and engagement of stakeholders and establish, in consultation with the stakeholders, whether this mechanism was successful, its strengths and weaknesses. Particular attention should be paid to the level of participation by scientists and national government institutions/organisations in the participating countries (Brazil, India, Kenya, Jordan).
    - Assess the degree and effectiveness of collaboration/interactions between the various project partners and institutions during the course of implementation of the project. .

7. Country ownership:
    - Assess the level of country ownership. Specifically, the evaluator should assess whether the project was relevant for national development and environmental agendas and to the regional and international agreements.

8. Implementation approach:
    - Ascertain to what extent the project implementation mechanisms outlined in the project document have been closely followed. In particular, assess the roles of the Project Steering Committee and whether the project document was clear and realistic to enable effective and efficient implementation, whether the project was executed according to the plan and how well the management was able to adapt to changes during the life of the project to enable the implementation of the project.
    - Evaluate the effectiveness of project execution arrangements at all levels (1) policy decisions; Project Steering Committee; (2) day to day project management; the Core Team and scientific leadership.

- Assess the effectiveness of supervision and administrative and financial support provided by UNEP/DGEF.
- Identify administrative, operational and/or technical problems and constraints that influenced the effective implementation of the project.

9. Replicability:
    - Assess whether the project has potential to be replicated, either in terms of expansion, extension or replication in other countries and/or regions and whether any steps have been taken by the project to do so and the relevance and feasibility of these steps.

10. Monitoring and Evaluation:
    - The effectiveness of the monitoring mechanisms employed throughout the project's lifetime; and how effective the project responded to the challenges identified through these mechanisms.

4. METHODOLOGY AND RATING

This terminal evaluation will be conducted as an in-depth evaluation using a participatory approach whereby the UNEP/GEF Task Manager, and other relevant staff is kept informed and regularly consulted throughout the evaluation. The consultant will consult with the UNEP/EOU and UNEP/DGEF Task Manager on any logistic and/or methodological issues to properly conduct the review in as independent a way as possible given the circumstances and resources offered.

The findings of the evaluation will be based on the following:

1. A desk review of project documents including, but not limited to:
    (a) The project documents, outputs, monitoring reports (such as progress and financial reports to UNEP and GEF annual Project Implementation Review reports) and relevant correspondence.
    (b) Review of specific products including computer software programmes (e.g. GEFSOC Modelling System), publications in international journals, peer-reviewed books, regional synthesis papers, reports from regional workshops as well as national case studies, highlighting case studies, technical information, research results, methodological guidelines, strategies and recommendations related to wider application of the generic tools and methodological approach developed by the project;
    (c) Notes from the Steering Committee and Technical Advisory Committee meetings
    (d) Other material produced by the project team
    (e) Project Web site, www.rdg.ac.uk/GEFSOC

2. Interviews with project management (such as International Project Coordinator, Scientists, Admin. & Finance Personnel in University of Reading, UK) and telephone interviews with members of collaborating groups and core team members in the USA, UK, Netherlands and Austria, as well as the Project Steering Committee.
3. Interviews and Telephone interviews with other stakeholders in the four participating countries, which were involved with this project. As appropriate, these interviews could be combined with an email questionnaire;

4. The Consultant shall determine whether to approach other representatives of donor agencies or stakeholder groups (Steering Committee members, representatives of the IPCC, national government officials in charge of Climate Change in the four participating countries, etc.). The task should then be performed by e-mail or telephone communication.

5. Interviews with the UNEP/DGEF project task manager and Fund Management Officer, and other relevant staff in UNEP/DGEF as necessary.

The success of project implementation will be rated on a scale from 'highly unsatisfactory' to 'highly satisfactory'. The following items should be considered for rating purposes:

- Attainment of objectives and planned results
- Achievement of outputs and activities
- Cost-effectiveness
- Impact
- Sustainability
- Stakeholders participation
- Country ownership
- Implementation approach
- Financial planning
- Replicability
- Monitoring and Evaluation

A brief terminology of the implementation aspects is available upon request. Each of the items should be rated separately and then an overall rating given. The following rating system is to be applied:

HS = Highly Satisfactory
S = Satisfactory
MS = Moderately Satisfactory
MU = Moderately Unsatisfactory
U = Unsatisfactory
HU = Highly Unsatisfactory

5. EVALUATION REPORT FORMAT AND PROCEDURES

The evaluation report shall be a detailed report, written in English, of no more than 25 pages (excluding annexes) and include:

i) An executive summary (no more than 3 pages)
ii) Introduction and background
iii) Scope, objective and methodology
iv) Project Performance and Impact
v) Conclusions and rating of project implementation success
vi) Lessons learned
vii) Recommendations
viii) Annexes, if any, fully typed.

The final report shall be submitted in electronic form in MS Word format and should be sent to the following persons:

Segbedzi Norgbey, Chief, Evaluation and Oversight Unit
UNEP, P.O. Box 30552
Nairobi, Kenya
Tel.: (254-20) 624181
Fax: (254-20) 623158
Email: segbedzi.norgbey@unep.org

With a copy to:

Ahmed Djoghlaf, Director
UNEP/Division of GEF Coordination
P.O. Box 30552
Nairobi, Kenya
Tel: + 254-20-624166
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Mohamed Sessay
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Division of GEF Coordination (DGEF)
PO Box 30552
Nairobi, Kenya
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The evaluation report will be printed in hard copy and published on the Evaluation and Oversight Unit's web-site www.unep.org/eou. Subsequently, the report will be sent to the GEFSEC for their review and inclusion on the GEF website.

6. RESOURCES AND SCHEDULE OF THE EVALUATION

The contract for this evaluation will begin on 25th August 2005 and end on 20th October 2005 [a month's work (30 days) spread over 8 weeks]. The consultant will submit a draft report to EOU on 26th September 2005, with a copy to the UNEP/GEF Task Manager for initial comments. Comments to the final draft report will be sent to the consultant by 7th October 2005 the latest after which the consultant will submit the final report no later than 20th October 2005.

The Consultant may travel to one of the case study countries, if deemed feasible, preferably Brazil to conduct in-depth discussions with participating national scientists and collaborating institutions.

In accordance with UNEP/GEF policy, all GEF project are evaluated by an independent evaluator contracted by the EOU. The evaluator should not have been associated with the design and implementation of the project. The evaluator will work under the overall supervision of the Chief, Evaluation and Oversight Unit, UNEP. The evaluator should have the following minimum qualifications: (i) experience with project management and

implementation and in particular with targeted research projects that generate policies/strategies, knowledge and information; (ii) scientific expertise in the subject matter (soil science, modeling and GIS); (iii) experience with projects in developing countries, and (iv) Project evaluation. Knowledge of UNEP programmes and GEF activities is desirable and a working knowledge of the Portuguese Language is also required.

7. SCHEDULE OF PAYMENT

The evaluator will receive an initial payment of 30% of the total amount due upon signature of the contract. A second payment of 30% upon submission of draft report and final payment of 40% will be made upon satisfactory completion of work. The fee is payable under the individual SSAs of the evaluator and is NOT inclusive of all expenses such as travel, accommodation and incidental expenses. Ticket and DSA will be paid separately. Consultant will buy his ticket and be reimbursed by the organisation after travelling.

In case, the evaluator cannot provide the products in accordance with the TORs, the timeframe agreed, or his products are substandard, the payment to the evaluator could be withheld, until such a time the products are modified to meet UNEP's standard. In case the evaluator fails to submit a satisfactory final product to UNEP, the product prepared by the evaluator may not constitute the evaluation report.

ANNEX D. CO-FINANCING AND LEVERAGED RESOURCES

Co financing (Type/Source)	IA own Financing (US$)		Government (US$)		Other* (US$)		Total (US$)		Total Disbursement (US$)	
	Planned	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**	**Planned**	**Actual**
– Grants			160,000	20,000	693,000	313,919	853,000	333,919		333,919
– Loans/Concessional (compared to market rate)										
– Credits										
– Equity investments										
– In-kind support			50,000	172,026	186,880	409,232	236,880	581,258		581,258
– Other (*)										
II. Totals			210,000	192,026	879,880	723,151	1,089,880	915,177		915,177

* Other is referred to contributions mobilized for the project from other multilateral agencies, bilateral development cooperation agencies, NGOs, the private sector and beneficiaries.

ANNEX E. FINANCIAL STATUS OF PROJECT AT TIME OF EVALUATION

Prepared by the DGEF Fund Management Officer

Project title:	Assessment of Soil Organic Carbon Stocks and Change at National Scale
Project no.:	GF/2328-2740-4381 PMS GF/1030-02-01
Duration:	39 months - originally January 2002 to March 2005 but implementation started six months late, hence the project ended in July 2005.

Total GEF Contribution = $0.98M

Budget remaining = $3,270

Co-financing (see Annex D)
Pledged $1.09M
Received $0.92M

The project was not officially "closed" at the time of the evaluation. The project had been extended to July 2005 and, within UNEP rules, the Executing Agencies submitted final financial reports within 90 days. The financial report included the audit fee as committed but not yet paid.

Implementation of the project made use of 100% of the project budget; all expenses are accounted for pending receipt of the final statement which will reflect audit fee of $3,720 paid.

During the life of the project there were 3 revisions financial revisions; all were year-end mandatory revisions to reflect actual expenditures and carry forward unspent funds. The Executing Agency demonstrated good planning by requesting an extension of three months in the very first revision - this was to cater for the delayed start of project - rather than waiting for the last month when extension was due. A final extension of one more month (July 2005) was granted to finalise reports etc. The major transfer of resources between budget lines was within UN limits (approx 20%). This was mainly due to the project co-ordinator's salary (three months extension) and some changes in UK salary scales last year (2004). The project showed savings from training workshops and equipment.

Overall Assessment of Executing Agency by DGEF.

Financial aspects of this project were well-managed by the executing agency and were rated by DGEF as exemplary. Budget revisions were few and those made are adequately justified. GEF funds have been fully accounted for and officially audited.