Soil Management
Collaborative Research Support Program

Grant Extension Proposal

Project Proposals

Volume 2

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NuMass

Testing, Comparing, and Adapting NuMaSS:
The Nutrient Management Support System

University of Hawaii

Adoption of the Nutrient Management
Support System (NuMaSS)
Software Throughout Latin America

North Carolina State University

Testing, Comparing, and Adapting NuMaSS:
The Nutrient Management Support System

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Testing, Comparing, and Adapting NuMaSS: The Nutrient Management Support System

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A revised proposal submitted to the Soil Management Collaborative Research Support Program by the University of Hawaii

Acronyms:
IRRI: The International Rice Research Institute, Philippines
CSAR: Centre for Soils and Agroc1imate Research, Indonesia
CARES: Center Agricultural Research and Ecological Studies, Vietnam
ISRA: l'Institut Senegalese de Recherche d'Agricole, Senegal
IER/Mali: l'Institute d'Economie Rurale, Mali
NARI: The National Agricultural Research Institute: The Gambia
INIDA: Instituto Nacional de Investigacoes de Agricultura, Cabo Verde
IFDC: International Fertilizer Development Center, USA
TSBF: Tropical Soil Biology & Fertility, Nairobi, Kenya
CIA T: Centro Internacional de Agricultura Tropical, Colombia

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Problem Statement

Improving soil nutrient status in support of food and income is a challenge for farmers, regardless of their land holding size and location in the world. In Africa and Southeast Asia, this challenge is even greater due to high population growth rates of 2 to 3 percent per year and resulting high land densities. These factors combined with others, such as lack of non-farm income sources, severe soil fertility depletion, excessive soil acidity, and very low levels of fertilizer use (4 to 7 kg/ha in Africa), result in chronic food insecurity for an increasing number of rural people. Paradoxically, a growing number of agricultural systems of the tropics are also leaking nitrogen and phosphorus into the groundwater and downstream water bodies. Such extremes call for improved management of nutrient stocks and flows.

Four example opportunities for improved nutrient management are given. Improved nutrient management opportunities in sub-Saharan Africa and South East Asia illustrate characteristic facets of nutrient management problems. In sub-Saharan Africa, per capita cereal production has declined an average of over 1 % per year from 1961-1991 (Sanders et al., 1996, pp. 3-5). The current low-input agriculture cannot meet the 4% annual increase in food production needed to keep pace with a burgeoning population (Shapiro et al., in review). Several factors contribute to such decreases in productivity, including disappearance or reduction of fallow land and loss of its nutrient regenerating benefits (Berthe et al., 2000). Amounts of animal manures are insufficient to meet this demand (Badiane,1993): e.g., only 1 to

3 tonnes of manure per hectare are available, which can seldom supply more than 20 percent of the needs of productive cereals. The result is a net "mining" or progressive decrease in nutrients and nutrient capacity to support and sustain crop growth and production: Smaling et al. (1997: p.52) records losses of22 kg ha.1 of nitrogen, 2.5 kg ha.1 of phosphorus, and 15 kg ha^{-1} of potassium per year in sub-Saharan Africa.

The impact of declining soil nutrient status has been particularly severe for the poorest percentage of the populations, including female-headed households in Africa (Gladwin et al., 1999), because their livelihoods are so closely linked to food and agricultural production and because they often produce the majority of the food consumed in the household. Another often hidden result of soil nutrient mining and depletion is the declining protein availability in household diets resulting from a cropping shift from grain crops to lower protein-producing crops such as cassava, yams, and enset (Hiebsch and Dougherty, 2000). Poor farmers' inabilities to apply adequate amounts of nutrients to high-protein crops is often the result of bad macroeconomic policies resulting in distorted "macro" prices (overvalued exchange rates, distortedly-low product prices and high input prices) as well as a lack of infrastructure (markets, electricity, roads, transportation, credit and banking institutions).

Another facet of nutrient management problems is illustrated in the Philippines, where food production is traditionally equated with lowland rice production (Corton et al., 2000). Until very recently, the upland soils were of little interest to mainstream agriculture; they could not easily be converted into paddy rice systems and were not even surveyed at a reconnaissance level. An anecdote from a recent study site in the Philippine uplands illustrates the common perception about upland soil potential. An experiment site was provided by villagers for an SM-CRSP study testing upland technology. The site was well-known; nearly every crop planted there failed inexplicably. Decision aids, however, recommended soil acidity amelioration and the provision of the nutrient phosphorus, based on the hypothesis that food production was particularly limited by excessive acidity and low nutrient status. As a result the legumes peanut and mung bean --local culinary favorites -- grew beautifully. To the amazement of farmers, maize, rice, and soybean are now producing well at the site. Local markets, however, do not yet offer the liming products needed to restore such soils to productivity, although this is likely to change soon due to intense land pressures, reflected by the recent increases in upland rice areas from 85,000 to 137,000 ha (George et al., 1999).

This site, further information now indicates, is not atypical. A recent survey of soils of the near the village of San Antonio, Isabela Province, including the site referred to above, indicates that the soils are not only highly acidic with aluminum toxicity, but are also manganese toxic (PhilRice,2000). The Philippine Bureau of Soils and Water Management reported for the first time in 1999 that soil surveys indicate there are 8.1 million ha of Ultisols, soils characterized by high acidity and low nutrient contents, covering nearly 27% of the country. At present, the use of these upland soils are restricted by the lack of nutrient management options available to farmers, which constrain food production not only in the Philippines but also in Laos and Vietnam (Corton 2000). As well as other sites that comprise the IRRI Uplands Consortium.

A third facet of the nutrient management constraints is illustrated in Thailand, SE Asia, where inappropriate fertilizers and the lack of soil information are considered problems in nutrient management. For example, farmers in Thailand apply a standard formula of fertilizer irrespective of crop needs (Attanandana, personal communication, 2000). At present, little attention is given to soil differences. Private fertilizer companies do not have research divisions to disseminate information on optimal fertilizer levels to the farmers. In some cases even the fertilizer distributor cannot be changed to apply variable amounts of fertilizers. The western model of a central soil testing laboratory that receives and tests a significant portion of soils from the surrounding agricultural community is not appropriate for the small Asian farmer, who may be farming one hectare in total, but on perhaps 10 separate fields. Clearly a new approach to nutrient deficiency diagnosis is needed on such small land parcels. The challenge of improved nutrient management of such small parcels is not unique in SE Asia but is typical of growers in many tropical regions in not only SE Asia, but also Central and South America as well as sub-Saharan Africa.

Recent work by a project supported by the Thailand Research Fund (TRF) gives an alternative to the Western, high tech model of collecting soil samples, sending them to a central laboratory, receiving a generic recommendation and then receiving the results a couple of weeks later. In this approach soils are tested on site with a calibrated soil test kit and the results are also entered on site, into a simplified decision-aid installed in a handheld computer (Attanandana et al, 2001). This approach will undergo field testing in the 2002 cropping year with TRF support. We believe the approach has possibilities in the small farm agriculture of SE Asia as well as Latin American and Africa.

A fourth facet of the nutrient management crisis has been seen in both Asian and African contexts. Since the early 1990s, structural reforms (such as the removal of fertilizer and credit subsidies) and recurrent devaluations of domestic currencies have made chemical fertilizers unaffordable for most smallholder households in southern Africa, with the result that hungry seasons have lengthened from two to five months in some locations and many more households are now chronically food-insecure (Kebbeh, 1999; Berthe et al., 1999; Gladwin, Uttaro, and Anderson 1999). Following the Asian crisis of 1997, similar macro-economic pressures have resulted in similar changes being made at the micro level in Southeast Asia.

Giving the farmer a choice between several recommended soil technologies further allows farmers to take ownership of, and responsibility for, the process of soil fertility replenishment on their own land, and empowers them. As suggested by Haggith et al (2001), one of the ways that may be useful for increasing technology adoption is for the technology to enhance the position of the user. Extension and NGO farm advisors, therefore, require tools or decision aids that present several soil fertility technologies to farmers in an organized fashion with explicit descriptions of assumptions and cause/effect relationships. Such a decision guide would assist farmers, farm advisors, and policy makers in understanding the benefits and costs as well as the resource requirements of each technology; and can synthesize options for a wide variety of smallholder farmers with varying resources of land, labor, capital, and knowledge.

One such aid could be NuMaSS (the Nutrient Management Support System), a software program with the specific intent of facilitating the transfer and access of soil nutrient management information between research centers and decision makers at the farm, extension, and policy levels. Based on user replies to questions about soils, crops, available nutrient sources and input-output prices, the decision support system diagnoses a nutrient deficiency in nitrogen (N) and/or phosphorus (P) and/or soil acidity, and recommends the best management methods of experts. Users can compare diagnoses and economic implications of management recommendations across multiple scenarios of soils, crops, cultivars, and sources of lime and nutrients. Multiple scenarios enable the users to determine the consequences of their agronomic decisions and allow them to make better informed cropping system choices.

Constraints Addressed

We propose testing NuMaSS software and knowledge in different geographical regions in Africa and S.B. Asia to determine under what agro-climatic, socioeconomic conditions NuMaSS and NuMaSS-based knowledge is adopted or adapted locally. We expect that there will be several ways that NuMaSS and NuMaSS knowledge can improve nutrient management. One of those will be with use of the diagnostic module, perhaps by those close to the production system such as farmers and extensionists. We are not proposing that smallholder farmers will physically manipulate computer software. But even lacking the resources to physically manipulate the NuMaSS software, farmers can be exposed to the knowledge base and recommendations generated by NuMaSS, given appropriate training to their extension agents and NGO farm advisors. Within a given region, we also propose to target farmers using different livelihood strategies as well as households with different household compositions, to test the impact on adoption of households with different sizes and household heads of different genders and marital status. If adoption rates are low to non-existent, we will adapt NuMaSS to these regions by refining the biophysical modules as well as the farmer decision making module. The resource poor farmers in West Africa will provide a challenge to the use of decision-aids, because of the low capital and options to obtain soil analyses. We believe that portions of the knowledgebase can be adapted for farmer use, for example, the diagnostic portion of the nutrient management structure of diagnosis, prediction, and economic analysis can be helpful for growers to identify problem situations and recognize that a yield and quality restraining problem exists.

Therefore, this proposal directly addresses constraints *a, b,* c, *d, e,* and *f* and associated first six objectives of the Soils CRSP. Because this proposal will match the biophysical requirements of nutrient management technology to the socioeconomic characteristics of the household, it will satisfy constraint a) Availability and accessibility of information to support household decision making and adoption of sustainable production practices. By adapting NuMaSS to several local sites in two continents and providing a protocol for testing and adapting NuMaSS to local conditions and households at additional sites, it will provide a methodology for scaling up from a few households to the hundreds of households which will never have an opportunity to be involved in participatory soil management technology testing and adoption.

By developing a methodology to enhance adoption of improved soil management practices in the face of market constraints to farm profitability and affordability of inputs, the proposal will also satisfy constraint b) Market constraints to farm profitability and to adoption of inputs and improved soil management practices. This will be done in the farmer decision making module, because each nutrient management decision model will contain constraints such as distance to market, cost and affordability of inputs, that usually constrain small farmers from adopting new nutrient-management technologies such as mucuna, pigeon pea, chemical fertilizers, etc. Similarly, the nutrient management decision models in the farmer decision module will contain institutional and informational constraints (e.g., knowledge and riskiness of the nutrient management innovations) and will therefore satisfy constraint c) Human and institutional factors that block technology adoption and d) Availability and accessibility of information to support public policies that encourage adoption of sustainable production practices. Finally, because we will test the adoption of NuMaSS recommendations by a variety of users at all levels of the information continuum (i.e., farmers at the household level, extension agents at the community level, and researchers and policy planners at the regional and national level -- see objectives and project strategy outlined below), then it will also satisfy constraints e) Ineffective transfer of soil management technologies from research centers to decision makers at the farm and policy levels and t) Reaching decision makers and integrating decision making at different levels in the agroecosystems hierarchy.

Goal

The goal of this project is to enable poor people to achieve food security without compromising the sustainability of the environment by testing, comparing, and adapting NuMaSS-based knowledge. This goal fits within USAID's broader goal of "broad-based economic growth and agricultural development achieved." Because NuMaSS is a software program that facilitates the transfer and access of soil nutrient management information between research centers and decision makers at the farm and local level, it can potentially give farmers expert information on how to solve their soil nutrient deficiency problems in nitrogen (N) phosphorus (P) soil acidity and potassium (K). Based on farmers' replies to questions about soils, crops, available nutrient sources, input-output prices, and the constraints they face in making decisions about their adoption or use of soil-fertility amendments of various kinds, the decision support system should diagnose a problem, provide a recommendation, and compare diagnoses and economic implications of different recommendations across multiple scenarios of soils, crops, cultivars, and sources of lime and nutrients. It should thus allow the users to determine the consequences of their agronomic decisions and allow them to make better informed cropping system choices. It cannot do this, however, unless it is *adaptable* to local conditions and found to be *useful* by a range of potential adopters: farmers at the household level, extension agents at the community level, and researchers and policy planners at the regional and national level. This project will therefore test the usefulness and adaptability of the software interface of NuMaSS, as well as the body of knowledge contained within NuMaSS, by each of the possible set of its adopters and users in a variety of geographical sites.

Project Objectives

The project will address the following three objectives:

1) *Test and compare NuMaSS predictions on nutrient diagnosis and recommendations with existing soil nutrient management practices of farmers at the household level, extension agents at the community level, and researchers and policy planners at the regional and national level.* We propose to test NuMaSS in different geographical regions in Africa and S.E. Asia to determine under what agro-c1imatic, sociological, and economic conditions NuMaSS or NuMaSS-based knowledge will be adopted and used. We are not proposing that smallholder farmers will physically manipulate computer software, as they lack the computer skills, the equipment, the electricity, and knowledge of written English to do so. But even lacking the resources to physically manipulate the CD-ROM known as NuMaSS, farmers and their extension agents can be exposed to the knowledge base and recommendations generated by NuMaSS, given appropriate training to researchers and policy planners at the regional and national level and given a user-friendly and adaptable NuMaSS.

Here, there will be different tests of adoption, as there are a continuum of users of NuMaSS based knowledge, ranging from farmers at the household level, extension agents at the community and district level, and policy planners and researchers at the regional and national level. In the regions we propose Africa and S.E. Asia, we will generate NuMaSS recommendations *for* a set *of* farmers in each site, and then survey those farmers and collect extensive data from them about their soil-fertility amendment use.

We will also conduct on-farm trials *of* farmers in each site to determine farmers' current nutrient management practices and needs. We will compare nutrient management by the farmers and determine where the NuMaSS software and knowledgebase can contribute.

Adoption of NuMaSS-based knowledge by an *extension agent* is defined here as whether *or* not the amounts and kinds *of* nutrients recommended by NuMaSS are appropriate *for* the farms in the area being studied. We will survey extension agents about what they recommend to farmers regarding their soil-fertility amendments, and correlate predicted recommendations (by NuMaSS) with the recommendations *of* the extension agent. If the NuMaSS predicted recommendations do not correlate with extension agents' reported recommendations, then farmer and extension agents will be surveyed to determine whether NuMaSS recommendations are appropriate and why if not. In the latter case, either more training is necessary and more accurate information needs to flow from regional research centers to local extension agents and vice-versa, *or* NuMaSS does not generate good accurate socioeconomic predictions and needs to be refined as described in objective (2) below.

Adoption of NuMaSS-based knowledge by researchers and *policy makers* at *the regional* and *national level* is the third test *of* the three tests *of* adoption planned. Here, we will invite potential software users **--** researchers in NARs and IARCs, extension administrators and agents, directors *of* experiment stations, fertilizer and seed distributors, and other policy makers in NGOs and PVOs **--** to a hands-on workshop during which they will evaluate the software interface as well as the usefulness *of* the decision-aids tool. Collaborators will be asked questions about the user-friendliness *of* the software interface, as well as the applicability and fit *of* the decision-aids tool to local crops and soils, farmer conditions, and knowledge systems *of* both farmers and extension agents. They will be shown how the various modules within NuMaSS work, and asked to critique them *for* goodness *of* fit to local conditions.

2) *Identify* and *refine the NuMaSS components that limit adoption* and *usefulness of NuMaSS-based knowledge.* If adoption rates are low *or* if preliminary testing indicates suggests limited adoption/ utilization, as determined in objective (1), we will identify and refine the NuMaSS components that limit adoption and usefulness of NuMaSS-based knowledge. If the NuMaSS predicted nutrient use does not correlate with farmers' reported nutrient use, then we will conclude that the NuMaSS prediction does not generate sufficiently accurate predictions and the farmer decision module needs refinement. If the NuMaSS prediction from the on-farm trial data does not generate good accurate biophysical predictions, it is not capable *of* replacing fertilizer-response on-farm trials and the biophysical data within NuMaSS needs refinement. If the NuMaSS predicted recommendations do not correlate with extension agents' reported recommendations, either more training is necessary and more accurate information needs to flow from regional research centers to local extension agents and vice-versa, *or* NuMaSS does not generate good accurate socioeconomic predictions and needs to be further refined. In addition, feedback from the workshop will be analyzed to determine the user-friendliness *of* the software interface, in order to further identify and refine the NuMaSS components that limit hands-on adoption and use of the software by researchers at the regional and national level. In short, at *all* levels of the information continuum from researchers at the national level to farmers at the household level, we will evaluate NuMaSS in order to identify and refine the NuMaSS components that limit adoption and usefulness of NuMaSS-based knowledge.

3) *Adapt NuMaSS data base and structure to different types of users and different geographical regions.* Within a given region, we propose to target farmers in different geographical regions, and after achieving objectives (1) and (2), adapt NuMaSS to those regions. Within the same region, we will target households and extension agents facing different agroclimatic, socioeconomic conditions and using different livelihood strategies (both short-run coping mechanisms (Devereux 1999) and longer-run adaptive strategies (Gladwin, Uttaro, and Anderson 1999)) and choosing different livelihood outcomes (both sustainable and not (Chambers and Conroy 1993)); and adapt NuMaSS to those households. To test the impact on adoption of households with different household composition and with household heads of different genders and marital status, we will also target households with different household compositions and headed by different genders, and adapt NuMaSS to those households. In short, we will follow the protocol: test, identify limiting factors to adoption, and adapt NuMaSS.

Project Strategy and Approach

We thus propose to:

1. Test, support, promote, and adapt NuMaSS software;

2. Prepare a protocol for testing, comparing, and adapting of nutrient management decision aids;

3. Enhance adoption or adaptation of NuMaSS-based knowledge by users in different geographical regions of Africa and S.E. Asia.

At all levels of the information continuum from researchers at the national level to farmers at the household level, we will evaluate NuMaSS in order to identify and refine the NuMaSS components that limit adoption and usefulness of NuMaSS-based knowledge. If NuMaSS adoption rates by farming households and extension agents are low to non-existent in a particular region or kind of household, NuMaSS-based knowledge will *not* be useful to policy makers who want to know what farmers will do and how they will react to their policies.

In practice, this means that NuMaSS should have a more cognitively-realistic, and sophisticated socioeconomic module than it currently has embedded within it. We therefore anticipate having to expand the economic module within NuMaSS, version 2, so that it is a *farmer decision module* capable of predicting the nutrient management decisions farming households make. If household production behavior is to be predicted, the question is what approach should be used to model this behavior? What is the most efficient means of obtaining an accurate solution to a decision problem? In this regard, there is a continuum that exists between a pure machine representation of the decision problem (structural, artificial intelligence approach) and a pure human process representation (procedural, cognitive or behavioral approach). The difference between structural and procedural approaches is the extent to which the framing of the problem represents the actual decision process (Simon, 1979). Structural approaches such as linear programming models (Hildebrand 2001) are not so concerned with modeling the exact human process, but seek some alternative processing technique that approximates the human solution. Procedural models a la Simon, however, try to represent the way humans process information while making decisions, and claim to be more accurate and more computationally efficient than a structural model.

According to the latter approach, the way we model how the farmer applies the nutrients may affect our ability to predict how much nutrient and what kinds of nutrients the plant gets. There are several different ways to model how the household decides on nutrient management strategies, of which there are many: inorganic fertilizer, animal manure, compost, improving soil organic matter (biomass transfer or interplanting, undersowing with green manures (mucuna, tithonia), interplanting with legumes (pigeon pea, soybeans, beans, etc.), rotating or interplanting crops with trees (adopting improved fallows with Sesbania, tephrosia, pigeon pea, etc.), hedgerow intercropping, biomass transfer).

In the farmer decision module, we therefore propose to test which of these methods, procedural models (EDT) or structural models (ELP) works better, and whether a hybrid household model using both EDT and ELP can predict better than either method alone. The hybrid model should combine the best of both cognitive-science and artificial intelligence models. However, it will look completely different from a set of if-then decision trees programmed in DELPHI, and should be programmed in java, to allow for a large number of livelihood activities to be programmed for all household members in a multi-year simulation.

We also propose several activities to assist the component projects of the SM-CRSP to work more closely together. We have allocated funds for an all-PI and collaborator workshop each year (see Travel fund descriptions in the budgets). We will invite members of the other SMCRSP projects to participate in our workshops to further cross-communication and thus increase the opportunities for collaboration among projects. Also proposed are combined visits, where members of different subprojects jointly travel to carry out tasks, also to promote cross communication among subprojects. We also propose to combine visits to missions and in participating with other projects in global issues and concerns.

Collaborative relationships

We will be subjecting NuMaSS knowledge and the interface to testing with potential users as soon as possible. Testing strategy is several-fold. We seek to test both the NuMaSS knowledgebase for adequacy in diagnosing nutrient deficiencies or excesses for acidity, nitrogen, phosphorus and potassium. Should deficiencies occur in the case of N, P, and acidity, the NuMaSS is currently capable of making prescriptions and estimating economic consequences as benefit / cost ratios.

In addition, we will be testing the software with researchers, extension scientists to determine whether the farmer decision-making model on which NuMaSS is based is appropriate to and matches farmer decision-making preferences (Yost et al., 2000). This will be determined with the assistance of Dr. M. Haggith in determining farmer decision-making preferences and by evaluation by potential users of the software. We anticipate that NuMaSS will need to be adapted for locally relevant crops, coefficients depending on soils, and the economic data. Based on earlier farmer surveys (Corton et al., 1998; George et al., 1999; Doumbia et al., 1998; Doumbia et al., 2000), the feedback from evaluation by potential users, and from studies of farmer decision-making protocol, we expect to update the software, likely to include an alternative interface that more intuitively matches farmer decision-making protocol. Approaches and concepts implemented in other studies of decision aids and decision-making will be brought into the options to be tested (Haggith et al., 2001).

Innovations in adapting decision-aids to farmer conditions are being tested in Thailand (Attanandana et al., 2001). Some innovations in obtaining the data required by NuMaSS will be further tested in Thailand where a low cost, tropics-adapted, nutrient test kit has been developed by Kasetsart University (Attanandana et al., 2001). This technology together with a simple, low-cost hand-held computers with a simplified version of NuMaSS will be used to test the concept of testing the soils on-site and then using a handheld decision-aid to analyze the results. With a handheld computer a hand-held version of NuMaSS will be developed that will generate the diagnosis and recommendation, and economic analysis on site so that the recommendations can be discussed with the farmer by the extension-agent. A prototype of such a system is being tested during the 2001 cropping season by Thai researchers and extension specialists with approximately 8000 farmers.

Institution	**Collaborative work**
PhilRice	Collaborating on logistic support for on-farm studies in Hagan (Luzon), Arakan (Cotobato, Mindanao), and Claveria (Misamis Oriental, Mindanao). Studies of NuMaSS software interface will be undertaken with both PhilRice and the Ministry of Agriculture extension and research scientists. Dr. Madonna Casimero will be coordinating the effort. Dr. Mandy Haggith will assist in the design, testing, and interpretation of such farmer surveys to assess their decision-making preferences. The surveys will be taken at the beginning, middle, and at the conclusion of the project to ascertain farmers nutrient decision-making preferences, to determine adoption of techniques and knowledge of NuMaSS, and to test the updated NuMaSS software.
IRRI, International Rice Research Institute	We will collaborate with the IRRI outreach programs that include sites in the Philippines, Thailand, Vietnam, Laos, and India for mutually beneficial nutrient management in the uplands of SE Asia. We will be testing NuMaSS in these various environments as a step in assisting the orderly development / improvement of nutrient management in these uplands as well.
Thailand	Collaboration with Thai researchers will be coordinated with Dr. Tasnee Attanandana, Kasetsart University. Work with this group is important in the testing of new approaches and concepts in nutrient management in the tropics because of the close relationships among researchers, extension scientists, farmer groups, and commercial fertilizer vendors. We expect this collaboration to suggest protocols of work with decision-aids that can be further tested in other collaborating countries. In addition, we will build on current work with Thai researchers to on an example protocol of upgrading nutrient management decision-making with scientists that already have a nutrient management infrastructure, but are interested in updating their approach with concepts and knowledge in the NuMaSS system. This will build on current work with the Department of Soil Science, Kasetsart University, the Department of Agricultural Extension and the Department of Land Development, with whom current work is ongoing where some 8000 farmers are comparing predictions using PDSS techniques that also form the conceptual basis of NuMaSS structure and implementation. Results developed with Thai collaborators may be applicable to improve nutrient management in Laos, the Philippines, as well as Africa. This will contrast with the Philippines and Africa where NuMaSS knowledge and interface represents a new approach to nutrient management in the uplands.
Africa, Including the Pole of West Africa, Eastern Africa, IITA and S. Africa	Testing, comparing and adapting of NuMaSS in Africa will be coordinated by Dr. Aminata Badiane, ISRA, Senegal and will be coordinated with the Pole of West Africa, which is a several country organization of scientific and agricultural expertise designed to efficiently allocate scarce resources in a coordinated manner among the 9 countries (Mali, Niger, Senegal, Burkina Faso, Mauritania, Cabo Verde, The Gambia, Guinea Bissau). Four "Pole" countries have research agenda Senegal, Mali, Niger, and Burkina Faso. NuMaSS testing and adaptation will be explored in key locations in these countries. Dr. Abou Berthe has conducted rapid rural appraisal surveys of farmers in the area and is well-prepared to suggest adaptations necessary in the NuMaSS software so that it deals with local conditions and issues (Berthe et al., 2000). We will work with Dr. Mandy Haggith to explore the previous farmer surveys to identify knowledge needs and use the NuMaSS knowledgebase to supply needed information. We will also explore the use of soil test kits developed in Thailand for possible on-farm use in the Pole countries of Sub-Saharan Africa. NuMaSS may also be tested at IITA and S. African scientists. Testing and comparison of organic fertilization and the use of rock phosphate management will be carried out with TSBF scientist Dr. Andre Bationo.

Annual Workplans

Objective 1: Test and compare NuMaSS predictions on nutrient diagnosis and recommendations with existing soil nutrient management by farmers, extension agents, and researchers.

Output 1: Test, support, promote, and adapt NuMaSS software.

Suboutput 1. Testing Recommendations of NuMaSS

Suboutput 1.	Africa	Philippines	Thailand	Laos
Initial surveys of farmers	Sep 2002	May 2002- Jun 2002	Jun 2002 - Jul 2002	Jun 2002 - Aug 2005
Testing NuMaSS recommendations	Mar 2003 - Oct 2006	Jun 2002- May 2006	Mar 2002 - May 2006	Jun 2002 - Aug 2006
Follow-up Survey of adoption of NuMaSS recommendations	May 2003- 2006	Oct - Dec 2002 - 2005	Oct - Dec 2002 - 2005	Oct - Dec 2002 - 2005
Suboutput 2: Testing the User-Friendliness of Software				
Software interface testing	Mar 2002	May - Jun 2002 - 2006	Jun - Jul 2002 - 2006	Jul - Aug 2002 - 2006
Workshop to analyze results of knowledge & software testing, propose revisions		Dec 2002, 2003,2004	Dec 2002, 2003,2004	Dec 2002, 2003,2004

Objective 2: Identify and refine the NuMaSS components that limit adoption and usefulness of NuMaSS-based knowledge.

Output 2: Prepare protocols for testing, comparing, and adapting of nutrient management decision aids.

Suboutput 1.prepare and compare protocols to adapt NuMass to local conditions

Suboutput 1.	Africa	Philippines	Thailand	Laos
Prepare protocols for testing, comparing, and adapting	Aug 2002 - 2006	Aug 2002 - 2006	Aug 2002 - 2006	Aug 2002 - 2006
Compare protocols to adapt nutrient mgmt decisions across locations considering range in local information needs	Aug 2005 - 2006	Aug 2005 - 2006	Aug 2005 - 2006	Aug 2005 - 2006
Suboutput 2. Adapt NuMaSS to local conditions in Sub-Saharan Africa				
Conduct RRAs, interviews, and surveys to determine farmer information needs and NuMaSS-based information	May 2003 - Feb. 2007			
Modify the data base and simplify the structure of NuMaSS to fit local conditions	April 2003 - Feb. 2007			

Objective 3: Adapt NuMaSS data base and structure to reflect different types of users and different geographical regions.

Output 3: Enhanced adoption or adaptation of NuMaSS-based knowledge by users in different geographical regions of Africa and S.E. Asia.

Suboutput 1. Develop a NuMaSS version for Sub-Saharan Africa farmers and growers

Suboutput 1.	Africa	Philippines	Thailand	Laos
Write program in Delphi, Prolog and Java to reflect farmer soil- fertility Decisions	Sept. 2002 - Feb. 2003			
Determine whether the revised/simplified farmer decision module is useful for farmers. Revise if not.	Feb. 2003 - 2007			
Suboutput 2. Adapt NuMaSS algorithms to handheld computers for acid upland soils of the Philippines, Thailand, IRRI Consortium & Africa				
Update Al & Mn module for upland soils in the Philippines. Other nutrients for Thailand and Laos.		Mar 2002 - 2004	Mar 2002 - 2004	Mar 2002 - 2004
Suboutput 3. Implement NuMaSS algorithm in a hand-held computer using the Kasetsart University developed soil test kit.				
Implement NuMaSS algorithm in a hand-held computer together with locally adapted soil test kit			Mar. 2002-2006	
Suboutput 4. Test for enhanced adoption of NuMaSS-based knowledge				
Follow-up Survey of Adoption of NuMaSS recs. In Arakan and Claveria, Mindanao; Hagan, Luzon Philippines		Mar 2003 - Feb 2007		
Follow-up Survey of Adoption of NuMaSS recommendations in each site in Thailand, IRRI sites		Mar 2003 - Feb 2007	May 2003-Feb. 2007	May 2003-Feb 2007
Conduct a Follow-up Survey of Adoption of NuMaSS-based recs: W. Africa, IITA, and S. Africa	Feb 2003 - Feb 2007			

Annex: Logical framework for impact assessment / verifiable indicators of success

Description	Objectively Verifiable Indicators	Means of Verification	Assumptions
Constraint:			
Objective 1*: *Test and compare NuMaSS predictions on nutrient diagnosis and recommendations with existing soil nutrient management by farmers, extension agents, and researchers. Output 1: Test, support, promote, and adapt NuMaSS software.			
Suboutput 1. Testing of Recommendations from NuMaSS	Field estimated response curves and experimental yields with and without NuMaSS recommendations	Compare field estimates of fertilizer requirement obtained on farmers fields using NuMaSS recommendations with those of the farmer and National recommendations	- Valid field estimates of responses to the comparative treatments are possible - Representative crops and soils are available for study - Farmers are willing to participate in such studies
Suboutput 2. Testing of U ser- Friendliness of the Software and Evaluation of the Interface and Usefulness of the Decision-Aids Tool	Potential user's evaluations of the NuMaSS software	Results of user evaluations and comments regarding using NuMaSS software	- Potential users are available and willing to evaluate NuMaSS - Potential users will provide direct feedback on usability
Objective 2*: *Identify and refine the NuMaSS components that limit adoption and usefulness of NuMaSS-based knowledge. Output2: Prepare protocols for testing, comparing, and adapting of nutrient management decision aids.			
Suboutput I. Prepare and compare protocols to adapt nutrient management decision aids to local conditions.	Potential user's evaluations of the protocols to evaluate and adapt decision-aids for nutrient management	Results of evaluations of the proposed protocol for decision-aid evaluation and adaptation	- Potential users are available, have experience in evaluating decision-aids or experience in nutrient management approaches -Potential users have experience in software evaluation

Suboutput 2. Adapt NuMaSS to local conditions in S.E. Asia, Sub-Saharan Africa	Characteristics and requirements of local nutrient management and nutrient decision-making	Potential users evaluate updated and modified NuMaSS software – both knowledge and interface components	-Potential users are available, have experience in evaluating decision-aids or experience in nutrient management approaches -Potential users have experience in software evaluation -NuMaSS code is available and can be modified and updated
<u>Objective</u> 3*: *Adapt NuMaSS data base and structure to reflect different types of users and different geographical regions. <u>Output 3</u>: Enhanced adoption or adaptation of NuMaSS-based knowledge by users in different geographical regions of Africa and S.E. Asia.			
Suboutput I. Develop a NuMaSS version for Sub-Saharan Africa farmers and growers	Farmer-decision descriptions and methods of making nutrient management decisions	Potential users evaluate the proposed farmer-decision modules and descriptions.	- Farmer decision-making methods can be obtained and described - Farmer decision-making methods can be modeled and represented in software
Suboutput 2. Adapt NuMaSS to be appropriate for acid upland soils of the Philippines, Thailand, IRRI & Africa	On- farm estimates of nutrient requirement	Comparisons of on-farm responses with NuMaSS predictions and recommendations	-Constraints and data to resolve the constraints are available for upland soils of the Philippines -NuMaSS code is available and can be modified and updated
Suboutput 3. Implement NuMaSS algorithm in a hand-held computer together with locally adapted soil test kit	Existing and functioning NuMaSS algorithms on a hand-held computer. Existing and functioning, locally adapted soil test kit	Comparisons of predictions of nutrient requirements using a hand-held computer with those generated by the NuMaSS software. Comparisons of laboratory estimates of nutrient status with those obtained with a locally-developed soil test kit	-Hand-held computers are capable of representing and operating selected NuMaSS algorithms -Soil test kit is available and operative -Extension personnel are available to test the combined decision-aid
Suboutput 4. Test for enhanced adoption of NuMaSS-based knowledge	Enhanced NuMaSS predictions and field studies of response	Evaluations of enhanced NuMaSS predictions relative to field studies of response	-NuMaSS can be enhanced with the knowledge modules proposed -Valid tests of the knowledge can be developed

Annex: University of Hawaii Budget Summary, across all objectives and outputs
($347,000 maximum)

Personnel	YR 1	YR 2	YR 3	YR 4	YR 5	Total
Res. Assoc.[1]	32,000	37,000	38,110	39,253	40,431	186,794
Grad. Asst. [1]	32,000	38,000	38,000	39,143	40,431	187,574
Student	0	0	5,000	5,000	7,500	17,500
Fiscal Specialist	7,500	7,500	7,725	7,957	8,195	38,877
Fringe*	16,504	18,944	19,357	19,937	20,579	95,321
Subcontract Contracts@						
Africa	25,000	60,000	60,000	60,000	60,000	265,000
Philippines	25,000	30,000	30,000	29,000	27,000	141,000
Thailand	25,000	25,000	25,000	25,000	22,000	122,000
IRRI	5,000	20,000	20,000	20,000	20,000	85,000
Worldforests	10,000	10,000	10,000	10,000	10,000	50,000
Supplies	3,898	5,367	7,679	7,646	6,468	31,058
Equipment	50,000	6,000	0	0	0	56,000
Travel	36,000	29,000	31,000	30,000	29,000	155,000
Modified Total Direct Cost	217,902	165,811	151,871	148,936	152,604	837,124
Indirect Cost@	79,098	60,189	55,129	54,064	55,395	303,876
Total	347,000	347,000	347,000	347,000	347,000	1,735,000

[1] Initial years salary is about 2 months less for the typical delay in startup.
* - Fringe Rates RA = 27.2%, GA = 18%, Student = 1%, Fiscal = 27.20%
@ - Indirect cost based on 36.30% of MTDC (Modified Total Direct Cost)

Cost Sharing: Required amount = 25% of Total Costs less Subcontracts to Host-countries and less Training of Participants (Grad Assistants). YR1 = Yost @.35FTE, UH Fac @.20FTE,
Fringe @27.17%. YR2-5 = Yost @.30FTE, UH Fac @.25FTE, Fringe @27.17%.
IRRI Costs include subgrants to Laos, Indonesia, and Vietnam for NuMass testing.
Worldforests costs will be handled as a subgrant with indirect costs on only the first $25,000.

Travel events:

- Year 1: GA to UH, $5000, RA, PI- SEAsia: $10,000, PI-Africa $5000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.
- Year 2: RA, PI, SEAsia: $8,000, RA to Phil, IRRI, Thail: $4000, PI-SEAsia: $5,000, Annual SM-CRSP workshop - 2 persons from collaborating countries $8,000.
- Year 3: RA, PI, SEAsia: $5000, PI-Africa $5000, Coordinators: Thail, IRRI $5000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.
- Year 4: RA, PI, SEAsia: $8,000, RA-Phil-Thail: $4000, Coordinator: Thail, IRRI $2000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.
- Year 5: RA, PI, SEAsia: $8,000, Coordinators - workshop $5,000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.

Equipment: Automobile for site maintenance by African coordinator (to be based in Bambey, Senegal, $50,000. A computer projector for presentations at workshops and for software demonstrations - $6,000. A set of Differential GPS units - $6,000.

Annex: University of Hawaii Budget Summary, across all objectives and outputs
($450,000 maximum)

Personnel	YR 1	YR 2	YR 3	YR 4	YR 5	Total
Res. Assoc.	37,000	38,110	39,253	40,431	41,644	196,438
Grad. Asst.	38,000	38,000	39,143	39,143	39,143	193,430
Student	0	0	5,000	5,000	7,500	17,500
Fiscal Specialist	15,000	15,000	15,000	15,000	15,000	75,000
Fringe*	20,984	21,286	21,853	22,173	22,528	108,824
Subcontract Contracts@						
Africa	61,000	90,000	95,000	90,000	90,000	426,000
Philippines	40,000	40,000	40,000	42,000	40,000	202,000
Thailand	40,000	40,000	40,000	40,000	40,000	200,000
IRRI	5,000	50,000	50,000	50,000	50,000	205,000
Worldforests	10,000	10,000	10,000	10,000	10,000	50,000
Supplies	3,662	7,621	5,159	8,194	6,594	31,230
Equipment	56,000	6,000	0	0	0	62,000
Travel	36,000	29,000	31,000	30,000	29,000	155,000
Modified Total Direct Cost	240,646	179,017	161,408	159,941	161,409	902,421
Indirect Cost@	87,354	64,983	58,591	58,059	58,591	327,579
Total	450,000	450,000	450,000	450,000	450,000	2,250,000

* - Fringe Rates RA = 27.2%, GA = 18%, Student = 1%, Fiscal = 27.20%
@ - Indirect cost based on 36.30% of MTDC (Modified Total Direct Cost)

Cost Sharing: Required amount = 25% of Total Costs less Subcontracts to Host-countries and less Training of Participants (Grad Assistants). YR1 = Yost @.35FTE, UH Fac @.20FTE,
Fringe @27.17%. YR2-5 = Yost @.30FTE, UH Fac @.25FTE, Fringe @27.17%.
IRRI Costs include subgrants to Laos, Indonesia, and Vietnam for NuMass testing.
Worldforests costs will be handled as a subgrant with indirect costs on only the first $25,000.

Travel events:

- Year 1: GA to UH, $5000, RA, PI- SEAsia: $10,000, PI-Africa $5000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.
- Year 2: RA, PI, SEAsia: $8,000, RA to Phil, IRRI, Thail: $4000, PI-SEAsia: $5,000, Annual SM-CRSP workshop - 2 persons from collaborating countries $8,000.
- Year 3: RA, PI, SEAsia: $5000, PI-Africa $5000, Coordinators: Thail, IRRI $5000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.
- Year 4: RA, PI, SEAsia: $8,000, RA-Phil-Thail: $4000, Coordinator: Thail, IRRI $2000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.
- Year 5: RA, PI, SEAsia: $8,000, Coordinators - workshop $5,000, Annual SM-CRSP workshop - 4 persons from collaborating countries 4x$4000 = $16,000.

Equipment: Automobile for site maintenance by African coordinator (to be based in Bambey, Senegal, $50,000. A computer projector for presentations at workshops and for software demonstrations - $6,000. A set of Differential GPS units - $6,000.

Annex: Biodata - Investigators and Co-Investigators

Russell Yost

Address:
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University of Hawaii Phone: 808-956-7066
3190 East West Road Fax: 808-956-3894
Honolulu, HI, 96822

Degrees:
Ph.D. Soils with minors in Plant Physiology and Statistics; North Carolina State University M.S. Soil Science, University of Nebraska at Lincoln

Current Position: Researcher, Professor of Soil Science

Professional Interests:
Soils: Tropical soils, soil phosphorus, soil acidity, statistics, geostatistics.
Crops: Plant nutrition, legumes, trees, green manures, VA mycorrhizae. .
Computer technology: Artificial intelligence, computer languages to capture and transfer expertise, geostatistics. Participatory Development

3 *Selected Publications:*

- Wang, x., R.S. Yost, and B. A. Linquist. 2001. Soil aggregate size affects phosphorus desorption from highly weathered soils and plant growth. Soil Sci. Soc. Am. J. 65:000-000.
- Li, Mengbo and RS. Yost. 1999. Management-Oriented Model Guided Within-season Nitrogen Management, *In* P. Robert (ed.), Proceedings Fourth International Symposium on Precision-Agriculture, St. Paul, Minnesota.
- Li, Z.C., RS. Yost, and R.E.Green. 1998. Incorporating uncertainty in a chemical leaching assessment. J. of Contaminant Hydrology 29(4):285-299.

3 *Software*

- Ogoshi, R and R Yost. 2001. Implementing the AFR (Revised Attenuation Factor) in a GIS framework for pesticide leaching assessments in Hawaii (Pesticide Branch, Dep. of Agriculture).
- Yost, R.S., R. Kablan, M. Doumbia, A. Berthe, A. Badiane, B. Jobe, and 1. Baptista. 2000. BILAN2: Nutrient balance estimation (en francais). InterCRSP/West Project, Honolulu, Hawaii.
- Li, Mengbo, R.S. Yost, 1. Silva, N.V. Hue, and R. Uchida. 1998. FACS2 (Fertility and Advice Consulting System, Internet version). Unpublished manuscript, 1998.

Approximately 150 peer-reviewed articles in national and international journals.

Collaborators on projects, books, articles, reports, or papers during the last 48 months:

Linquist, Bruce - Lao-IRRI, Laos	Ikawa, Haruyoshi - University of Hawaii
Hue, Nguyen - University of Hawaii	Smith, Chris - NRCS, Honolulu, HI

Time Commitment: 25%

Co-investigator 1. Dr. Mandy Haggith

Curriculum Vitae

December 2001

Full name: Dr Mandy Caroline Haggith

Current job: Freelance researcher and writer

Date of birth: 17 August 1966

Contact information
Address: *Worldforests,* 95 Achmelvich, Lochinver, Sutherland, Scotland, IV27 4JB
Tel: +44 (0)7050-641866 or +44 (0) 1571-844020
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Qualifications
PhD, Department of Artificial Intelligence, Edinburgh University. 1996.
Title: A meta-level argumentation framework for reasoning about disagreement
MSc, Department of Artificial Intelligence, Edinburgh University. 1988.
B.A.Hons, Mathematics and Philosophy, St John's College, Oxford University. 1987.
ALCM, Piano Performance Diploma, London College of Music. 1982.

Career

June 1997- present
Running *Worldforests,* a small independent research organization specializing in information technology and policy in support of people in forests. Since November 1999, I am also editor of Taiga News, the newsletter of the Taiga Rescue Network.

January 1997 - June 1997
Assistant Director, Centre for the Study of Environmental Change and Sustainability, and Research Fellow, Department of AI, University of Edinburgh.

October 1995 - December 1996
Research Associate, Department of AI, Edinburgh University.
STEM Project Coordinator. EC grant EN1014,

October 1992 - September 1995
Lecturer, Department of Artificial Intelligence, Edinburgh University.
November 1991 - September 1992
Research Associate, Department of AI, Edinburgh University.
Overseas Development Administration grant no. R4731.

January 1990 - July 1991
Lecturer, School of Computer and Information Technology,
Griffith University, Queensland, Australia.

October 1989 -December 1989

Lecturer, Department of Artificial Intelligence, Edinburgh University.
October 1988 -September 1989
Research Associate, Department of AI, Edinburgh University.
ECO Project. SERC grant GR/D/44294

June-September 1987
IBM Newcastle-upon-Tyne, Vacation Student,

June-September 1986
IBM Newcastle-upon- Tyne, Vacation Student,

Memberships
Member of the Culag Community Woodland Trust.
Member of Reforesting Scotland. Member of the Green Party. Member of Trees for Life.
Member of the International Working Group on Community Involvement in Forest Management.

Interests
Forests. Poetry. Bears. Travel. Walking and camping in the woods. Organic gardening. Vegetarian cooking. Music. Reading. The Alexander Technique. Current affairs. Philosophy.

Grants and Contracts
Contract for Global Forest Coalition to monitor UK implementation of its commitments on forests under the Convention on Biodiversity, as part of a global review. November 200 I-April 2002.

Research contract for CIFOR, Harare, Zimbabwe, to lead the development of a workbench and manual for visioning and participatory modeling by communities. October 2001-March 2002.

Research contract for CIFOR, Harare, Zimbabwe, to develop and trial a methodology for participatory modeling in the ACM program. July-August 2001.

Contract for UK Department for International Development to facilitate a workshop to identify stakeholder needs for the Multi-Objective Forest Management (MOFORM) research program. Edinburgh, June 2001.

Contract for CIFOR to demonstrate the FLORES model as part of the CGIAR Future Harvests initiative at the World Bank Rural Week, Washington DC, April 2001.

Research contract for International Institute for Tropical Agriculture (IITA), Yaounde, Cameroon, to facilitate part of a workshop on modeling household decisions as part of the Alternatives to Slash and Bum program, April 2001.

Research contract for CIFOR, Harare, Zimbabwe, to develop decision modeling in the Adaptive and Collaborative Management (ACM) program. November 2000 - July 2001.

Research contract for the University of Bangor, Wales to facilitate workshops and support modeling of household decision making in the DfID funded FLORES Adaptation and Callibration (FLAC) project. August 2000 - March 2001

Research contract for CIFOR, Bogor, Indonesia, to support transfer of the FLORES model from Indonesia to Zimbabwe. Apri12000.

Co-author of case study on Crofter Forestry in Scotland for IUCN European Profile on Community Involvement in Forest Management 2000.

Co-facilitator for *WWF/IUCN* of the launch of a new global initiative on forests, Forest PACT. Jan - March 2000.

Co-facilitator of a workshop for non-governmental organizations and indigenous peoples organizations to develop a joint international forest policy strategy, Ottawa, December 1999. UK monitor for the international non-governmental organizations and indigenous peoples organizations (IPONGO) review of governments' implementation of their international forest commitments. November-December 1999.

Research contract for World Wide Fund for Nature (WWF) International to report on self. mobilized community initiatives for forest management in Far East Russia (August-October 1999).

Research contract for CIFOR to write a guide for communities developing Criteria and Indicators of Sustainable Forest Management. June-August 1999.

UNED-UK representative at 1999 UN Intergovernmental Forum on Forests, Geneva, May 1999 and New York, January 2000.

Research contract for CIFOR, Bogor, Indonesia, to develop a land use decision-making model for integration into the FLORES model. April-June 1999.

Research contract for the University of Edinburgh (Department of Philosophy), E1enchos project, to develop an argumentation model of Plato's Protagoras debate on democracy. March-July 1999.

Research contract for CIFOR, Bogor, Indonesia, to guide development of a computer based tool (CIMAT) for Criteria and Indicators of Sustainable Forest Management, and analyze Criteria and Indicators for community forestry. April-Dee 1998.

Teaching contract for the University of Edinburgh to teach New Information Technologies in Natural Resource Management for the MSc program on Sustainable Development. January 1998.

Consultancy contract for CIFOR, Bogor, Indonesia to lead a course on Prolog Programming for natural resource management. January 1998.

Research contract for the University of Edinburgh to model decision making by forest frontier households as part of the FLORES model. Funded by CIFOR. December 1997.

Consultancy contract for CIFOR (Centre for International Forestry Research), Bogor, Indonesia to lead a course on AI applications in natural resource management. March 1997.

Scottish Environment Forum representative at 1997 UN Intergovernmental Panel on Forests, (also working for the Alliance of Indigenous Peoples of Tropical Forests), New York. February 1997.

Consultancy with Tony Clayton & Roger Talbot (University of Edinburgh) for Scottish Borders Enterprise RETEX project. 1996.

Coordinator of EC research project (EN1014) called STEM (Sustainable Telematics for Environmental Management), involving the University of Edinburgh, the Assynt Crofters Trust, Software AG Espana, CEAM (Spanish reforestation institute), the University of Karlsruhe, Implex Environmental Systems and CWI (Amsterdam IT research institute). 1995-7.

Grant Holder of UK Overseas Development Administration grant (R473I) for project "Formal Representation and Use of Indigenous Ecological Knowledge about Agroforestry", with University of Wales, Bangor, and Dept of AI, and IERM, Edinburgh. Oct 1992-94.

Research grant from the Australian Research Council, for the construction of a natural language front end to an ecological database. Griffith University, Jan-Jul1991.

Publications

Burford de Oliveira with B.Ritchie, M.Haggith, C.McDougall, H.Hartanto, and T. Setyawati. Developing Criteria and Indicators of CMFs as Assessment and Learning Tools: Objectives, Methodologies, Results. 2000. CIFOR report. CIFOR, Bogor, Indonesia.

B. Ritchie, C. McDougall, M. Haggith, N. B. de Oliviera. Criteria and Indicators of Sustainabi1ity in Community Managed Forest Landscapes. CIFOR 2000.

M. Haggith, R. Prabhu, H. Purnomo, A. Riza1, D. Sukadri, 1. Taylor & Y.Yasmi. CIMAT: a knowledge-based system for developing criteria & indicators for sustainable forest management. In the proceedings of AAAI workshop on Environmental Decision Support Systems. 1999.

M. Haggith & C. Colfer. Artificial Intelligence meets Traditional Wisdom. *Agroforestry Forum.* 2000.

M.Haggith, R.Prabhu, D.Sukadri, H.Purnomo and Y.Yasmi. CIMAT : Criteria and Indicators Modification and Adaptation Tool. CIFOR discussion paper. July 1998.

B.Ritchie and M.Haggith. *Trees Please.* Wordscape, Kathmandu. 1998.

S.Reta1is, M.Haggith and H.Pain. Arguing with the Devil: an argumentation-based tutor for teaching in controversial domains. Proceedings of AIED-96. Montreal, 1996.

D. Robertson, G. Kendon, M.Haggith, R. Muetze1fe1dt, D. Goldsborough and 1. Agusti. A Toolkit approach to Resource Management Decision Support *Journal of AI Applications.* 1996.

S. Dircks, M.Haggith and 1. Kingston. The use of KADS to develop a fmancia1 advisor. *Journal of Expert Systems with Applications.* 1995.

M.Haggith. Argumentation in Natural Resource Management. Proceedings ofIJCAI-95 Workshop on AI and the Environment. Montreal. 1995.

M.Haggith. A meta-level framework for exploring conflicts in multiple knowledge bases. J.Hallam (ed). Hybrid problems, hybrid solutions. IOS Press 1995.

M. Haggith. Beyond Expert Systems in Agroforestry Development. Proceedings of the BCS Special Interest Group on Developing Countries Symposium, London, 1994.

M. Haggith. A Meta-level framework for exploration of multiple knowledge bases. Proceedings of 1994 Conference on Cooperating KBS, University of Keele, 1994.

M. Haggith. Disagreement in Creative Problem Solving, Proceedings of the AAAI Spring Symposium on AI & Creativity, Stanford University, 1993.

M. Haggith, D. Robertson, D. Walker, F.Sinc1air and R.Muetzelfeldt. TEAK: Tools for Eliciting Agroforestry Knowledge. Proceedings of the BCS Symposium on IT-Enabled Change in Developing Countries, London, 1992.

M. Haggith, L. Stewart-Zebra, P. Douglas. BIRDZ : Making Ecological Data Digestible. European Conference on Computers and Environmental Protection, Munich, 1991.

M. Haggith. Artificial Intelligence Tools for Ecologists. Proceedings of Australian AI-90 Conference, Perth, 1990.

M. Haggith. Sheltering Under a Tree: An Artificial Intelligence Perspective on Idealization in Ecological Modeling. Pacific Rim International Conference on Artificial Intelligence (PRICAI), Tokyo, 1990.

D. Robertson, A. Bundy, R. Muetzelfeldt, M. Haggith, M. Uschold. EcoLogic - The Application of Logic Programming to Ecological Modeling, MIT Press, 1991.

M. Haggith. Interactive Program Construction. Proceedings of UK IT-90.Southampton, 1990.
D. Robertson, A. Bundy, R. Muetzelfeldt, M. Haggith, M. Uschold. Using Ecological Descriptions to Guide the Construction of Simulation Programs. Proceedings of the Alvey Annual UK IT 88 Conference. Brighton, 1988.

M. Haggith, A survey of Ovingham Graveyard. Tyne and Tweed. 1982.

Co-Investigator 2
Dr. Aminata Badiane, Director Natural Resources Management, ISRA/ Senegal

Aminata Niane Badiane, soil scientist, Institut Senegalais de Recherches Agricoles (ISRA), under the Ministry of Agriculture and Animal Husbandry.

Training:
1979 Graduate as Agronomy engineer from INA of Algiers (major soil chemistry);
1983 MS in Soil Science at NCSU at Raleigh, North Carolina, USA,
1993; PhD in Agronomic Sciences at INPL, Nancy, FRANCE.

Experience:
Worked over 20 years at ISRA in Soil Science related in soil Organic Matter, Natural resources management

Publications:
Badiane, A.N., 1993. Le statut organique d'un sol sableux de la zone Centre-Nord du Senegal. Docteur de L'INPL-Institut National Poly technique de Lorraine, Lorraine, France.

Diack, M., M.Sene., and A.N. Badiane, 2000 *Piliostigma reticulatum* used for soil organic matter build up: Effects on soil quality and crop yield in the peanut basin of Senegal Improving and Sustaining Food and Raw Material Production in West Africa. Institut Senegalais de Recherche de Agricole, Kaolack, Senegal.

Diack, M., M. Sene, A.N. Badiane, and M. Diatta, 2000. Decomposition of a native shrub, *Piliostigma reticulatum,* litter in soils of semiarid Senegal. Arid Soil Research and Rehabilitation 14: 205-218.

Badiane, Aminata (Editor) Improving and Sustaining Food and Raw Material Production in West Africa, vol. 1. ISRA, Senegal, Kaolack, Senegal, Proceedings of a Workshop held in Kaolack, Senegal, Jan. 1999. InterCRSP/West Project.

Co-Investigator 3
Dr. Tasnee Attanandana

Present Position:
Dean, Graduate School, Kasetsart University
Professor of Soil Science.
Director, Soil and Plant Analysis Project, Department of Soil Science, Kasetsart University. Vice President, Soil and Fertilizer Society of Thailand.
Committee member of the Advisory Committee of Global Soil Remediation Network-Asian Centre (GSRN-AC)

Education:
B.S. (Hons.) Kasetsart University
M.S. (University of the Philippines)
D.Agr. (Kyoto University)
Certificate of Soil Chemistry(IRRI)
Certificate of Plant Nutrition(Technical University of Berlin)

Research interests:

- Rice production: chemical changes, fertilization of rice soils.
- Acid sulfate and peat soils: amelioration and management for rice and other crop production.
- Domestic wastewater treatment: utilization of soil and agricultural waste as the treatment system.
- Soil testing: a tool for fertilizer recommendation for some agronomic crops.

Current research
Development of fertilizer recommendation for com production using decision-aids Wastewater treatment using Multi-soil layering system Rock phosphate solubility in the actual acid sulfate soil of Thailand

Awards:

- Third prize award on soil pH test kit as the useful invention in agriculture from the National Research Council of Thailand, 1994. .
- Runner up award on Azolla research from the Kasetsart University Research Development Institute, 1998.
- Runner up award on wastewater treatment research from the Kasetsart University Research Development Institute, 1998.
- Runner up award on Soil test kit for NPK from Kasetsart University, Annual Conference 2000.
- Outstanding Soil Science Alumni award for academic and administrative work from Soil Science and Agricultural Chemistry Association, 2001

Inventions:

- pH test kits for soil and water
- Chemical fertilizer test kit
- Soil test kit for NPK

Selected Publications:

Luanmanee, S. P. Boonsook, T. Attanandana, and T. Wakatsuki. 2001. The effect of organic components and aeration regimes on the efficiency of a multi-soil-layering system for domestic wastewater treatment. Japanese Journal of Soil Science and Plant Nutrition (in press).

Luanmanee, S., P. Boonsook, T. Attanandana, B. Saitthiti, C. Panichajakul, and T. Wakatsuki. 2001. Effect of an intermittent aeration regulation of a multi-soil-layering system on domestic wastewater treatment in Thailand. Ecological Engineering.(in press).

Luanmanee, S., T. Attanandana, T. Masunaga, and T. Wakatsuki. 2001. Efficiency of the multi-soil layering system for wastewater treatment at the ninth and the tenth years of operation. Ecological Engineering 18(2): 185-199.

Attanandana, T., B. Saitthiti, S. Thongpae, S. Kritapirom, S. Luanmanee, and T. Wakatsuki. 2000. Multi-media-layering system for food service wastewater treatment. Ecological Engineering 15(2000): 133-138.

Attanandana, T. C. Suwannarat, T. Vearasilp, S. Kongton, R. Meesawat, P. Boonampol, K. Soitong and A. Charoensaksiri. 1999. Nitrogen fertilizer recommendation for grain yield of com using a modeling approach. Thai J. Agric. Sci. 32(1):73-83.

Attanandana, T., B. Chakranon, K. Kyuma and P. Moncharoen. 1999. Improvement of a peat soil for rice cultivation in Thailand. Japanese Journal of Tropical Agriculture 43 (2): 91-96.

Attanandana, T., W. Sritanyarat and R. Na Ranong. 1998. Rock phosphate availability in rice growing acid sulfate soils of Thailand. *In* Nutrient Management for Sustainable Crop Production in Asia. CAB International, Wallingford, U.K. 394 p. Johnston, A.E. and J.K.Syers (editors).

Attanandana, T. B. Saitthiti, S. Thongpae, S. Kritapirom and T. Wakatsuki. 1997. Wastewater treatment study using the multi-soil-layering system. International Conference on " Soil Quality Management and Agro-ecosystem Health" 11-14 November, 1997. Cheju, Republic of Korea.

Attanandana, T., K. Kyuma and S. Kunaporn. 1996. Paddy soils-a resource base for rice production in Thailand. International Symposium on "Maximizing Sustainable Rice Yields through Improved Soil and Environmental Management", Khon Kaen, Thailand, November 11 17, 1996.

Attanandana, T. and S. Kunaporn. 1995. Rice soils and rice cultivation systems of Thailand. Pedologist 39 (2): 64-72.

Attanandana, T., R. Meesawat and A. Pinchongsakundit. 1994. Fertilizer recommendation for economic field crops in Thailand. International Workshop on "Leaf Diagnosis and Soil Testing as a Guide to Crop Fertilization" at TAR!, Taichung, Taiwan, ROC, September 12-17,1994.

Academic background of Prof. Tasnee Attanandana

The author has been teaching and researching aspects of soil chemistry and soil fertility at the Department of Soil Science, Kasetsart University since 1966. At present, her position is Professor of Soil Science and the Dean of the Graduate School, Kasetsart University.

In 1974, the world's oil crisis led to chemical fertilizer shortages in Thailand. As a consequence, low-quality fertilizers entered the Thai agricultural market and these were applied by farmers to rice and field crops. To combat this, the author and her colleagues developed an appropriate, reliable field-based fertilizer test kit and trained extension staff in its use. This was successfully adopted and the poor-quality fertilizers removed from the market. During this period, the author and her staff also produced a field-based soil and water pH test kit for farmers and shrimp cultivators. The pH and fertilizer test kits are still the standard kits used by the Thai Department of Agricultural Extension, to support their soil and water management recommendations.

From 1985-1992, the author was the Deputy Director of the Soil and Plant Analysis Project in the Department of Soil Science, Kasetsart University. This involved considerable research and results' interpretation, ultimately leading to the dissemination of fertilizer recommendations to farmers and the private sectors. She has been the Director of Soil and Plant Analysis Project since 1992. Prior to 1985 and post 1974, her principal area of research was the improvement of acid sulfate and peat soils for rice cultivation.

In Thailand, few fertilizer/crop trials have been undertaken. At times, this has made fertilizer recommendation based on soil and plant analysis inaccurate. In turn, this may have led to soil degradation where excessive or insufficient fertilizers have been applied. Since 1997 the author and her colleagues have been using the DSSAT-CERES-maize model to predict fertilizer recommendation for com. Suitable planting date, predicted yield, optimum nitrogen fertilizer application rate and maximum gross income are predicted by the model. Nitrogen fertilizer application rate is determined more accurately because the major soil, climatic and plant factors affecting crop growth are incorporated within the model. This may reduce the environmental impact of chemical fertilizers by increasing the efficiency of their use. Phosphorus(P) requirement is generated by PDSS program. Potassium(K) fertilizer is applied using Mitscherlich-Bray equation. The initial status of NPK in the soil will be determined using a new soil NPK test kit that has been developed by the author as a direct result of the above study. The modeling approach to fertilizer recommendation can be applied to other locations, soils and crops within Thailand. Time consuming and costly field experiments can therefore be reduced. The simplified program of NPK fertilizer recommendation will be in the form of software that the extension workers can use to help the farmers in the determination of fertilizer recommendation for com in the country.

The Department of Agricultural Extension has accepted these research results and established a policy of training 200 leading farmers in 10 provinces of corn production in 2001. Each trained farmer will be disseminating the process of fertilizer recommendation to another 40 members. About 32,000 hectares of com producing areas have received suitable amount of fertilizer based on the output of the author and the colleagues 'work. The training will be further continued in another 30 provinces of corn producing area in the country in 2002.

Currently the author is a member of the Advisory Committee of Global Soil Remediation Network, Asia Centre (GSRN-AC).

Co-Investigator 4:

Name: Madonna Carbon Casimero

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Educational Attainment:

Degree	Major Field	Minor Field	University/ Year Obtained
Bachelor of Science	Agronomy	Plant Pathology	UP Los Banos /1983
Master of Science	Agronomy	Plant Pathology	UP Los Banos /1988
Doctor Philosophy	Agronomy	Chemistry	UP Los Banos

Field Of Expertise:

Agronomy, weed science and rice based farming systems

Position/Designations Held:

Position/Designation	Office	Date
Program Leader Rice-based Farming Systems For Fragile Environments Program	PhilRice	November 2001 - present
Program Leader Rice-based Farming Systems Program	PhilRice	August 2000 - present
Acting Program Leader Rice for Adverse Environments	PhilRice	December 2000 - present
Program Leader Direct-Seeded Irrigated Lowland Rice Program	PhilRice	June 16 - Aug 15, 2000

Chief Science Research Specialist	PhilRice	March 1, 2001 - present
Supervising Science Research Specialist	PhilRice	Sept 2000 - 28 February 2001
Senior Science Research Specialist	PhilRice	June 1997- Aug 2000
Science Research Specialist I	PhilRice	Feb 1993 - May 1997
Science Research Specialist I (on detail)	Naphire	Feb 1992 - Jan 1993
Science Research Specialist I	Cotton Research and Devt. Institute	Aug 1989 - Jan 1992
Research Assistant II	University of the Phil. Los Banos	May 1986 - Jul1989
Research Assistant I	University of the Phil. Los Banos	May 1983 - May 1986

Membership in Professional and/or Honor Societies:

Name of Organization/Society	Position
The International Honor Society of Phi Kappa Phi	Active Member
Gamma Sigma Delta Honor Society of Agriculture	Member, Regional Representative Central Luzon Area
International Weed Science Society	Member
Asian Pacific Weed Science Society	Member
Weed Science Society of the Philippines	Board Member
UPCA Alumni Association	Member
UPLB Society of Agronomy Majors	Alumni

Honors/Awards Received:

Best Research Paper. 1st Place. Population dynamics and growth of weeds in rainfed rice-onion systems in response to chemical and cultural control methods. 18th Asian-Pacific Weed Science Society Conference. 28 May - 2 June 2001. Beijing, China

Best PhD Thesis Award. Finalist. Given by the Gamma Sigma Delta Honor Society of Agriculture on 23 March 2001, UP Los Banos. College, Laguna.

Academic Excellence Award for Graduate Student, PhD Level. Department of Agronomy, UP Los Banos. April 14, 2000

Best Paper in Weed Science. Morphologic and genetic variations in the lowland and upland ecotypes of purple nutsedge *(Cyperus rotundus* L.) in rainfed rice-onion cropping systems. 31st PMCP Annual Scientific Meeting, Baguio City. 3-6 May 2000

Best Paper in Weed Science. Agro-ecological approaches to managing weeds in rice-onion cropping systems. 30th PMCP Annual Scientific Meeting. PhilRice, Maligaya, Munoz, Nueva Ecija. 2-5 May 1999

Outstanding Researcher Level I. Philippine Rice Research Institute. November 1995

Publications/Technical Papers:

Weed Science:

As Senior Author:

Casimero MC, SR Obien and RT Cruz. 1995. Weed management for wet-seeded rice in the Philippines. In Moody K. (ed) Constraints, Opportunities and Innovations for Wet-Seeded Rice in Asia. IRRI Discussion Paper Series No. 10. IRRI. PO Box 933, Manila, Philippines.

Casimero, MC, AM Baltazar, JS Manuel, SR Obien and SK De Datta. 2001. Population dynamics and growth of weeds in rainfed rice-onion systems in response to chemical and cultural control methods. In Proc. 18th Asian-Pacific Weed Science Society Conference. Pp.5l-62.28 May - 2 June 2001. Beijing, China (First Place, Best Paper Competition)

Casimero MC, AM Baltazar, JS Manuel, SR Obien and SK De Datta. 2000. Morphologic and genetic variations in the lowland and upland ecotypes of purple nutsedge *(Cyperus rotundus)* in rainfed rice-onion cropping systems. Proc 17th Asian Pacific Weed Sci Conf. Bangkok, Thailand. 22-27 November 1999.

Casimero. Me. 2000. Population dynamics, growth and weed control in rainfed rice-onion cropping systems in Nueva Ecija province, Philippines. PhD Thesis. University of the Philippines Los Banos. College Laguna.

Casimero MC, AM Baltazar, JS Manuel, SR Obien and SK De Datta. 2000. Morphologic and genetic variations in the lowland and upland ecotypes of purple nutsedge *(Cyperus rotundus)* in rainfed rice-onion cropping systems. Paper presented at the 31st Pest Management Council of the Philippines Annual Scientific Meeting. Hotel Supreme, Baguio City. 3-6 May 2000. (Best Paper)

Casimero MC, EC Martin, AM Baltazar, JS Manuel, RP Robles, JS Lales, SR Obien and SK De Datta. 2000. Population dynamics, growth and control of weeds in onion as affected by tillage and weed management strategies. Paper presented at the 31st Pest Management Council of the Philippines Annual Scientific Meeting. Hotel Supreme, Baguio City. 3-6 May 2000.

Casimero MC, EC Martin, AM Baltazar, JS Manuel, RP Robles, JS Lales, SR Obien and SK De Datta. 2000. Evaluation of rice hull burning combined with chemical weed control methods in onion. Paper presented at the 31st Pest Management Council of the Philippines Annual Scientific Meeting. Hotel Supreme, Baguio City. 3-6 May 2000.

Casimero, MC, AM Baltazar, EC Martin, SR Obien and SK De Datta. 2001. Agro-ecological strategies to reduce weed populations in rainfed rice-onion cropping systems. Proc. Asian Agriculture Congress. 24-27 April 2001. Westin Philippine Plaza, Manila, Philippines.

Casimero, MC, S Furuya, FD Garcia and EF Javier. 2001. Establishment of agro-ecological strategies to manage weeds in wet- direct seeded rice. Paper presented during the 32nd PMCP Conference and Annual Meeting. 1-6 May 2001. CSSAC, Pili, Camarines Sur, Philippines.

Casimero, MC and A V Antonio. 2001. Management Options for Rice field Weeds. PhilRice Tech Bull. #38. 14 pp.

As Co-Author

Baltazar AM, SR Obien and MC Casimero. 1995. Weed management in rice in the Philippines: status and research agenda. Pages 171-186. In Weed Management in Rice Production. Proceedings of a Workshop of the IPM Network. Penang, Malaysia. June 19-23, 1995. IRRI, Los Banos, Laguna.

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1997 . Weed management in rice-onion systems. Progress in IPM-CRSP Research: Proceedings of the 2nd IPM-CRSP Symposium. Guatemala City, Guatemala. May 16-20, 1997. Pp 95-104.

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1998. Major weeds and their management in rainfed rice-onion cropping systems in the IPM -CRSP site in the Philippines. Progress in IPM-CRSP Research: Proceedings of the 3rd IPM-CRSP Symposium. Virginia Tech, Blacksburg, VA, USA. May 15-17,1998. Pp. 57-72.

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1997. Characterization of purple nuts edge in rainfed rice ecosystems. Proc. 16th Asian-Pacific Weed Sci. Soc. Conf. 8-12 September, 1997. Ku1ala Lumpur, Malaysia. Pp. 326-329.

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1999. Agro-ecological approaches to managing weeds in rainfed rice-onion cropping systems. Paper presented during the 30th Pest Management Council of the Philippines Annual Scientific Meeting. PhilRice, Maligaya, Munoz, Nueva Ecija. May 2-6, 1999 (Best Paper)

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1999. Major weeds in rainfed rice-onion cropping systems. The Phil. Agric. Scientist. 82(2): 166-177.

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1999. A survey of weeds in rainfed rice-onion cropping systems in Central Luzon, Philippines. Proc. 17th Asian Pacific Weed Science Conf.. Bangkok, Thailand. 22-27 November 1999.

Baltazar AM, EC Martin, MC Casimero, FV Bariuan, SR Obien and SK De Datta. 1999 . Weed management strategies in onion grown after rice. Proc. 17th Asian Pacific Weed Science Conf.. Bangkok, Thailand. 22-27 November 1999.

Baltazar, AM, EC Martin, AM Mortimer, MC Casimero, SR Obien and SK De Datta. 2001. Reducing Cyperus rotundus tuber populations using stale seedbed techniques in rice-onion cropping systems. . In Proc. 18th Asian-Pacific Weed Science Society Conference. Pp.215-223. 28 May - 2 June 2001. Beijing, China.

Agronomy and Plant Physiology

Carbon-Casimero, M. 1988. Response of wheat *(T. aestivum)* to Heat Stress at Germination and Early Seedling Stages. MS. Thesis. University of the Philippines Los Banos. 110 pp.

Rice-based Farming Systems

Casimero, MC and RG Corales. 1996. Dry-seeded rice-based cropping technologies. PhilRice Technical Bull. No. 12. PhilRice, Maligaya, Munoz, Nueva Ecija.

Obien SR, MC Casimero, RO Retales and RT Cruz. 1996. Sustainable high yields in rice-based cropping systems in the Philippines. Proc. 2nd Asian Crop Sci Conf. Fukui, Japan. 22-26 Aug 1996.

Cruz, RT, SR Serrano, MC Casimero, PR Casayuran and SR Obien. 1996. Direct seeding technology in the Philippines. In ACIAR Proc. No. 70. Proc. Of the International Workshop on Management of Clay Soils in Rainfed Lowland Rice-based Cropping Systems. BSWM, Diliman, QC. 22-25 Nov 1995. Pp. 228-236.

Obcemea, WM. FD Garcia, EF Javier, MC Casimero, ID Dumaoal, C Pascual, ML Aragon and SR Obien. 1999. Dry seeding establishment methods in rainfed lowland rice. The Phil Agricultural Scientist. 82(3): 100-106.

Agustin, EP. MC Casimero, TF Marcos and A Aguinaldo. 2001. Use of Indigo Green Manure. PhilRice Tech. Bul #39. 14 pp.

Research Papers and Projects:

Weed science

Research papers and completed projects

1) Casimero, MC, S Furuya, FD Garcia and EF Javier. 2001. Establishment of agro-ecological strategies to manage weeds in wet- direct seeded rice. Paper presented during the 32nd PMCP Conference and Annual Meeting. 1-6 May 2001. CSSAC, Pili, Camarines Sur, Philippines.

2) Casimero. Me. 2000. Population dynamics, growth, and control of weeds in rainfed rice-onion cropping systems in Nueva Ecija province, Philippines. PhD Thesis. University of the Philippines Los Banos. College, Laguna.

3) Casimero MC, EC Martin, AM Baltazar, JS Manuel, RP Robles, JS Lales, SR Obien and SK De Datta. 2000. Population dynamics, growth and control of weeds in onion as affected by tillage and weed management strategies. Paper presented at the 315t Pest Management Council of the Philippines Annual Scientific Meeting. Hotel Supreme, Baguio City. 3-6 May 2000.

4) Casimero MC, EC Martin, AM Baltazar, JS Manuel, RP Robles, JS Lales, SR Obien and SK De Datta. 2000. Evaluation of rice hull burning combined with chemical weed control methods in onion. Paper presented at the 3I5t Pest Management Council of the Philippines Annual Scientific Meeting. Hotel Supreme, Baguio City. 3-6 May 2000.

5) Casimero, MC and EC Martin. 2000. Evaluation of the efficacy and economics of butachlor-based herbicides in lowland transplanted rice in comparison with competitor herbicides. PhilRice-Monsanto Collaborative Project (1999-2000)

6) Casimero, MC and SR Obien. 2000. Adaptability of imidazolinone-resistant rice (IMI-RICE) and efficacy of some imidazolinones against major weed species in transplanted and direct seeded rice. PhilRice-Cyanamid Collaborative Project (1999-2000)

7) Casimero, MC and EC Martin. 2000. Field performance and evaluation of new Sofit N 300 EC formulation as compared to the original composition and standard herbicides in wet direct seeded rice in the Philippines. PhilRice-Novartis Collaborative Project (1999-2000).

8) Casimero. MC and Y. Kawana. 2000. Control of grass weeds in wet direct seeded rice. PhilRice-JICA Collaborative Project 2000.

9) Casimero, MC, T. Panyakaew, S Khotsimuang, Shen Go Hui, C van Hach, S Badaruddin, S Chhay and K Moody. 1994. Farmer's weed control practices in wet-seeded rice in Nueva Ecija and Noilo, Philippines. Paper presented during the 25th PMCP Convention. Pryce Plaza Hotel, Cagayan de Oro City 2-5 May 1994.

10) Casimero, MC. Field evaluation of Adjuvant 1 in combination with some selected herbicides in irrigated lowland rice. Paper presented during the 26th PMCP Convention, Benguet State University, Baguio City. 2-6 May 1995

11) Casimero, MC and J Cadiao . Field evaluation of selected Swire herbicides against some cotton weeds. (CRDI-Swire Agchem Collaborative Project, 1990-1991)

12) Casimero, MC and J Cadiao. Field evaluation of Nabu S against grass weeds of cotton. (CRDI-Shell Phils Collaborative Project 1990-1991)

Projects to be completed

1) Casimero MC and EC Martin. 2001. Evaluation of the performance of pyriftalid + cinosulfuron (Apiro 40.8 WG) applied as splash against other standard herbicides in direct wet sown rice. PhilRice-Syngenta Collaborative project to be completed in 2001)

2) Casimero, MC and LM Juliano. Agro-ecological weed management strategies to control weeds in wet direct seeded rice. (PhilRice Project 2001- 2003)

3) Casimero, MC, S Furuya, FD Garcia and LM Juliano. Establishment of stable weed management strategies in wet direct seeded rice. (PhilRice-JICA Collaborative Project 2000-2002)

4) Baltazar AM, MC Casimero, EC Martin, FV Bariuan, SR Obien and SK De Datta.. Integrated weed management in rainfed rice-onion systems. PhilRice-IPM-CRSP Project in collaboration with Virginia Tech, USA, International Rice Research Institute and the University of the Philippines Los Banos (1994- 2003)

5) Malabayabas, MD, MC Casimero and JL De Dios. Impact of herbicides on the biomass of microfauna in the soil. (PhilRice Project 2001- 2003)

6) CA Mabayag and MC Casimero. Development of agro-ecological management approaches for the irrigated lowlands of Caraga region. (Philrice proj ect 2001-2003)

Farming Systems

a. Research papers and completed projects

1) Casimero, MC, RO Retales and RG Corales. Crop productivity and soil management in rainfed lowland rice-based cropping systems. (PhilRice Rice-based farming systems project 1994- 1996)

2) Casimero MC, RO Retales, RG Corales and C Escano. On-farm trial of rice-soybean cropping pattern.(PhilRice-PCARRD collaborative project, 1995-1996)

3) Casimero MC and SR Obien. Field evaluation of promising soybean lines after rice. (PhilRice Rice-based farming systems project 1994- 1996)

4) Casimero MC, RO Retales, RG Corales and SR Obien. Field verification and technology packaging of selected vegetables after rice in rainfed lowland rice areas. (PhilRice-A VNet Collaborative Project, 1994-1996)

5) Retales RO, MC Casimero and RG Corales. Crop residue management in various rainfed lowland rice-based cropping patterns. (PhilRice Rice-based farming systems project 1994-1996)

6) Sumida H, MC Casimero, RO Retales, RG Corales and JA Prudente. Recommendation on high yielding rice cultivation on rice-based cropping systems. (PhilRice-JICA Collaborative project, 1994-1996)

7) Corales RG, RO Retales and MC Casimero. Dynamics of pest populations in various rainfed lowland rice-based cropping patterns. . (PhilRice Rice-based farming systems project 1994-1996)

8) Labios RV, RO Retales, MC Casimero and RG Corales. Sustainable agricultural technologies in small rice farms in the Philippines utilizing the farming systems approach. . (PhilRice Rice--based farming systems 1994 - 1996)

9) Fernandez, TS, NM Lalican, MC Casimero, TI Suazon, JB Reyes and PD Banatlao. High Impact Project: Quezon Bondoc Peninsula Integrated Area Development Program. (UPLB-CA-NFAC Project 1983-1990)

2. Projects to be completed

1) MC Casimero, RG Corales, LM Juliano and AO Capistrano. Village level integration of alternative rice-based farming systems technologies in the rainfed lowland areas. (PhilRice Project 2001-2003)

2) RG Corales, MC Casimero, LM Juliano and H Tobias. Establishment of an integrated farming systems model farm for the rainfed lowland rice areas. . (PhilRice Project 2001-2003)

3) MC Casimero,. Diversifying land use in the upland rice areas. (PhilRice project 2001-2004)

4) MC Casimero, PA Alviola, A Castaneda, J Madamba and Z. Macazieb. Technology propelled Rice-based Key Commodity Systems Project for Nueva Ecija. PhilRice Project. 2001-2006.

Agronomy and Plant Physiology

a. Research papers and completed projects

1. Carbon-Casimero, M. 1988. Response of wheat *(T. aestivum)* to Heat Stress at Germination and Early Seedling Stages. MS. Thesis. University of the Philippines Los Banos. 110 pp.

2. Casimero, MC and SR Obien. Field evaluation of Ritz Harvest on the growth and yield of transplanted lowland rice. (PhilRice-Ritz Corporation Collaborative project, 1994-1995)

3. Casimero MC. Preliminary cotton variety trial. (CRDI project 1990-1992)

b. Projects to be completed:

1) Casimero, MC S Furuya, BD Tadeo, C Arroyo and L Fulgueras. Village level integration of wet direct-seeded rice in Iloilo province. (PhilRice-JICA Collaborative project 2000-2002)

2)Nishida M, MC Casimero, MD Malabayabas and JL De Dios. Improvement of nitrogen use efficiency for higher productivity: direct seeded rice technology.(PhilRice-JICA Collaborative Project, 2000-2002)

Trainings Attended:

Training on Research Monitoring and Evaluation. PhilRice, Maligaya, Munoz, Nueva Ecija. 2728 September 2001.

Training on Geographic Information Systems (GIS) Application in Agriculture and Fisheries Research and Development. PhilRice, Maligaya, Munoz, Nueva Ecija. 17-21 Spetrnebr 2001.

Training on Supervisory Effectiveness for Improved Quality and Productivity. PhilRice, Maligaya, Munoz, Nueva Ecija. July 2000.

Training on Plant DNA Extraction and Analysis. Department of Biochemistry, VPI-SU, Blacksburg, Virginia. 1-15 May 1998.

Training on Systems Analysis and Simulation in Rice Production. PhilRice, Maligaya, Munoz, Nueva Ecija. 25 July-4 August 1994

Training Course on Weed Control In Direct-seeded Rice. IRRI. Los Banos, Laguna. 4 June-30 July 1993

Training Course on Rice Production Technology. IRRI, College, Laguna. 11-16 June 1993

Conferences and Workshops Attended:

Symposium on Institution Building and Research Management, PhilRice, Maligaya, Munoz, Nueva Ecija 6 November 2001 (Convenor)

Symposium on Farm Mechanization for High Productivity. PhilRice, Maligaya, Munoz, Nueva Ecija 27 June 2000 (Convenor)

First Symposium on Institution Building and Research Management, . PhilRice, Maligaya, Munoz, Nueva Ecija 24 July 2000 (Convenor)

18th Asian Pacific Weed Science Conference. Beijing, China. 28 May - 2 June 2001.

32nd Pest Management Council of the Philippines Annual Scientific Meeting. CSSAC, Pili, Camarines Norte. 2-6 May 2001.

4th Asian Crop Science Conference. Manila, Philippines. 24-27 April 2001.

14th National Rice R and D Conference. 7-9 March 2001. PhilRice, Maligaya, Munoz, Nueva Ecija

Symposium on Improving Tolerance to Abiotic Stresses in Rainfed Lowland Rice. 21-22 October 2000. International Rice Research Institute. Los Banos, Laguna

Rainfed Lowland Rice Research Consortium Annual Conference and Planning Workshop. 2124 October 2000. International Rice Research Institute.

International Workshop on Biological Control in Rice. International Rice Research Institute, Los Banos, Laguna. 10-12 May 2000.

31st Pest Management Council of the Philippines Annual Scientific Meeting and Convention. Baguio City, Philippines. 3-6 May 2000

17th Asian Pacific Weed Science Society Conference. Central Plaza Hotel, Bangkok, Thailand. 22-27 November 1999

30th Pest Management Council of the Philippines Annual Scientific Meeting and Convention. PhilRice, Maligaya, Munoz, Nueva Ecija. 2-5 May 1999.

Rice-based Farming Systems Program Planning Workshop. Philippine Rice Research Institute, Maligaya, Munoz, Nueva Ecija. 21 September 1998

Transplanted and Direct Seeded Lowland Rice Programs Planning Workshop. Philippine Rice Research Institute, Maligaya, Munoz, Nueva Ecija. 19-20 August 1998

Third IPM-CRSP Symposium. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 15-18 May 1998

International Rice Weed Ecology Planning and Workshop. Maruay Hotel, Bangkok, Thailand. 26 February -1 March 1996

National Farming Systems Commodity Research and Development Program Review and Evaluation Workshop. PCARRD, Los Banos, Laguna. 21-22 August 1995

International Workshop on the Constraints and Opportunities in Wet-seeded Rice. Maruay Garden Hotel, Bangkok, Thailand. 30 May-3 June 1994

IPM-CRSP Participatory Appraisal and Planning Workshop. Philippine Rice Research Institute, Maligaya, Munoz, Nueva Ecija. 11-22 July 1994

International Workshop on Conservation Farming for Sloping Uplands in Southeast Asia: Challenges, Opportunities and Prospects. Manila, Philippines. 20- 26 November 1994

Other Work Related Assignments

Lecturer, National Training on Rice Specialists and Refresher Training Course implemented by the Agricultural Training Institute, effective November 21,2001

Member, National Technical Committee for the Search for Outstanding Farmers Adopting Integrated Farming Systems of the Department of Agriculture. 1994-1996.

Lecturer on Weed Management and Integrated Nutrient Management in Rice. Farmer Productivity Training Center, Ciba-Geigy Foundation, Sta. Rosa, Nueva Ecija. 1994-1996.

Lecturer on Weed Management, Integrated Nutrient Management and Methods of Crop Establishment in Rice. National IPM Program (KASAKALIKASAN) Rice Specialists Season Long Training Course, PhilRice. 1993- present.

Lecturer on Weed Management in Rice-Vegetable Systems. Training for Agricultural Technologists and Farmer leaders on Rice and Vegetables with Emphasis on IPM, PhilRice

Lecturer on Weed Management in the Training of Trainers (ToT) for Integrated pest Management (IPM) in Onion. National IPM Program in support of the High Value Commercial crops program of the Philippines Department of Agriculture. 15 November 1999 to 24 March 2001.

Lecturer of Rice-based farming Systems in the Philippines, Training for Technologists and Farmer Leaders on Rice-based Farming Systems, PhilRice. 17 January to 15 April 2001.

Technical Reviewer on Weed Management in Rice. Let Us Produce More Rice: A Training Manual. 2000. PhilRice.

Coordinator, 30th Pest Management Council of the Philippines Annual Scientific Meeting 2-5 May 1999, PhilRice, Munoz, Nueva Ecija

Symposium Chair, Institutional Development and Research Management, 27 June 2000, PhilRice, Munoz, Nueva Ecija

Chair, Symposium on Farm Mechanization for High Productivity. 24 July 2000, PhilRice, Munoz, Nueva Ecija

Chair, 3rd Symposium on Institution Building and Research Management, 6 November 2001. PhilRice, Maligaya, Munoz, Nueva Ecija.

Annex: Collaborators

Thailand:

- Taweesak Vearasilp
  Information Science Specialist
  Department of Land Development
  Bangkok, Thailand
  Time commitment: 15%

- Kukiat Soitong
  Extension Director
  Ministry of Agriculture Extension
  Bangkok, Thailand
  Time commitment: 15%

Philippines:

- Miguel Aragon
  Senior Agronomist and SM-CRSP Coordinator
  Dr. Miguel L. Aragon
  Research Fellow and Project Leader
  Agronomy, Soils, and Plant Physiology Division
  BS Agriculture, UP Los Banos 1972
  MS Soil Science, UP Los Banos 1977
  PhD Soil Science, UP Los Banos 1984
  Field of Specialization: Soil Fertility; Agronomy
  Time commitment to Project: 65%

- Josephina Lasquite
  B.S. Soil Science
  University of the Philippines at Los Banos Science Research Specialist
  PhilRice
  Hagan, The Philippines
  Time commitment: 95%

- Dr. Rodolfo S. Escabarte,Jr.
  Supervising Science Research Specialist Head, Research and Development
  PhilRice Midsayap (Mindanao Coordinator)
  BS Agriculture(Cum laude), USM 1990
  MS Crop Science, Yamagata University, Japan 1996
  PhD Plant Science, Yamagata University, Japan 1999
  Field of Specialization: Agronomy; Plant production and protection
  Time commitment to Project: 20%

- Jocelyn Bajita
  Ph.D. Soil Science, University of Hawaii (in progress)
  M.S. Soil Science, The University of the Philippines at Los Banos
  Agronomist
  PhilRice
  Malagaya, The Philippines
  Time commitment: 10%

IRRI:

- Jim Hill
  Head, Crop, Soil and Water Sciences Division and Program Leader, Program 2, Enhancing Productivity and Sustainability of Favorable Environments
  IRRI
  The Philippines

- Gary Adin
  Director of Uplands Consortium
  IRRI, The Philippines

- Bruce Linquist
  Uplands Agronomist
  Lao/IRRI Program
  IRRI, The Philippines
  Ph.D. Soil Science, University of California at Davis

- Anolath
  Director NAFRI, IRRI Upland Consortium

- Olayvanh Singvilay,
  Research Scientist NAFRI, IRRI Upland Consortium

Mali - West Africa:

- Abou Berthe, IER/Mali

  A. Name and title:

  BERTHÉ Abou, Farming Systems Research and Natural Resources Management (FSR&NRM) Program Officer, IER/Mali
  Institutional affiliation: Institut d'Economie Rurale, Ministry of Rural Development/ Mali

  B. Relevant training and experiences

  Academic training

  1991, PhD Animal Science, University of Florida (Gainesville/USA)

  1984, Diploma of Advanced Studies in Range Management and Animal Nutrition, National Polytechnical Institute/ENSA (Toulouse/France)

1976, Diploma of Engineering in Animal production, National Polytechnical Rural Institute (Katibougou/Mali).

Training courses/seminars

April 1999, Short course in GIS on fishery monitoring in the Inlet Delta of Niger IRD Bamako

August 1994, Internal training course on "Environmentally Sound Resources Planning in Intensive Agriculture:, Concepts and Tools for Sustainable Agricultural Development". DSE-Food and Agriculture Centre - Feldafmg and Schortau - German Foundation for International Development.

From 1991 to 1993, diverse training on Participatory approaches in agricultural (PRA, RRA, Gender) and farming systems research and extension, etc..

C. Experience

Has worked as Animal scientist, project officer, Team officer and Program officer since 1979 on interdisciplinary research on farming system and natural resource management and development

From 1996 a 1999: 55 consulting reports on community natural resource development and planning, community natural resource management planning for different projects, NGO's.

D. Titles of relevant publications

Berthé, A., M.A. Diallo, N. Koné, S. Mahotière et Y. Cissé, 1992: Eléments de reconnaissance générale dans les zones du Delta et du Seno en 5ème région, Rapport de recherche, 162 p.; CRRA de Mopti, A vriI1992.

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Devereux, Stephen. 1999. Making Less Last Longer: Informal Safety Nets in Malawi. Institute for Development Studies (IDS) Discussion Paper 373. Brighton: IDS.

Doumbia, M., Adama Coulibaly, Oumar Coulibaly, Zoumana Kouyate, Aminata Badiane, and F.S. Sidibe, Lloyd Hossner and Jot Smyth. 1998. Baseline Study of Socio-economic Conditions and Decision Making Processes with a Focus on Small Farmers, Nutrient Management And Millet Production in the Segou Region of Mali. *LaboSEP, Programme Mil, ESPGRN and Programme Niebe* - *Institut d 'Economie Rurale, Mali; North Carolina State University, Raleigh; and Texas A&M University, College Station* Decision Aids for Integrated Soil Nutrient Management Project (IntDSS), Soil Management Collaborative Research Support Program, U.S. Agency for International Development.

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Annex: Letters of support

FROM : PhilRice CES FAX NO. : 0444560112 Dec. 21 2001 04:42PM P1

Department of Agriculture
PhilRice
PHILIPPINE RICE RESEARCH INSTITUTE

Maligaya, Muñoz, 3119 Nueva Ecija, PHILIPPINES
Tel :63 (044) 456-0113, -0277, -0285, -0258, -0354; (0612) 315-6092
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19 December 2001

Dr. RUSSEL YOST
University of Hawai'i at Manoa
Department of Tropical Plant and Soil Sciences
3190 Maile Way
Honolulu, Hawai'i
96822

Fax: 808-956-3894

Dear Dr. Yost,

It has been a pleasure working with you in the Phase 1 of tho Soil Management Collaborative Research Support Project (SM-CRSP). Indeed, the Nutrient Management Decision Support System (NuMass) is an important tool that extensionists and farmers can use to increase productivity in the upland rice areas. I am very glad that the project is progressing to the second phase which will now bring the NuMass to the field for testing.

I am very pleased to inform you that I have approved the involvement of Dr. Madonna C. Casimero as Site Coordinator for the Phase 2 of the SM-CRSP in the Philippines. Her active involvement in the SM-RCSP will facilitate the introduction of the NuMass to agricultural extensionists and farmers through the Village Level Integration Project of the Rice-based Farming Systems for Fragile Environments Program.

Thank you for involving PhilRice again as a collaborator and lead institution in the implementation of the Phase 2 of SM-CRSP in the Philippines. I am looking forward to another fruitful collaboration with you.

My best wishes for the holiday season.

Very truly yours,

LEOCADIO S. SEBASTIAN
Executive Director

Republic of the Philippines
DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
Elliptical Road Diliman, Quezon City, PHILIPPINES
Telephone nos. : 920-4323, 920-4358, 928-8426
Telefax : 926-6140, 929-8183

From: Tasnee Attanandana <agrtna@ku.ac.th>

At 02:30 PM 11/27/00 -1000
Dear Dr. Tsuji,
I would like to indicate the strong interest of Kasetsart University and the Thailand Research Fund program that I direct to participate with the Soil Management Collaborative Research Support Program in the second phase of activities. The objectives of the proposal prepared by Dr. Yost matches those of my program and that supported by the Thailand government and we look forward to a very productive collaboration in using and adapting the decision-aids that the SM -CRSP has available. We will be collaborating in this work with our Extension Service in order to reach a large number of farmers in the 4 provinces that we presently are targeting.

With my best regards.
Tasnee Attanandana, D. Agr.
Professor of Soil Science
Kasetsart University,
Bangkok, Thailand

From:"Hill, James" <J.HILL({V,CGIARORG> Fri 10:19 PM
Subject: RE: Wind down of the SM-CRSP Program Phase I in SE Asia To: 'Russell Yost' <rsyost@hawaii.edu>
CC: "Mew, Tom (IRRI)" <T.MEW@CGIARORG>, Gordon <gordont@hawaii.edu>, "George, Thomas (IRRI)" <T.GEORGE@CGIARORG>, "'p.singleton2@gte.net'" <p.singleton2@gte.net>, "Bell, Mark" <M.BELL@CGIARORG>, "Atlin, Gary" <G.ATLIN@CGIARORG>, "Wang, Ren" <RW ANG@CGIAR.ORG>

Dear Russ:

IRRI has and continues to appreciate our partnership with the U. Hawaii. We recognize the need for the SM-CRSP to move towards testing and adoption of farmer decision aids. In this regard, I suggest that you contact Dr. Mark Bell, Team Leader for IRRI's Impact Project and Dr. Gary
Atlin, leader of the Upland Consortium.
Again, thank you for informing me of the upcoming changes in the SM-CRSP. I look forward to further discussions on how to assist Dr. George in this transition and on our continued working partnership with U. Hawaii.
With best regards,

Jim
IRRI
Los Banos,
The Philippines

Subject: Re: Some discussion / description of the Pole
Date: Sun, 16 Dec 2001 12:32:48 -1000
From: aminiane@arc.sn
To: Russell Yost <rsyost@hawaii.edu>

Hi Russ, I accept your proposal of the Africa Coordinator and when we will meet in March we will have the opportunity to talk with the Pole members. I am in the France right now up to January 10. But you still can send me the mail . I'll read my mail every day. Thanks Merry Christmas and happy new year.
Aminata

> Hi, Aminata,
> In developing the NuMaSS proposal, we will need a coordinator for the
> work in Africa, it should include the Pole, I think, but there will be a slight
> possibility of work in IITA and S. Africa (1. Smyth). I wonder if you
> would agree to be the coordinator for this work? I expect that the most
> substantial work would be through the Pole, building on the work that has been done in the InterCRSP > and other projects and linking with the SM-CRSP Carbon project work.
> I'm proposing that there be a SE Asia coordinator at Phi1Rice,
> Ma1igaya and yourself for Africa. There will be substantial support for assistants and
> student training. There will be an overall coordinator that will be a
> person well-versed in decision-aids, working with farmers, and that understands
> information technology.
>-
> Russell Yost
> University of Hawai'i at Manoa
> Dep. Tropical Plant and Soil Sciences
> 3190 Maile Way
> Honolulu, Hawai'i
> 96822
>
> Phone: 808-956-7066
> Fax: 808-956-3894
> Emai1: rsyost@hawaii.edu
>
>
>

Adoption of the Nutrient Management Support System (NuMass) Software Throughout Latin America

North Carolina State University

Adoption of the Nutrient Management Support System (NuMaSS) Software Throughout Latin America

A Joint Proposal by
North Carolina State University
Texas A&M University

Submitted to
Soil Management Collaborative Research Support Program

Principal Investigators:

T. Jot Smyth   Deanna L. Osmond

Addresses:
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E-mail - Jot_Smyth@ncsu.edu; Deanna_Osmond@ncsu.edu

Voice – 919-515-2838

Fax – 919-515-7422

Amount Requested for the 5 project years: $1,250,000

10/26/01
North Carolina State University
GINNY MOSER
Manager, Client Relations
and Facilitation

PROBLEM STATEMENT

Identification of Constraints to be Addressed

This proposal directly addresses the constraint (and its associated objective) on *ineffective transfer of soil management technologies from research centers to decision makers at the farm and policy levels*. The NuMaSS software knowledge base can only recommend corrections to nutrient constraints or provide economic evaluations of potential management options upon user input of soil and crop coefficients for the targeted problem site. National research centers are the providers of the required soil and crop data. With the involvement of national research centers, the proposed products to be delivered by this project would also contribute, but not completely address, the constraints/objectives enumerated as *a, b, c, d* and *f* in the Request for Proposals.

Relevance of NuMaSS to the Transfer of Nutrient Management Information

A proper diagnosis of a nutrient deficiency or sufficiency for a given farm field must consider the combination of numerous soil, crop, economic and environmental factors. Whether an existing nutrient level in a field is sufficient or deficient depends on several factors: the target production level and different nutrient demands or tolerance to toxic elements among crops and cultivars within crops. If a nutrient in a field is deficient, a feasible recommendation to correct it must consider the various nutrient sources that are available to the farmer, their immediate and long-term cost/benefits, and the associated management that is needed to maximize returns while avoiding detrimental consequences to the environment. Farmers might have access to more than one source of a nutrient, each with trade-offs between costs/benefits, management requirements and environmental risks. Suitable decisions on nutrient management at both farm and policy levels require access to this information in a manner that enables comparisons among available options.

Most soils present a combination of nutrient constraints. Multiple constraints escalate the decision-making complexity of nutrient diagnoses and recommendations, as well as choices of management options and crops for a given farm field. Failure to correct one nutrient deficiency or toxic element can limit crop response to the application of other nutrients that, in turn, changes cost/benefits, management strategies and risks to the environment. Decisions on multiple nutrient constraints, thus, require the consideration of options for each individual nutrient and the resulting interactions among the combined nutrient problems. Decisions, at both farm- and policy-levels within a given region, also include choices between different soil types or fields and different crop species. Each species, and even cultivars within species, can have a different demand for a nutrient (or tolerance to a toxic element). In addition, the amount of nutrient that must be applied to correct a given level of deficiency varies with soil type.

Few regions in the world have access to locally-derived information for all the variables needed to produce agronomic, economic and environmentally sound choices in nutrient management technologies. This is particularly true in developing countries targeted by USAID for “improved food availability, economic growth and conservation of natural resources through agricultural development”. In these regions, experts from research and information-transfer centers must prioritize investment of their limited human and financial resources to either acquire the necessary information locally or transfer and adapt existing knowledge developed elsewhere. The demands for assistance in policy- and farm-level decisions on soil nutrient management exceeds the human capacity of experts available in most of these regions, leading to “bottlenecks” in both the access and transfer of pertinent technologies. The consequences are (a) agricultural development policies based on information that is both inaccurate and incomplete; (b) limited infrastructure development by the agribusiness sector because the market potential is not evident; and (c) failure of farmers to adopt practices that improve productivity and avoid natural resource degradation, because the risk factors remain too high. Scarcity of experts can be alleviated if the required knowledge is organized in a manner that enhances both the efficiency of assistance by country-level experts and the capabilities of less-experienced personnel.

During the ongoing 5-year phase of the SM-CRSP, investigators of this proposal have been developing the Nutrient Management Support System (NuMaSS) software with the specificintent of facilitating the transfer and access of soil nutrient management information between research centers and decision-makers at the farm and policy levels. Based on user replies to questions about soils, crops, available nutrient sources and input-output prices, the decision support system diagnoses acidity, N and P problems and recommends best management strategies to correct these soil nutrient constraints using the same logic and problem-solving methods of experts. Users can compare diagnoses and economic implications of management recommendations across multiple scenarios of soils, crops, cultivars and sources of lime and nutrients. Multiple scenarios enable the users to determine the consequences of their agronomic decisions and allow them to make better informed cropping system choices.

NuMaSS construction has followed a “participatory” approach, wherein nutrient management research and information-transfer experts from centers throughout tropical Africa, Asia and Latin America evaluated and recommended improvements to a sequential series of interim software releases. By the end of the current 5-year phase, NuMaSS software will be at release version 2.0 and a stage of development where it is ready for adoption at country and regional levels. Known improvements for NuMaSS 2.0 over the currently released version 1.5 (Osmond et al., 2000b) include (a) integration of the acidity, N and P modules to operate as a single unit in the nutrient diagnoses, prediction and economics components; (b) reduction in the number of variables required as user input; (c) printed output options for the diagnosis, recommendation and economics components; and (d) database editing capabilities to enable local users to include their own soil and crop coefficients. The latter improvement will enable users to “customize” the software database for their location-specific conditions. Version 2.0 will contain an extensive database of soil and crop coefficients, collected from published and grey literature searches, for the diagnosis and recommendation of most crops grown for food and forage production in the tropics: cassava, corn, cowpea, bean, groundnut, peanut, millet, potato, sorghum, soybean, yam, upland rice, wheat and forage grasses and legumes. A module for diagnosis and recommendation of tree crops, using peach palm for heart-of-palm production as the test crop, will be fully implemented.

Justification in Terms of Goals and Objectives of USAID and AFS

Excess soil acidity and nutrient deficiencies limit crop yields in most underdeveloped countries. Poor yields contribute to food insecurity and economic hardship. Unfavorable weather, even for one growing season, can lead to famine in areas with limited agricultural productivity. Increased production of food and raw products contributes to income and provides more options for resource-limited farmers. Upon improving soil fertility, soil protection increases, erosion and downstream sedimentation decrease, new cropping alternatives are possible and there are more products and associated services. Adoption of the NuMaSS knowledge base will improve the transfer of information which agricultural-support services need to help farmers increase crop yields and income.

OBJECTIVES AND OUTPUTS

The goal of this project is to support the adoption of NuMaSS-based knowledge via a network of on-going programs throughout Latin America with potential to benefit from the improved access to information on N, P and/or soil acidity management. Specific objectives are as follows:

a. test and compare NuMaSS predictions on nutrient diagnosis, recommendation and economic evaluation to those currently in use;

b. identify and refine software components that limit adoption and use of the NuMaSS knowledge base; and

c. monitor the local adoption process and develop auxiliary tools, when needed, that improve the use of NuMaSS-based knowledge within the regional user domains.

The expected outputs and products from this project are as follows:

1. NuMaSS software - a computerized knowledge base to aid in the evaluation of multiple scenarios and decisions on the diagnosis, recommendation and economic consequences of lime, N and P inputs. The software will be improved to reflect experiences gained from adoption under a variety of specific conditions addressed by collaborators throughout Latin America.

2. examples of successful approaches to test, adapt and apply nutrient management decision aids.

3. auxiliary information tools that enhance the portability and transferal of the computer knowledge base within the regional level.

STRATEGY AND APPROACH

The project activities will be conducted in collaboration with a network of ongoing programs in Latin America which have an expressed interest in NuMaSS adoption. These programs have the basic support structure and information base to benefit from improved access to information on N, P and/or soil acidity management. The primary target groups within the policy-to-farmer decision-making continuum are the national research/extension services; this group provides, interprets and has immediate access to the location-specific soil and crop data required to develop nutrient recommendations and economic evaluations from the NuMaSS knowledge base. Through work with this primary target group, however, we also expect that our activities will include direct participation of both farmers and the policy and marketing sectors.

Description of Targeted Programs for Potential Collaboration

Table 1 provides a list of regional consortia and national institutions with ongoing programs providing conditions favorable to investigations on the transferability and adoption of NuMaSS. Collectively, this network of institutions and programs also offer a diverse combination of soils, climate and crop conditions that are addressed by the NuMaSS software.

As existing members of the extensive evaluation network during Phase One of the SM-CRSP, many of the proposed collaborators have contributed in development and evaluation of preliminary NuMaSS prototypes. Funding limitations, however, allowed only a few of these collaborators to attend the NuMaSS workshop in the Philippines (Osmond et al., 2000a). Other proposed collaborators actively participated in the SM-CRSP's Latin American Soils Research Network (RISTROP) during the late '80s (Smyth et al., 1991), and have demonstrated abilities to effectively participate in the transferral and adoption of improved soil management technologies.

Several existing networks and consortia have expressed interest in collaborating on NuMaSS adoption within their ongoing programs. The three regional Potash&Phosphate Institute (INPOFOS) offices in Latin America support numerous N, P and K fertilization trials by national institutions. INPOFOS is willing to share these data, many of which are unpublished, in our efforts to test and compare NuMaSS predictions with observed field and laboratory data. Their experiences with soil nutrient management issues throughout the region will also be useful in our efforts to adapt NuMaSS to local conditions.

The International Potato Center (CIP) coordinates a potato research network, 'Papa Andina', comprised of national institutes in Bolivia, Ecuador and Peru. One of the primary issues addressed by this network is the application of technological innovations that improve marketing, reduce poverty and improve the use of natural resources. Potato is one of the few crops that is intensively fertilized throughout the Andean highlands, and 'Papa Andina' is interested in the potential use of NuMaSS for fertilizer recommendations and management. Each member-country in the network has a modest soil fertility database from field trials at both experiment stations and in farmer fields. One of the interesting opportunities for collaboration via this network is the comparison of N and P predictions for a single crop across diverse soils and socio-economic conditions. Soils in potato-growing regions of Bolivia and Peru are dominated by clays with crystalline mineralogy as opposed to amorphous minerals (Andisols) in

Table 1. Potential Latin American institutions and consortia for network collaboration in the transferral and adoption of NuMaSS.

Institution or Consortia	Country	Principal Contacts	Climatic Regime	Dominant Soils	Principal Crops
IBTA	Bolivia	Mr Severo Espana	Humid tropical	Inceptisols, Entisols, Ultisols	Rice, corn, pastures
EMBRAPA- CNP Gado de Corte	Brazil	Dr. Manuel Macedo	Wet-dry	Oxisols, Ultisols	pastures and ley cropping with soybean and rice
EMBRAPA- CP Rondonia	Brazil	Dr. Marilia Locatelli	Humid tropical, wet dry	Oxisols, Ultisols, Alfisols	rice, corn, cowpea
EMBRAPA- CP Teresina	Brazil	??	Semi-arid	Entisols, Inceptisols, Alfisols	sorghum, cassava, cowpea

MAG & UCR	Costa Rica	Mr. Jose Soto, Dr. Alfredo Alvarado, Mr. Eloy Molina	Highlands	Andisols	potato
INIAP-Pichilingue	Ecuador	Mr. Francisco Mite	Humid tropical	Alfisols, Andisols, Mollisols	rice, corn, soybean, peach palm
INPOFOS - Northern S. America	Northern South America	Dr. Jose Espinosa	various	various	various
INPOFOS - Cono Sur	Southern Latin America	Dr. Fernando Garcia	various	various	various
INPOFOS - C. America	Mexico & Central America	Dr. Ignacio Lazcano	various	various	various
CIP-Papa Andina	Boliva, Ecuador & Peru	Drs. Walter Bowen, Andres Devaux	Highlands	Inceptisols, Andisols	potato
CIAT-MIS	Honduras & Nicaragua	Dr. Miguel Ayarza	Wet-dry	Inceptisols, Alfisols, Andisols, Ultisols	corn, bean, cassava, soybean, rice
INIFAF	Mexico	Dr. Jamie Salinas	Semi-arid	Alfisols, Entisols	corn, sorghum
IDIAP-Santiago	Panama	Mrs. Benjamin Name, Ramon Gordon	Wet-dry	Alfisols, Ultisols	rice, corn, cassava, bean

Ecuador. In our efforts to identify and refine NuMaSS components related to nutrient management for potato, we propose to involve the extensive knowledge on this crop's management in Costa Rican Andisols. This will ensure that software improvements are also relevant to the extensive regions of potato production in the Andean highlands of Central America. Further information on 'Papa Andina' is available at http://www.cipotato.org/papandina/.

The International Center for Tropical Agriculture's Hillsides Project, based in Honduras, coordinates the Consortium for Integrated Management of Fragile Soils in Central America (MIS). The consortium was created in 1999 and consists of universities, national research institutes and several non-governmental organizations in Honduras and Nicaragua. MIS has the goal of improving small-farmer life quality through sustainable increments in agricultural productivity with concomitant conservation of soil and water resources. Consortium activities target four watersheds in Honduras and Nicaragua. The two core watersheds are Yoro in the hilly central region of Honduras dominated by Inceptisols, and San Dionisio in Nicaragua with extensive areas of Andisols. Secondary watersheds are located in the Lempira Province of Honduras, which is drier than Yoro and has extensive areas of Andisols and Ultisols; and La Dalia, Nicaragua where forest lands are undergoing rapid conversion to pastures and grain crop production by small farmers. Nutrient management issues focus on traditional crops (corn and bean) and new crops (cassava, yam, sorghum and soybean). The new commodities allow for the development of crop rotation alternatives with differing nutrient requirement scenarios. Further information on MIS is available at http://www.intertel.hn/org/ciathill/.

Preliminary discussions with members of the MIS Executive Board identified several potential areas for mutually beneficial collaboration on NuMaSS. Planned nutrient spot trials throughout the watersheds with single rates of N, NP and NPK treatments for corn could be easily supplemented with additional measurements to test the software's diagnosis of nutrient constraints. NuMaSS nutrient recommendations could aid in the planning and strategic selection of sites for field trials to evaluate nutrient requirements and yield potentials for the introduction of new crop commodities. Once local performance of NuMaSS is deemed satisfactory, software linkages with CIAT's extensive geo-referenced database of soil chemical properties, landscape position, infrastructure and other land use components could be used to produce maps that assist in planning and local assistance to farmers.

Collaboration with other individual institutions in Bolivia, Brazil (EMBRAPA), Ecuador, Mexico and Panama (Table1) expands validation and adaptation of the NuMaSS knowledge base to encompass a broader spectrum of soils, climate and economic conditions. EMBRAPA's beef-cattle research center in Campo Grande, Brazil has an extensive collection of field trials to validate nutrient management predictions in pastures; farmer adoption of ley cropping practices with intermittent rotations between pastures and grain crops provides an interesting opportunity for testing and adapting the software's diagnoses and recommendations. The EMBRAPA station in Rondonia, Brazil provides technical assistance to World Bank-funded colonization projects in the Western Amazon and provides a setting for software diagnoses and recommendations to farmers clearing land by slash-and-burn. The EMBRAPA station in Teresina, Ceara provides an opportunity to evaluate transferability of nutrient management knowledge from the African Sahel to the "catinga-sertao" ecosystems.

Approach to NuMaSS Adoption

We propose to visit each targeted group of collaborators as the first project activity. During these meetings collaborators will be provided hands-on exposure and training with the NuMaSS 2.0 software, which is scheduled for release in November 2001. During practice with the software, collaborators will use their own data and evaluate outputs for scenarios within their local conditions. Discussions will seek to elicit collaborator ideas, interests and opinions as to how NuMaSS can be used to address nutrient problems within their local domain, the extent to which their existing data can be used to validate software predictions and the types of adoption research which are needed to fill existing information gaps. Upon completion of these visits, we will have a more concrete appreciation for how individual collaborators wish to use the NuMaSS tool in addressing local nutrient management issues and the types of support we need to provide towards their adoption efforts. We will also seek to identify linkages among targeted collaborators based on common interests. Some of the group linkages are readily apparent as described in the 'Papa Andina' network and the MIS consortium. Commonalities between climatic regimes, soil nutrient constraints and principal crops also suggest the potential for linkages among collaborators in Mexico, Panama, INIAP-Pichiligue, IBTA and EMBRAPA centers in Brazil.

The outcome of these initial visits will be development of a detailed outline of annual activities across the project's five years in support of the adoption research by the network of collaborators. Whenever possible, collaborators with common interests will be encouraged to work together in order to avoid duplication of efforts. A significant portion of project funds have been set aside in "Other Direct Costs" (see the "Budget" section of proposal). We intend to use these funds in support of collaborator activities in a manner that promotes synergism and collaboration among network groups with common interests and adoption research needs.

We anticipate that network activities among the targeted ongoing programs will encompass a series of overlapping tasks that match the project objectives: (a) testing and comparing NuMaSS predictions with field results; (b) identifying and refining NuMaSS components that limit local performance; and (c) developing auxiliary tools to enhance portability and local use of the NuMaSS knowledge base. Although the structure of these sequential activities must be flexible enough to match the different needs of the ongoing targeted programs, there are common elements to each that highlight the overall project's approach.

Testing and Comparing NuMaSS Predictions

In most developed countries nutrient management is based on the combined output of the analysis-interpretation-recommendation of a location-specific soil or plant tissue sample. NuMaSS 2.0 divides this process into three separate steps: diagnosis, recommendation and economic evaluation. Diagnosis seeks to answer the question of whether a nutrient problem exists, and is based on cumulative probabilities for observations on indicator plants, plant nutrient deficiency symptoms, previous yields and nutrient management, and geographical location. Soil and plant analyses are considered, if available, but are not required. A nutrient recommendation, however, is only provided by NuMaSS with user input of soil or plant data.

Separation of diagnosis from recommendation, enables users to concentrate use of limited funds for soil/plant analytical costs only in those situations where a nutrient constraint is identified and a recommendation is needed. An economic evaluation can only be provided if the user provides the minimum data set required for a nutrient recommendation.

NuMaSS uses various soil and crop coefficients in diagnosing nutrient constraints and recommending their corrections. Examples of soil coefficients are soil acidity and P buffer coefficients; examples of crop coefficients are aboveground crop N concentrations and critical % Al saturation values. Existing coefficients in NuMaSS came from extensive reviews of published and gray literature for lime, N and P field trials throughout the tropics. Although this is the best information available, there is no guarantee that NuMaSS predictions will be correct for every specific condition in Latin America. It needs to be tested to ensure that the local crop cultivars and soil conditions are adequately represented by coefficients in the existing software database. We plan to test and compare the predictions for both the diagnosis and recommendation components of NuMaSS with field results. The test-comparisons will initially focus on available data sets from previous field trials. We believe that some of this information is available in unpublished data with many of our potential network collaborators.

Diagnosis - the desirable data set includes field evidence of response or no response in yield to the nutrients in question and historical site information on factors used to determine the cumulative probabilities of nutrient deficiencies. Trials to test and compare diagnosis could be easily incorporated into any planned field demonstrations that involve the input of nutrients as one of the factors. Our interest would be to participate in the planning of such field demonstrations by performing and documenting the output for NuMaSS Diagnosis on each site. Secondly, we would like to assist in the design of the demonstrations to ensure that comparisons can be made between no nutrient input and at least one level of applied P and N (lime would also be included if deemed appropriate for the soil conditions and targeted crop). Chi-square statistical procedures can be used to develop an accuracy index for diagnosis by comparing crop yield response between the control treatment and the single nutrient rates with the initial diagnosis assessment for each site and across sites (SM-CRSP, 2001). Field trials with single rates of N, NP and NPK treatments for corn, which are currently planned by the MIS consortium for various locations in their watersheds, exemplify the type of investigation we would propose.

Recommendation - desirable data for NuMaSS recommendations are soil and/or plant nutrient analyses and crop response to incremental levels of the applied nutrient. Tests and comparisons of NuMaSS nutrient recommendations could be incorporated into field experiments with multiple levels of applied nutrients, but would require supplementary soil and crop measurements. We would like to include the NuMaSS-recommended nutrient level as one of the experimental treatments, bracketed between a lower and higher nutrient application rate to assess the extent of under- or over-estimation in the software's prediction. Nitrogen, P and lime recommendations by NuMaSS involve software predictions of several soil and crop coefficients, any of which could lead to an incorrect prediction. Therefore, we would like to undertake supplementary soil and crop measurements in these field trials, as shown in Table 2, to test and compare the coefficients for NuMaSS recommendations on N, P and acidity.

Table 2. Desirable soil and plant measurements in field experiments to test and compare NuMaSS coefficients for nutrient recommendations.

Nutrient Constraint	Soil/Plant Measures	NuMaSS Coefficients
All	Crop yield and residues	Various
Acidity	Soil pH, Ca, Mg, K and Al	crop critical Al saturation %, soil buffer acidity
	lime $CaCO_3$ equivalence, Ca and Mg content	
N	aboveground plant N, soil organic matter	native soil N supply, apparent N recovery, organic input N supply, N efficiency factors for input sources
	dry weight and N for organic inputs	
P	Soil clay % and soil extractable P	crop critical soil P level, soil P buffer capacity

Unless sufficient data from prior experiments is readily available to assess software predictions, we anticipate that most collaborators will be interested in testing NuMaSS recommendations with new field trials. In fact, NuMaSS nutrient recommendations could serve as the starting point for the MIS consortium in planning field experiments to determine nutrient input requirements for the new crops which are being introduced to watersheds in Honduras and Nicaragua.

<u>Identifying and Refining NuMaSS Components</u>

Evaluation and interpretation of results obtained during testing and comparing NuMaSS predictions on nutrient diagnosis and recommendations will reveal (identify) the software components that should be refined in order to provide reliable predictions at the local level. In some cases, refinements may be as simple as adding values to the software's database to serve as default coefficients for the targeted regions. The inclusion of database editing capabilities in NuMaSS 2.0 is specifically intended to enable users to replace our "best" estimates of globally-relevant soil and crop coefficients with values derived from local or regional experimentation while maintaining integrity of the software's original decision support system structure. Examples of editable coefficients include crop critical values for tissue N and P, crop critical values for soil extractable P and Al saturation %, soil acidity and P buffer values, N content of organic inputs, N efficiency factors for organic and inorganic input sources, regional optimal yields, and cultivar grain:stover ratios. Inclusion of locally-relevant soil and crop coefficients will affect the output of both the diagnosis and nutrient recommendation components of NuMaSS.

The probability values associated with information about regions, soils, crop history, indicator plants, visual symptoms and soil-plant analysis in the diagnosis module may also need refinement if local tests and comparisons reveal frequent misses in determining presence or absence of nutrient constraints. Existing probability values are based on surveys of nutrient management experts throughout the tropics, and may not adequately reflect conditions within a given region.

Refinements of some of the soil and crop coefficients may entail adjustments to algorithms by which NuMaSS predicts coefficient values based on certain soil proxy variables. An example for this adjustment would be prediction for potatoes of values for critical soil extractable P and soil P buffer capacity among collaborator sites with Andisols and soils with crystalline mineralogy in the 'Papa Andina' network. Similar adjustments may also be needed for the algorithm used to predict native soil N supply from soil organic matter content.

NuMaSS recommendations and economic evaluations also include guidance and caution statements concerning timing and application methods for nutrient inputs, potential environmental risks, and possible occurrence of nutrient constraints that are not considered by the software. These advisory statements need to the refined to reflect local experience related to soil types, cropping systems and available nutrient sources.

Developing Auxiliary Tools and Monitoring Adoption

Although project activities target collaboration with national agricultural research service staff we will encourage participation of their extension and agri-business counterparts. The intent is to collectively identify within each targeted region how to facilitate the transfer and use of NuMaSS-based information beyond those users with immediate access to the computer software. During field validation of the NuMaSS diagnoses with field trials, for example, some of the diagnostic information on prior crop yields and land management history requires interviews with farmers. During this process, we believe that users will begin to identify innovative approaches to transport and convey the pertinent information without depending on computers as the media.

Since network-wide workshops are cost-prohibitive, we propose to encourage this collective dialogue within network subgroups with common interests through a series of discussions at critical stages during testing and comparing, and identifying and refining NuMaSS components. For some of the groups, like MIS and 'Papa Andina', these discussions can be carried out during their own scheduled meetings. For other network groups we will use web-based forums or e-mail discussion groups, supplemented by interactions with collaborators during our travels for technical backstopping support. Similar group discussion formats will also be used at pertinent stages during the project to elicit collaborator feedback on (a) the summary of results from the "test and comparison" phase, and (b) assessment of NuMaSS performance after incorporating refinements to the various coefficients.

The nature and content of the auxiliary tools are expected to evolve from group discussions within each targeted region. A possible example of such a tool for the diagnosis component could include printed guides for identifying nutrient constraints on a numerical grading system that would include color printouts of indicator plants and visual nutrient deficiency symptoms. An auxiliary tool for the nutrient recommendations and economic evaluations could be a summary sheet for the most common NuMaSS predictions according to soil type, cropping system, targeted yield and available nutrient sources; the summary sheet might be linked to a spreadsheet or word processing template where critical components of NuMaSS output for a series of regionally-relevant scenarios can be easily assembled upon changes in prices or the introduction of new commodities and nutrient sources. Within the MIS consortium there is interest in producing map overlays with NuMaSS output that is based on CIAT's geo-referenced database.

As part of the first year visits, discussions with each target group of collaborators will consider opportunities for impact, performance indicators and strategies for adoption. After initial visits are concluded a matrix will be constructed to summarize the adoption goals, strategies, methods and expected impacts across collaborator groups and intended software use. Formats for reporting results on adoption progress will be distributed via e-mail and the web. Requested information will include pre-adoption disposition of client groups and adoption results (frequency and results derived from NuMaSS use). The cumulative data set, encompassing responses at several times during the 5-year project, will enable several types of analyses including (a) range of software applications and variance of methods and results; (b) relations between users characteristics and the adoption process; (c) best practices for successful adoption; and (d) barriers to adoption. Collectively, the data will also support longitudinal analysis of adoption and impact.

Coordination and Communication Throughout the Network

Most if not all of the proposed network collaborators have access to e-mail. Therefore, we will continue to use this media as our primary communication tool. We will also continue to maintain a project website where annual reports, work plans and trip reports are posted and can be easily downloaded. We will continue to use our existing trip report format wherein data from visited sites are analyzed and summarized so that it is readily accessible to other network collaborators.

Overseas collaborators and U.S.-based faculty will contribute information for each year's progress report and the subsequent year's plan of work. Deanna Osmond, Jot Smyth and Frank Hons will meet annually to coordinate preparations of annual reports and workplans.

ANNUAL WORK PLAN

The project's plan of work is outlined in sequential order across the five years for Phase Two of the SM-CRSP for each of the three objectives. Milestone events, international travel and a condensed budget are included for each project objective. The condensed budgets reflect support for part of the on-site costs to perform activities by collaborators plus overlapping campus-based costs in support of overseas activities.

Objective 1: test and compare NuMaSS 2.0 predictions on nutrient diagnoses, recommendations and economic evaluations to those currently in use.

Project Year	Activity	Investigators		Estimated Completion
		Responsible	Contributors	
1	1. Initial visit to collaborator sites a. Training with NuMaSS 2.0 b. Collaborator interests and potential contributions identified c. Existing data sets for validating NuMaSS predictions identified d. NuMaSS predictions compared to data set results e. Local information gaps for testing/comparing NuMaSS predictions identified	Hons, Osmond, Smyth	Juo, Hossner, Network Collaborators, Smith, Wagger, White	November 2002
	2. Outline of 5-year plan for network activities a. Collaborator linkages identified b. Collaborator activities and support needs defined	Hons, Osmond, Smyth	Juo, Hossner, Network Collaborators, Smith, Wagger, White	December 2002
	3. Field trials to test/compare NuMaSS diagnosis for corn initiated in MIS watersheds (Honduras/Nicaragua)	Ayarza, Smyth	MIS members, Hons Osmond, Smith	August 2003
2	1. Field trials to test/compare NuMaSS diagnosis initiated at all network sites	Bowen, Hons, Osmond, Smyth	Juo, Hossner, Network Collaborators, Wagger, White	February 2004
	2. Assessment of corn diagnosis results for MIS watersheds a. Diagnosis success/failure stratified by soil type, landscape position, land-use history, etc b. Potential factors for diagnosis failures identified	Ayarza, Osmond	MIS members, Hons, Smyth	December 2003
	3. Field trials to test/compare NuMaSS diagnosis for other crops initiated in MIS watersheds (Honduras/Nicaragua)	Ayarza, Smyth	MIS members, Juo, Hons, Osmond	August 2004
	4. Field trials to test/compare NuMaSS recommendations for new crop introductions (cassava, yam, sorghum, soybean) initiated in MIS watersheds (Honduras/Nicaragua)	Ayarza, Hossner, Smyth	MIS members, Hons, Osmond, Wagger, White	December 2005

Project Year	Activity	Investigators		Estimated Completion
		Responsible	Contributors	
3	1. Assessment of diagnosis field trial results across all network sites	Bowen, Hons, Osmond, Smyth	Juo, Hossner, Network Collaborators, Smith, Wagger, White	April 2004
	2. Assessment of field trial results on NuMaSS recommendations for new crops in MIS watersheds	Ayarza, Hossner, Osmond	Juo, MIS members, Smyth, Wagger, White	December 2004
	3. Field trials to test/compare NuMaSS recommendations for crops initiated at all network sites	Bowen, Hons, Osmond, Smyth	Juo, Hossner, Network Collaborators, Wagger, White	May 2005
4.	Assessment of field trial results on NuMaSS recommendations completed for all network sites	Bowen, Hons, Osmond, Smyth	Juo, Hossner, Network Collaborators, Wagger, White	August 2005

Milestone Events:

- Detailed 5-year plan of network activities - Year 1
- Assessment of diagnosis field trial results - Year 3
- Assessment of recommendation field trial results - Year 4

International Travel:

Year	Traveler	Destination	Days TDY	Cost in US$
1	Juo, Hons, Hossner, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	8,750
2	Juo, Hons, Hossner, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	12,150
3	Juo, Hons, Hossner, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	6,400
4	Juo, Hons, Hossner, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	6,800

Budget in US $:

	Project Year			
Object	**1**	**2**	**3**	**4**
Personnel	25,608	26,594	18,004	18,679
Equipment	0	0	0	0
Supplies	3,750	1,500	990	990
Travel	10,600	14,810	7,880	8,280
Other Direct Costs	95,974	99,942	48,429	47,726
Total	**135,932**	**142,846**	**75,303**	**75,675**

Objective 2: identify and refine software components that limit adoption and use of the NuMaSS knowledge base.

Project Year	Activity	Investigators		Estimated Completion
		Responsible	Contributors	
3	1. Network-wide evaluation and discussion of test results for NuMaSS diagnosis a. Needed improvements identified b. Refinement tasks planned	Hons, Osmond, Smyth	Ayarza, Bowen, Juo, Hossner, Network collaborators, Smith, Wagger, White	August 2004
	2. Necessary field and laboratory tasks to refine NuMaSS diagnosis initiated	Bowen, Hons, Osmond, Smyth	Ayarza, Juo, Hossner, Network collaborators, Wagger, White	January 2006
4	1. Network-wide evaluation and discussion of test results for NuMaSS recommendations a. Needed improvements identified b. Refinement tasks planned	Hons, Osmond, Smyth	Ayarza, Bowen, Juo, Hossner, Network collaborators, Smith, Wagger, White	December 2005
	2. Necessary field and laboratory tasks to refine NuMaSS recommendation initiated	Bowen, Hons, Osmond, Smyth	Ayarza, Juo, Hossner, Network collaborators, Wagger, White	March 2006
5	1. Field/lab work for NuMaSS refinements completed, summarized, and incorporated to NuMaSS	Osmond	Hons, Smith, Smyth	November 2006
	2. Revised NuMaSS released, tested and compared with existing data sets	Osmond, Smyth	Ayarza, Bowen, Juo, Hons, Hossner, Network collaborators, Smith, Wagger, White	February 2007

Milestone Events:

- NuMaSS 2.0 performance assessed, weaknesses identified, and strategies for refinements defined - reports in YR3 and YR4
- NuMaSS with refinements released and performance assessed - YR5 report

International Travel:

Year	Traveler	Destination	Days TDY	Cost in US$
3	Juo, Hons, Hossner, Osmond and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	6,400
4	Juo, Hons, Hossner, Osmond and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	6,800
5	Juo, Hons, Hossner, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	8,047

Budget in US $:

	Project Year		
Object	**3**	**4**	**5**
Personnel	18,549	19,245	29,024
Equipment	0	0	0
Supplies	1,020	1,020	1,325
Travel	7,880	8,280	9,897
Other Direct Costs	48,429	47,726	60,124
Total	**75,878**	**76,271**	**100,370**

Objective 3: monitor collaborator use of NuMaSS and, when needed, develop auxiliary tools to help users make better use of the software knowledge in their decisions about nutrient management.

Project Year	Activity	Investigators		Estimated Completion
		Responsible	Contributors	
1	Survey network collaborators to identify intended applications of NuMaSS for local nutrient management decisions	Smith	Ayarza, Bowen, Hons Network members, Osmond, Smyth	May 2003
2	Develop map overlays of NuMaSS predictions based on CIAT's geo-referenced soil and land-use database a. test and design linkages for input and output between geo-referenced database and NuMaSS b. develop maps for corn diagnosis results in MIS watersheds	Osmond, Ayarza	MIS members, Smyth	March 2004
3	Survey network collaborators to assess extent of adoption and applications of NuMaSS a. Service to and types of clients b. Nature of NuMaSS uses c. Frequency of use d. Benefits derived from use	Smith	Ayarza, Bowen, Hons Network members, Osmond, Smyth	February 2005
4	1. Auxiliary tools developed, as needed, to facilitate use of software knowledge a. Need identified b. Paper prototype designed c. Collaborators assisted in developing tool prototype d. Prototype is tested and refined as needed	Osmond, Smyth	Bowen, Juo, Hossner, Hons, Network members, Smith	February 2007
	2. Continue developing map overlays for NuMaSS predictions of diagnoses, recommendations and economic evaluations for traditional and new crops in MIS watersheds	Osmond, Ayarza	MIS Members, Smyth	February 2007
5	1. Auxiliary tools and MIS map overlays completed	Osmond, Ayarza, Smyth	Bowen, Juo, Hons, Hossner, Network members, Smith, Wagger, White	February 2007

Project Year	Activity	Investigators		Estimated Completion
		Responsible	Contributors	
	2. Survey network collaborators to assess extent of adoption and applications of NuMaSS a. Service to and types of clients b. Nature of NuMaSS uses c. Frequency of use d. Benefits derived from use	Smith	Ayarza, Bowen, Hons, Network members, Osmond, Smyth	February 2007

Milestone Events:

- Report of survey on collaborator goals for local adoption of software - YR2
- Report of surveys on collaborator adoption of software - YR3 and YR5
- Auxiliary tools released - YR 2-5

International Travel:

Year	Traveler	Destination	Days TDY	Cost in US$
1	Hons, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	8,750
2	Hons, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	4,350
3	Hons, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	3,200
4	Hons, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	3,400
5	Hons, Osmond, Smith and Smyth	Multi-network site travel events in Central (Mexico, Honduras, Nicaragua, Costa Rica, Panama) and South (Ecuador, Peru, Bolivia, Brazil) America	between 10 and 15 days for each event	8,047

Budget in US $:

	Project Year				
Object	**1**	**2**	**3**	**4**	**5**
Personnel	25,608	26,594	18,004	18,679	29,024
Equipment	0	0	0	0	0
Supplies	3,750	1,500	990	990	1,325
Travel	10,600	5,390	3,940	4,140	9,897
Other Direct Costs	13,181	18,196	20,507	18,867	54,146
Total	**53,139**	**51,680**	**43,441**	**42,676**	**94,392**

IMPACT ASSESSMENT/VERIFIABLE INDICATORS OF SUCCESS

Narrative Summary	Measurable Indicators	Means of Verification	Assumptions
Goal: Promote adoption of NuMaSS knowledge in targeted on-going programs in order to benefit yields from improved access to nutrient management information	1.1 Increased food productivity 1.2 Increased farm incomes	1.1 Yield records from project areas and NARES 1.2 National records of NARES and any project reports	Lack of knowledge on integrated soil nutrient management is a major bottleneck to achieve food security
Purpose: Empower decision makers and technical specialists with expert knowledge and capability to diagnose plant nutrient deficiencies and excesses	1.1 Establishment of integrated soil nutrient management systems and programs by user groups 1.2 Increased sales of fertilizers 1.3 Increased yields	1.1 Reports and policy statement from collaborating projects 1.2 Project and/or NARES reports on fertilizer procurement 1.3 Project and/or NARES reports on agricultural productivity	Extreme weather, economic, and political events do not interfere with our collaborations and the ability to obtain field data and test NuMaSS
Outputs: 1. Test and compare NuMaSS predictions on nutrient diagnosis, recommendation and economic evaluation to those currently in use	1. Comparison between NuMaSS results and in-country data	1. Reports of NuMaSS and in-country data comparisons	1. Sufficient in-country crop and soil data is available for comparisons
2. Identify and refine software components that limit adoption and use of the NuMaSS knowledge base	2. Limitations of NuMaSS are identified and appropriate algorithms are changed	2. Portions of NuMaSS re-programmed to reflect identified limitations	2. Major differences between the data and NuMaSS can be adequately identified
3. Develop auxiliary tools, when needed, to help user make better use of the NuMaSS knowledge in their decisions about nutrient management	3. Auxiliary tools produced	3. Reports and/or user information on the auxiliary tools developed	3. In-country personnel want auxiliary tools developed
Activities: Initial visits to collaborators to introduce NuMaSS, determine their needs and interests, and delineate participants individual tasks	*Inputs/Resources:* Regional agronomists, both research and extension, as well as project scientists	Trip reports and workplans outlining work tasks and responsibilities	Countries remain stable
Test NuMaSS outputs against field data for different crops in Central and South America	Field data of the quantity and quality that will allow the comparison of NuMaSS results with field data	Report describing the differences in diagnosis and prediction between NuMaSS and the in-country data for the listed commodities	Sufficient in-country data to run the field trials

Narrative Summary	Measurable Indicators	Means of Verification	Assumptions
NuMaSS weaknesses identified and strategies for refinement determined	Reports from Activities 1 and 2	Report weakness of NuMaSS and necessary updates	Activities 3 and 4 can be brought to a closure
Changes made to NuMaSS and new version released	Programmer to enter the new algorithms and data in NuMaSS	Next release of NuMaSS (version 2.5 or 3, depending on magnitude of the changes)	Funding is adequate for programming
Identify, design and release auxiliary tools	Funding is adequate for programming	Auxiliary tools released	In-country project personnel can identify useful auxiliary tools

PROPOSAL ANNEX

Contact of Business Office Personnel for Grant Negotiations:

Name - Mathew Ronning

Mail Address - Sponsored Programs and Regulatory Compliance, N.C. State University, Box 7514, Raleigh, NC 27695

Phone - 919 515 2444

Fax - 919 515 7721

E-mail - sps@ncsu.edu

N.C. State University federal tax identification number - 56 6000 756

Budget (in US$) for North Carolina State University by Year and Total:

	Project Year					
Object	**1**	**2**	**3**	**4**	**5**	**Total**
Personnel	48,657	49,988	51,357	52,763	54,207	256,972
Secretarial	35,337	36,397	37,489	38,614	39,772	187,609
Student, part-time	5,200	5,300	5,400	5,500	5,600	27,000
Fringe benefits	8,120	8,291	8,468	8,649	8,835	42,363
Equipment	0	0	0	0	0	0
Supplies	7,500	3,000	3,000	3,000	2,650	19,150
Travel	16,200	15,700	15,200	16,200	15,700	79,000
Domestic	2,700	2,700	2,700	2,700	2,700	13,500
International	13,500	13,000	12,500	13,500	13,000	65,500
Subcontracting (Texas A&M)	31,500	31,000	30,000	30,000	29,500	152,000
Other Direct Costs	93,474	102,942	102,857	100,451	100,248	499,972
Facilities/Administrative Costs	52,669	47,370	47,586	47,586	47,695	242,906
NCSU	45,769	47,370	47,586	47,586	47,695	236,006
Subgranting	6,900	0	0	0	0	6,900
Total	**250,000**	**250,000**	**250,000**	**250,000**	**250,000**	**1,250,000**

Budget Notes:

Salaries - one full time equivalent of a secretarial position and part-time student labor. The secretarial position is for 100% support of a grade 63 Administrative Assistant. Because the project is of a complex and international nature involving assembly and management of a team of scientists from both domestic and overseas institutions, assistance is needed in managing team activities, coordinating their international travel and providing backstopping support to their long term investigations at remote overseas field sites in various Latin American countries. The assistant will provide multi-lingual capabilities, and experience in complying with USAID guidelines and regulations for foreign travel and overseas expenses, which change on a monthly basis – normal campus based administrative services do not include such expertise. The assistant will help coordinate international meetings, scheduled for most project years, including orchestration of international travel arrangements, multi-lingual correspondence with participants and preparation of meeting materials. The assistant serves as the contact person for receipt of data, as well as the maintenance and distribution of field and laboratory databases among all domestic and international project participants. The assistant has a fundamental role in assembling, proofreading, distributing and preparing budgets for manuals of produced software, project publications, and reports on project activities, workplans and budgets which are required on an annual basis by the Management Entity of the Soil Management CRSP. The Administrative Assistant activities in support of the project comply with various circumstances in OMB Circular A-21 wherein direct charge of clerical services are justified. Differences in annual totals for each year reflect a projected legislative increase of 3% in salary.

Part-time student labor will assist various faculty in repetitive tasks such as keying in field and lab data as it is received from collaborator sites for subsequent faculty use in statistical analysis and model development.

Fringe Benefits -

Secretarial - 15.38% of salary plus $2,256 for Health Insurance
Student labor - 8.25% of salary

Equipment - no items are contemplated with prices exceeding $5,000

Supplies - based on cost-experience during the SM-CRSP project for Phase One

Campus-based - equipment items <$5000 such as digital cameras, photographic film, computer projector, and software and computer parts pro-rated according to project use; the computer projector ($4,500) will be used for software demonstrations during international travel; $6,500 for year 1, $2,000/year for years 2-4, and $1,650 for year 5.

Other - materials for use by overseas collaborators at their overseas locations in conducting project field trials (scales, nursery markers), laboratory analyses (instruments <$5000, replacement parts, reagents, glassware), and data analysis/reporting (software and computer replacement parts) that cannot be purchased on-site; these are materials which cannot be purchase within country at many of the collaborator sites; $1,000/year

Travel -

Domestic - travel to Annual ASA Meetings ($2,000/year) to present project research results, and one trip/year for Raleigh/College Station/Raleigh for project related discussions with Texas A&M faculty ($700)

International - as listed in "Annual Work Plan" section of proposal

Subcontracting to Texas A&M University -
Participation of Drs. Lloyd Hossner, Frank Hons and Anthony Juo in activities as outlined in the "Annual Work Plan" section of the proposal. Budget breakdown by year for the subgrantee institution is shown in the following table.

	Project Year				
Object	**1**	**2**	**3**	**4**	**5**
Personnel	2,560	3,200	3,200	3,840	3,840
Secretarial	2,000	2,500	2,500	3,000	3,000
Fringe benefits [a]	560	700	700	840	840
Equipment	0	0	0	0	0
Supplies	0	0	0	0	0
Travel	5,000	4,500	4,500	4,500	4,094
Domestic	1,000	1,000	1,000	1,000	1,000
International [b]	4,000	3,500	3,500	3,500	3,094
Other Direct Costs	15,681	15,196	14,507	13,867	14,022
Indirect Costs (Int'l) [c]	2,300	2,300	2,300	2,300	2,300
Indirect Costs (Dom)[d]	5,959	5,804	5,493	5,493	5,244
Total	**31,500**	**31,500**	**30,000**	**30,000**	**29,500**

[a] Fringe benefits calculated at 28% of salary
[b] Travel events are listed in the "Annual Work Plan" section of the proposal
[c] International indirect cost calculated at 23% of expenditures
[d] Domestic indirect cost calculated at 45% of expenditures

Other Direct Costs -

Campus-based - international telephone, postage and courier freight service expenses, and printing expenses such as technical bulletins, proceedings of workgroup discussions and software releases on CDs; based on cost-experience during the SM-CRSP project for Phase One. Distributed among project years as described in the following table.

Software programming - contracted services with off-campus private company for revisions of NuMaSS software and associated auxiliary tools. Distributed among project years as described in the following table.

Reimbursible Expenses for Overseas Field and Laboratory Research - partial support of costs in labor, supplies, reagents, fertilizers, local transportation, soil and plant analytical services, lodging and meals for collaborators throughout Latin America (see Table 1 on page 5 of the proposal for a list of institutions and countries) to conduct field trials and associated laboratory tests of the NuMaSS software diagnoses and nutrient recommendations at their respective sites.

	Project Year				
Object	**1**	**2**	**3**	**4**	**5**
Campus-based	2,000	2,200	1,600	1,451	2,000
Software programming	7,500	13,000	16,000	15,000	15,000
Overseas Research Expenses	83,974	87,742	85,257	84,000	83,248

Facilities and Administrative Costs - (i.e. overhead or indirect costs)

NCSU - for North Carolina State University's portion of the budget, the off-campus rate of 27.6% is applied to costs for personnel, supplies, travel and other direct costs.

Subcontracting - North Carolina State University's off-campus rate of 27.6% is applied to the first $25,000 of a subgrant to each institution for the life of the grant.

Institutional Cost Sharing on Requested Funds -

	Project Year				
Object	**1**	**2**	**3**	**4**	**5**
N.C. State Univ.[a]	53,025	55,146	57,352	59,644	62,030
Texas A&M Univ.[b]	11,571	9,894	9,538	9,824	10,119

[a] Salary, fringe benefits and overhead for Osmond (15 %), Smyth (25 %), Wagger (5 %) and White (5 %).

[b] Salary, fringe benefits and overhead for a total time commitment of 10% by Hossner, Hons and/or Juo

Bio-data:

Miguel A. Ayarza
Regional Coordinator, CIAT - Hillsides Project
Executive Secretary, Consortium for Management of Fragile Soils of Central America (MIS)
Apartado 1410
Tegucigalpa, Honduras

Education:

- B.S. 1975 Agronomy National University of Colombia
- M.S. 1980 Agric. Science University of Reading, England
- Ph.D. 1988 Soil Science North Carolina State University

Positions:

- 1999-present Regional coordinator, CIAT - Hillsides Project
- CIAT - Savannah Project, EMBRAPA/CPAC, Brasilia, Brazil
- CIAT Pastures Prgram, Cali, Colombia

Experience Related to Proposed Program:

- Development of improved crop-pasture systems
- Identification of biophysical indicators of impact of land use
- Development of technical innovations to improve competitiveness of small farmers in hillsides

Pertinent Recent Publications:

Lilienfein, J., Wilcke, W., Ayarza, M.A., Vilela, L., do Cormo Lima, S., and Zech, W. 2000. Chemical fractionation of phosphorus, sulphur, and molybdenum in Brazilian savanna Oxisols under different land use. Geoderma 96:31-46.

Lilienfein, J., Wilcke, W., Ayarza, M.A., Vilela, L., do Cormo Lima, S., Thomas, R. and Zech, W. 2000. Effect of no-tillage and conventional tillage systems on the chemical composition of soil solid phase and soil solution of Brazilian Savanna Oxisols. J. Plant Nutr. Soil Sci. 163:411-419.

Lilienfein, J., Wilcke, W., Ayarza, M.A., Vilela, L., do Cormo Lima, S., and Zech, W. 2000. Soil acidification in Pinus caribea forests on Brazilian Savanna Oxisols. Forest Ecol. Management 128:145-157.

Lilienfein, J., Wilcke, W., Thomas, R., Vilela, L., do Cormo Lima, S., and Zech, W. 2000. Nutrient concentrations in soil solution of some Brazilian Oxisols under conventional and no-tillage systems in the early part of the rainy season. Aust. J. Soil. Res. 38:851-866.

Zech, W., H.M. Morras, M.A. Ayarza, M.C. da Silva, S.C. Lima, C. da Silva, C. Valarezo and L. Vilela. 2000. Geoecological studies in selected Latin American ecosystems. In Zeitschrift fur Angewante Geology. 31st Int. Geological Congress, Rio de Janeiro, Brazil.

Walter T. Bowen
Soil Scientist, joint appointment with the International Potato Center (CIP) and the International Fertilizer Development Center (IFDC)
CIP-Quito/IFDC
P.O. Box 17-21-1977
Quito, Ecuador
E-mail: w.bowen@cgiar.org

Education:
- B.S. 1976 Agronomy Clemson University
- M.S. 1983 Soil Science Cornell University
- Ph.D. 1987 Soil Science Cornell University

Positions:
- 1996-present Soil Scientist, joint appointment between International Fertilizer Development Center (IFDC) and International Potato Center (CIP), Lima, Peru (1996-2000) and Quito, Ecuador (2000-present)
- 1992-1996 Soil Scientist, IFDC, Muscle Shoals, AL
- 1990-1992 Postdoctoral Associate, Agricultural Engineering Department, University of Florida, Gainesville, FL
- 1989-1990 Visiting Assistant Professor, Soil Science Department, University of Florida, Gainesville, FL
- 1986-1989 Senior Research Associate, outpost to Brazil (EMBRAPA), Department of Soil, Crop, and Atmospheric Sciences, Cornell University, Ithaca, NY

Relevant experience:
A Soil Scientist with IFDC since 1992, Walter Bowen's research emphasizes the development, testing, and application of soil and crop growth simulation models. He has worked on collaborative research and model application projects, including training, in Albania, Bangladesh, Bolivia, Brazil, Colombia, Ecuador, India, Malaysia, Peru, Philippines, Romania, and Venezuela. In 1996 he moved to Peru where he has developed a successful collaboration with the International Potato Center (CIP) and IFDC focusing on integrated natural resource management research. He transferred his physical base to Ecuador in 2000 where he continues to work with IFDC, CIP, and other collaborators on establishing a center of excellence for soil management research in the high Andes. Research and modeling activities are done together with regional and international collaborators through the Management of Soils in the Andes (MOSAndes) consortium and the International Consortium for Agricultural Systems Applications (ICASA). He is also an investigator on the SM-CRSP Tradeoffs Project with Montana State University.

Pertinent recent publications:
Quiroz, R., C. Leon-Velarde, and W. Bowen. 2000. Farming systems research from a modelling perspective: experiences in Latin America. p. 342-354. In M. Collinson (ed.) A history of farming systems research. CABI and FAO, Rome.

Bowen, W., H. Cabrera, V. Barrera, and G. Baigorria. 1999. Simulating the response of potato to applied nitrogen. p. 381-386. CIP Program Report 1997-1998. International Potato Center, Lima, Peru.

Bowen, W., G. Baigorria, V. Barrera, J. Cordova, P. Muck, and R. Pastor. 1999. A process-based model (WEPP) for simulating soil erosion in the Andes. p. 403-408. CIP Program Report 1997-1998. International Potato Center, Lima, Peru.

Bowen, W.T. and W.E. Baethgen. 1998. Simulation as a tool for improving nitrogen management. p. 193-208. In G.Y. Tsuji, G. Hoogenboom, and P.K.Thornton (ed.) Understanding options for agricultural production. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Bowen, W.T., P.K. Thornton, and G. Hoogenboom. 1998. The simulation of cropping sequences using DSSAT. p. 317-331. In G.Y. Tsuji, G. Hoogenboom, and P.K.Thornton (ed.) Understanding options for agricultural production. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Armando Ferrufino C.
Visiting Assistant Professor of Soil Science
North Carolina State University
Assistant Technical Advisor CONCADE Project
Box 1327
Cochabamba, Bolivia

Education:

- B.S. 1983 Agronomy Universidad Mayor de San Simon, Cochabamba, Bolivia
- M.S. 1987 Tropical Pastures CATIE, Turrialba, Costa Rica
- Ph.D. 1998 Soil Science North Carolina State University

Positions:

- 2000-present Visiting Assistant Professor of Soil Science, Assistant Technical Advisor of the CONCADE Project, Cochabamba, Bolivia

- 1998-2000 National Director PRAEDAC project funded by the European Union, Cochabamba, Bolivia

- 1991-1993 Research and Extension Director of the Bolivian Institute of Agricultural Research (IBTA) in the Chapare Region

- 1982-1991 Leader of the Tropical Pastures Research Program, IBTA, Chipiriri Experiment Station, Chapare, Bolivia

Experience Related to Proposed Program:

- Nine years of work in selecting tropical grasses and legumes tolerant to acid soil conditions; management practices for grass-legume pasture associations; characterization of pasture-based production system and mineral content of grasses and legumes; research on degraded pasture renovation with legumes and fertilization in the Chapare region of Bolivia.

- Three years leading the research and extension program (30 researchers and extensionists) for annual and perennial crops, including fertilization trials in the Chapare region.

- Two years leading planning and a rural development program in the Chapare, including natural resources components in which a nutritional plan for banana and peach palm was developed.

- Five months as scientific advisor of IBTA, with emphasis in developing fertilization trials with banana and peach palm, and a massive demonstration trial in banana, peach palm, pineapple, black peper and passion fruit fertilization (1000 ha).

- During the last ten years served as principal advisor or thesis committee member of more than ten students at the Universidad Mayor de San Simon in Cochabamba.

Pertinent Recent Publications:

Ferrufino, A. 2000a.Diagnosis of soil nutrient constraints and recommendations for lime, nitrogen and phosphorus in Bolivia. pp. 60-65. In Osmond, D.L., Metra-Corton, T., Smyth, T.J., Yost, R.S. and Reid, W.S. (eds.) Decision processes for determining diagnostic and predictive criteria for soil nutrient management. SM-CRSP Tech. Bulletin 2000-03, Philippine Rice Research Institute, Nueva Ecija, Philippines.

Ferrufino, A. 2000b. Estudio de linea base en el tropico de Cochabamba. PRAEDAC Informa 1:16- 30.

Ferrufino, A. 2000. Respueasta a la fertilizacion en los cultivos comerciales mas importantes del Tropico de Cochabamba. Proyecto CONCADE, DAI, NCSU. 46p.

Ferrufino, A., T.J. Smyth, D.W. Israel and T.E. Carter, Jr. 2000. Root elongation of soybean genotypes in response to acidity constraints in a subsurface solution compartment. Crop Sci. 40:413-421.

Frank M. Hons
Professor
Department of Soil and Crop Sciences
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College Station, Texas 77843-2474

Education:
- B.A., Chemistry, University of Dallas, 1972
- M.S., Soil Chemistry, Texas A&M University, 1974
- Ph.D., Soil Science, Texas A&M University, 1978

Positions:
- 1991-Present Professor, Texas A&M University
- 1986-1991 Associate Professor, Texas A&M University
- 1981-1986 Assistant Professor, Texas A&M University
- 1978-1981 Assistant Professor, Texas Tech University
- 1972-1978 Research Assistant, Texas A&M University

Experience Related to Proposed Program:
- Advised the research programs of four graduate students whose work was conducted in West or Central Africa or on associated soil problems.

- Cooperator for SM-CRSP in Mali, 1998-2001.

- Participant in Alpbach European Forum, August 17-30, 1985.

- Served as major advisor to eight graduate students from Mali, Swaziland, Mexico, Honduras, Argentina, Uruguay, and Brazil. 1982 to present.

- Hosted visiting scientist (Dr. Shalaby) from Egypt for 5 months, Nov. 1988 - Apr. 1989.

- Interacted with visiting scientists from Czechoslovakia (Bartosova) during her 1 month Texas tour (June, 1989) and Huska during his 2 week visit (Jan., 1991).

- Czechoslovakia - presented lectures and reviewed scientific programs at the University of Agriculture, Nitra, CSFR, April-May, 1991.

- Mexico - interacted with producers and reviewed crop production practices at Los Mochis, March, 1991.

- Hosted visiting scientist from Slovakia (Bartosova) during her two week Texas visit (May, 1997).

- Hosted Mexican scientists from INIFAP concerning conservation tillage and agricultural sustainability, June, 1997.

- Mali, Africa - traveled to Mali and helped formulate and review research plans, sites, activities and reports for Soil Management CRSP. February, 1998; June-July, 1999; August, 2000.

- Assiut, Egypt   traveled throughout Egypt in conjunction with Binational Fulbright Project for continuing education of agricultural graduates. January, 1999; May, 2000. Presented two lectures at Assiut University.

Pertinent Recent Publications:

Powell, J.M. and F.M. Hons. 1988. Sorghum stover removal effects on crop yields and selected soil properties. In: Proceedings of the International Conference on Dryland Farming p. 498-500. P.W. Unger, W.R. Jordan, T.V. Sneed, and R.W. Jensen (eds.).

Powell, J.M. and F.M. Hons. 1992. Fertilizer N and stover removal effects on sorghum yields and nutrient uptake and partitioning. Agric., Ecosystems Environ. 39:197-211.

Salinas-Garcia, J.R., F.M. Hons, and J.E. Matocha. 1997. Long-term effects of tillage and fertilization on soil organic matter dynamics. Soil Sci. Soc. Am. J. 61:152-159.

Haney, R.L., F.M. Hons, M.A. Sanderson, and A.J. Franzluebbers. 2001. A rapid procedure for estimating nitrogen mineralization in manured soil. Biol. Fert. Soils (In Press).

Doumbia, M.A., A. Sidike, A. Bagayoko, A. Bationo, R.A. Kablan, R.S. Yost, L.R. Hossner, and F.M. Hons. 2001. Recommandations specifiques d'engrais calibration et validation du module phosphore de NuMaSS. African Crop Sci. Assoc. J. (In Press).

Lloyd R. Hossner
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Soil and Crop Sciences Department
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College Station, Texas 77843

Education:

- B.S. 1958 Utah State University
- M.S. 1961 Utah State University
- Ph.D. 1965 Michigan State University

Positions:

- 1977-Present Professor, Texas A & M University
- 1986-1988 Coordinator, TROPSOILS Program
- 1970-1977 Associate Professor, Texas A & M University
- 1968-1970 Assistant Professor, Texas A & M Universi
- 1965-1968 Research Soil Chemist, International Minerals and Chemical Corporation, Research & Development Division, Libertyville, Illinois
- 1962-1965 Research Assistant, Michigan State University
- 1961-1962 Instructor and Assistant in Soils, Montana State University
- 1959-1961 Research Assistant, Utah State University

Experience Related to Proposed Program:

- Fourteen years experience working in West Africa in the Soil Management CRSP.
- Advised research programs of 11 graduate student programs whose research was conducted in West Africa or on West African soil problems
- Technical assignments to Niger, Nigeria and Mali for TropSoils program and to evaluate analytical soils laboratory operation in Niamey, Niger. 1985, 1986, 1987.
- National Academy of Science Assignment. Review of Malaysian tin mine research program. Selangor, Malaysia. 1987.
- Member, TropSoils Team to Nigeria and Cameroon. A study of the potential for selective expansion of TropSoils in Africa. 1988.
- Member, Technical Research Team to evaluate soil resources and prioritize research needs. Niger, West Africa. July, 1989.
- Lecturer and workshop participant. Variable charge soil management. Peru. 1991.

- Member Planning Team to evaluate potential for SANREM CRSP in Malawi and Zimbabwe. 1992.

- Member, Review Team to consult with International Center for Research on Agroforestry (ICRAF) scientists on research on reclamation of bauxite mines. Jamaica, 1993.

- Member, Research Team to prepare and deliver proposal for Geographic Information System (GIS) in West Africa. Mali, 1995.

Pertinent Recent Publications:

Doumbia, M.D., L.R. Hossner and A.B. Onken. 1998. Sorghum growth in acid soils of West Africa: variations in soil chemical properties. Arid Soil Res. Rehab. 12:179-190.

Hossner, L. R. And David W. Dibb. 1995. Reassessing the role of agrochemical inputs in developing country agriculture. P. 17-32. In Anthony S. R. Juo and Russell Freed (eds.). Agriculture and the Environment: Bridging Food Production and Environmental Protection in Developing Countries. ASA Special Publication No. 60. American Society of Agronomy. Madison, Wisconsin.

Hossner, L.R. and A.S.R. Juo. 1999. Soil nutrient management for sustained food crop production in upland farming systems in the tropics. Food and Fertilizer Technology Center for the Asian and Pacific Region. Extension Bulletin 471. 19p.

Wilding, L. P. And L. R. Hossner. 1989. Causes and effects of acidity in Sahelian soils. P. 215-227. In Soil, Water, and Crop Management in the Sudano-Sahelian Zone. International Crops Research Institute for the Semi-arid Tropics. Patancheru, INDIA.

Zaongo, C.G.L., C. W. Wendt and L. R. Hossner. 1994. Constraints of Sahelian soils to sustainable rainfed crop production and management implications. J. Sustainable Agriculture. 4:47-78.

Daniel W. Israel
Research Plant Physiologist (USDA) and Professor
Soil Science Department
North Carolina State University
Raleigh, North Carolina 27695

Education:

- A.S. 1967 Agriculture Abraham Baldwin Agricultural College, Tifton, Georgia.
- B.S. 1969 Agronomy University of Georgia, Athens, Georgia
- M.S. 1970 Soil Science University of Georgia, Athens, Georgia
- Ph.D. 1973 Plant Physiology Oregon State University, Corvallis, Oregon

Positions:

- 1987 -Present Research Plant Physiologist (USDA) and Professor (Soil Science), Soil Science Department, North Carolina State University, Raleigh, North Carolina

- 1981 - 1987 Research Plant Physiologist (USDA) and Associate Professor (Soil Science), Soil Science Department, North Carolina State University, Raleigh, North Carolina

- 1977 - 1981 Research Plan Physiologist (USDA) and Assistant Professor, (Soil Science), Soil Science Department, North Carolina State University, Raleigh, North Carolina

- 1975 - 1977 Assistant Professor, Soil Science Department, North Carolina State University, Raleigh, North Carolina

- 1973 - 1975 Research Associate, Department of Biochemistry and Nutrition, Virginia Polytechnic Institute and State University, Blacksburg, Virginia

Experience Related to Proposed Program:

- Dr. Israel conducted a systematic investigation of the role of phosphorus in symbiotic N2 fixation by soybean plants. He developed experimental procedures to delineate the direct and indirect effects of phosphorus nutrition on the process. Aspects of the approach used to study phosphorus nutrition of soybean have been applied to evaluate cowpea cultivars as to their tolerance of acid, low P soils of the humid tropics. This work was a part of a project funded by the Rockefeller Foundation to develop alternatives to slash and a agriculture in the Western Amazon.

- Dr. Israel's recent domestic research has focused on assessing the contribution of symbiotic N_2 fixation to the N requirements of soybean grown in the Coastal Plain of North Carolina and to the soil N reserve. Approaches used in this work are directly applicable to the proposed assessment of the contribution of symbiotic N2 fixation by legumes to the N requirements on nonlegumes in cropping systems and will provide information needed for adjustment and refinement of the Nitrogen Decision Support System to tropical conditions.

- As a co-investigator on a SM-CRSP grant "Decision Aids for Integrated Soil Nutrient Management", Dr. Israel made two site visits to the Cinzana Research Station in Mali to evaluate the progress of research experiments to be used in validating predictions of the decision support system. He organized data and wrote reports on the Mali experiments for the annual reports. He also coordinated a literature search for information on nitrogen response of corn, millet, sorghum and upland rice grown in tropical agricultural systems. This information was incorporated into the database that supports the Nitrogen Decision Support System component of the Nutrient Management Support System (NuMass).

Pertinent Recent Publications:

Israel, D. W. 1987. Investigation of the role of phosphorus in symbiotic dinitrogen fixation. Plant Physiol. 84:835-840.

Israel, D. W. and T. W. Rufty, Jr. 1988. Influence of phosphorus nutrition on phosphorus and nitrogen utilization efficiencies and associated physiological responses in soybean. Crop Sci. 28:954-960.

Sa, T-M., and D. W. Israel. 1991. Energy status and functioning of phosphorus-deficient soybean nodules. Plant Physiol. 97:928-935.

Israel, D. W. 1993. Symbiotic-dinitrogen fixation and host-plant growth during development of and recovery from phosphorus deficiency. Physiol. Plant. 88:294-300.

Reid, W.S., Osmond, D.L., Smyth, T.J., Luna, P., Israel, D.W. and Branch,W.1999. IV. Nitrogen Decision Support System. In Integrated Soil Nutrient Management Decision Support System (IntDSS), Version 1.0 Software Installation and User's Guide. D.L. Osmond et al. Eds. Soil Management Collaborative Research Support Program. Technical Bulletin No. 99-02. N.C. State University.

A. S. R. Juo
Professor
Soil and Crop Sciences Department
Texas A & M University
College Station, Texas 77843

Education:

- M.S. 1959 National Taiwan University
- Ph.D. 1966 Michigan State University

Positions:

- 1988-Present Professor, Texas A&M University, Program Coordinator and Principal Investigator, USAID/TAMU Soil Management CRSP
- 1987-1988 Visiting Scientist at the Beltsville Agricultural Research Center, USDA/ARS and the Bureau of Science & Technology, USAID
- 1970-1987 Soil Scientist and Director of Farming Systems Research Program at the International Institute of Tropical Agricultural (IITA) in Nigeria
- 1978 Visiting Scientist, North Carolina State University
- 1977 Visiting Professor at the University of Minnesota
- 1968-1969 Associate Professor at National Chung Hsing University in Taiwan.
- 1967-1968 Assistant Professor at the Department of Agronomy of Purdue University in Indiana
- 1963-1966 Graduate Research Assistant at Michigan State University

Experience Related to Proposed Program:

- Traveled to more than 35 countries in Latin America, Africa, Asia, Western Europe participating in project design, implementation and evaluation, and as invited speakers in scientific conference symposiums.
- Supervised more than 30 graduate students and research scholars at IITA and at TAMU in collaboration with universities in Africa, Europe and Latin America.
- Major responsibilities in teaching and research in tropical soil and crop management and developing research and teaching programs in sustainable farming systems.
- Projects with collaborative research and training programs in Honduras, Costa Rica, Jamaica, Niger and Mali.

Pertinent Relevant Publications:

Mueller-Harvey, I., A. S. R. Juo and A. Wild. 1985. Soil organic C, N. S, and forest clearance in Nigeria: mineralization and spatial variability. J. Of Soil Sci. 36:585-589.

Juo, A. S. R. 1989. New farming systems development in the wetter tropics. Exp. Agric. (Cambridge), 25:145-163.

Juo, A. S. R. And B. T. Kang. 1989. Nutrient effects of modification of shifting cultivation in West Africa. P. 289-301. In J. Proctor (ed.). Mineral Nutrients in Tropical Forest and Savanna Ecosystems. Blackwell Scientific Publications. Oxford/London.

Juo, A. S. R. 1992. Mixed root crop ecosystems in the wetter tropics. P. 234-258. In: C. J. Pearson (ed.). Field Crop Ecosystems. Elsevier Scientific Publications. Amsterdam.

Juo, A. S. R. And R. D. Freed (eds.). 1995. Agriculture and the Environment: Bridging Food Production and Environmental Protection in Developing Countries. ASA Special Publication . American Society of Agronomy. Madison, WI. (in press).

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Associate Professor and Extension Specialist
Soil Science Department
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Box 7619
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Education:

- B.S. 1975 Agronomy Kansas State University, Manhattan, Kansas
- M.S. 1979 Soil Science, North Carolina State University, Raleigh, N.C.
- Ph.D. 1991 Agronomy, Cornell University, Ithaca, New York

Experience:

- 1997 - Present: Associate Professor and Extension Specialist, Department of Soil Science, North Carolina State University, Raleigh, N.C.
- 1992 1997: Extension Specialist, NCSU Water Quality Group, Department of Biological and Agricultural Engineering, North Carolina State University, Raleigh, N.C.
- 1988 - 1990: Graduate Research Assistant, Soil, Crop and Atmospheric Sciences Department, Cornell University, Ithaca, N.Y.
- 1983: Agricultural Project Consultant, United States Agency for International Development, Senegal, Africa
- 1981 -1983: Agricultural Project Officer, United States Agency for International Development, Zaire, Africa
- 1979 –1980: Research Associate, Soil Science Department, North Carolina State University, Raleigh, N.C.
- 1976 – 1979: Graduate Research Assistant, Soil Science Department, North Carolina State University, Raleigh, N.C.

Experience Related to Proposed Program:

Dr. Osmond's international experience has included work as an agricultural project officer with the U.S. Agency for International Development. She designed, evaluated, and implemented agricultural projects in Zaire and Senegal. Dr. Osmond has served as the coordinator for the integration and development of the components of NuMaSS 2.0 during the past phase of this project. In addition she has been very involved in the development of the nitrogen module in NuMaSS 2.0. In addition, she is involved in pollution prevention activities at North Carolina State University that involve research and information exchange. As part of these pollution prevention activities, she has designed and implemented a watershed-scale decision support systems. The first, WATERSHEDS (Water, Soil and Hydro-Environmental Decision Support System) contains significant information on agriculture and nonpoint source pollution. Located on the web, it is used worldwide by scientistists, teachers, students, and government officials interested in water quality and land use issues. The second decision support system, NLEW (Nitrogen Loss Estimation Worksheet) is used to track nitrogen reductions from agricultural best management practices.

Pertinent Recent Publications:

Osmond, D.L., T. Jot Smyth, R.S. Yost, W.S. Reid W. Branch, and X. Wang. 2000 Nutrient Management Support System (NuMaSS), Version 1.5: Software Installation and User's Guide. United States Agency for International Development Soil Management Collaborative Research Project. Technical Bulletin No. 2000-02.

Osmond, D.L., R.W. Gannon, J.A. Gale, D.E. Line, C.B. Knott, K.A. Phillips, M.H. Turner, M.A. Foster, D.W. Lehning, S.W. Coffey, and J. Spooner. 1997. WATERSHEDSS: A Decision Support System for Watershed-Scale Nonpoint Source Water Quality Problems, Water Resources Bulletin 33:327-341.

Osmond, D.L., J. Spooner, S.W. Coffey, J.A. Gale, D.E. Line, and J.A. Arnold. 1995. The Rural Clean Water Program: A Voluntary, Experimental Nonpoint Source Pollution Control Program and its Relevance to Developing Nations. In: Agriculture and the Environment: Bridging Food Production and Environmental Protection in Developing Countries. Proceedings of an International Symposium sponsored by Division A-6 of the American Society of Agronomy in Cincinnati, OH, November 7-12, 1993. ASA Special Publication Number 60.

Osmond, D.L., and S.J. Riha. 1996. Nitrogen Fertilizer Requirements for Maize Produced in the Tropics: a Comparison of Three Computer-based Recommendation Systems. Agricultural Systems 50:37-50.

Luna, P., D.W. Israel, T.J. Smyth, and D.L. Osmond. 1999. Nitrogen Decision Support System. Collection and Evaluation of Literature on Crop Response to Nitrogen Application: The Case of Corn in South America. SM-CRSP Project: Decision Aids for Integrated Nutrient Management.

Frank James Smith
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Director of the Human Resource Development Research Program
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Raleigh, North Carolina 27695

Education:

- B.S. 1967 Biology Michigan State University
- M.S. 1969 Psychometrics Iowa State University
- Ph.D. 1972 Psychometrics Michigan State University

Positions:

- 1990-Present Professor, Human Resource Development and Director of the Human Resource Development Research Program

- 1977-1990 Associate Professor

- 1984-1986 Education Advisor, USAID/North Carolina State University REE Project, and Honorary Professor of Economics and Planning, Universidad Nacional Agraria, Lima, Peru. 1984-1986.,

- 1972-1977 Assistant Professor

Experience Related to Proposed Program:

Since 1972 Smith has directed international evaluation research and integrated human resource policy and program planning for education, employment, and resource management. Smith is a specialist in cognitive, social and organizational factors in decision-making and innovation and his primary area of application concerns human adaptation to social, organizational and technological change. Smith has served as the principle investigator on several USAID projects, served as Chief of Evaluation Missions for UNDP and provided technical assistance to USAID, UNDP, IDB, the U.S. Department of Interior (Office of Water Resources) in support of evaluation and information systems development. Currently, Smith is the international coordinator of a USAID/APEC project involving ten APEC economies investigating human resource development policies and programs. Smith is a member of several professional associations including the American Evaluation Association and is a former associate editor of Evaluation Review. His work has contributed to public/private sector cooperation, project evaluation and outreach approaches to technology transfer education and sustainable development.

Pertinent Recent Publications:

Bhandari, R. & Smith, F. (2000, in press) Education and food consumption behavior in China: Household analysis and policy implication. Journal of Nutrition Education.

Smith, F.J. & Schwartz, S.J. Eds. (2001, in press) Human Resource Development for the Food Industry in Asia and the Pacific. Conference report for United Nations Economic and Social Commission for Asia and the Pacific.

Smith, F.J. (2000) Analysis and design of systems for monitoring and evaluation of research and extension services and impacts. Report prepared for the USAID/Bolivia, CONCADE project.

Smith, F. (1999)) Decision aids for integrated nutrient management in Costa Rica. Report prepared for the USAID/SM-CRSP.

Bhandari, Rajika & Smith, Frank (1997). Rural women in India: Assessment of educational constraints and the need for new educational approaches. Journal of Research in Rural Education. 13(3), 183-197.

T. Jot Smyth
Professor and Coordinator Tropical Soils Program
Soil Science Department
North Carolina State University
Raleigh, North Carolina 27695-7619

Education:

- B.S. 1973 Soil Science Texas Tech University, Lubbock, TX
- M.S. 1976 Soil Science North Carolina State University, Raleigh, NC
- Ph.D. 1981 Soil Science North Carolina State University, Raleigh, NC

Positions:

- 1998-present Professor, Coordinator of Tropical Soils Research Program, North Carolina State University

- 1993-1998 Assoc. Prof., Coordinator of Tropical Soils Research Program, North Carolina State University, Raleigh, NC

- 1986-1992 Assist. Prof., Tropical Soils Research Program, Soil Science Dept., North Carolina State University, Raleigh, NC

- 1981-1985 Assist. Professor, Soil Science Dept., North Carolina State University; Leader of Tropical Soils Research Program in the Central Amazon and located at Manaus, Brazil

- 1978-1981 Grad. Res. Assistant, Soil Science Dept., North Carolina State University, Raleigh, NC

- 1976-1977 Grad. Res. Assist. at EMBRAPA-CPAC in Bras¡lia, Brazil for Soil Science Dept., North Carolina State University

- 1974-1975 Graduate Research Assistant, Soil Science Dept., North Carolina State University, Raleigh, NC

Experience Related to Proposed Program:

- Project leader and coordinator of the acidity component of the ongoing SM-CRSP project entitled Decision Aids for Integrated Soil Nutrient Management. The project involves 16 faculty from four U.S. universities (Cornell, Hawaii, N.C. State and Texas A&M) and collaborative research with NARS scientists throughout tropical regions of Africa, Asia and Latin America. This project will release NuMaSS version 2.0 during the coming year.

- Two years of collaborative field and laboratory research with EMBRAPA comparingeffectiveness and management strategies between soluble P and rock phosphate P on Cerrado soils.

- Five years as on-site project leader of a collaborative research program with EMBRAPA in Manaus on long-term soil fertility management of clayey Oxisols in the Brazilian Amazon. Field and laboratory research focused on development of diagnostic indices and recommendations for N, P, K, Mg, and lime requirements for long-term cultivation of annual and perennial crops. Strategies included nutrient cycling with crop residues and incorporation of legume cover crops into crop rotations.

- Principal investigator for a 4-year U.S. AID project to provide technical backstopping support for soil management researchers in tropical Latin America. Activities included training and progress reporting workshops, on-site monitoring and assistance to participating network scientists, and on-campus library and laboratory support. During this project a 2 week workshop for field and laboratory training and research network planning was also provided to African scientists in IBSRAM's network on acid soil management.

- Principal investigator on a 4-year agroforestry project to develop management alternatives for shifting cultivation in the Western Amazon. Principal investigator on a Texasgulf project comparing agronomic effectiveness of soluble P and N.C. rock phosphate, PR in field trials throughout Central America. Coordination of the NCSU Tropical Soils Research Program entails establishment and maintenance of collaborative linkages with NARES and IARCS, and technical and administrative support to overseas activities by faculty and research assistants in Africa, Asia and Latin America. Domestic research focuses on development of diagnostic indices for subsoil acidity constraints and differential tolerance of crop species and cultivars to subsoil Al toxicity, low pH and Ca deficiency.

Pertinent Recent Publications:

Cravo, M.S. and T.J. Smyth. 1997. Soil fertility management for sustainable cropping on an Oxisol in the central amazon. R. bras. Ci. Solo 21:607-616.

Novais, R.F. and T.J. Smyth. 1999. Phosphorus in soils and plants under tropical conditions. Federal University of Vi‡osa, Vi‡osa, Minas Gerais, Brazil. 399p. (in Portuguese).

Osmond, D.L., Metra-Corton, T., Smyth, T.J., Yost, R.S. and Reid, W.S. (eds.). 2000. Decision processes for determining diagnostic and predictive criteria for soil nutrient management. SM-CRSP Tech. Bulletin 2000-03, Philippine Rice Research Institute, Nueva Ecija, Philippines.

Osmond, D.L., T.J. Smyth, W.S. Reid, R.S. Yost, W. Branch and X. Wang. 2000. Nutrient management support system, NuMaSS (version 1.5). Soil Management Collaborative Research Support Program, North Carolina State University, Raleigh, NC.

Smyth, T.J., and D.K. Cassel. 1995. Synthesis of long-term soil management research on Ultisols and Oxisols in the Amazon. pp.13-60. In R. Lal and B.A. Steward (eds.) Soil management: experimental basis for sustainability and environmental quality. Lewis Publishers, Boca Raton, FL.

Jeffrey G. White
Assistant Professor
Soil Science Department
North Carolina State University
Raleigh, North Carolina 27695-7619

Education:

- B.A. 1975 Biology, Biochemistry, Chemistry Brandeis University, Waltham, MA
- M.S. 1987 Agronomy: Soil Science Cornell University, Ithaca, NY
- Ph.D. 1988 Agronomy: Soil Science Cornell University, Ithaca, NY

Positions:

- 1999-present Assistant Professor, Department of Soil Science, North Carolina State University, Raleigh, NC
- 1996-1999 Assistant Research Scientist-Agronomy, Mississippi State University, Pontotoc Branch Experiment Station, Pontotoc, MS
- 1993-1996 Post-Doctoral Associate: Dept. of Soil, Crop, and Atmospheric Sciences, Cornell University-USDA Plant, Soil, and Nutrition Laboratory, Ithaca, NY
- 1989-1993 Research Agronomist and Assistant/Acting Chief of Party: Burundi Small Farming Systems Research Project (USAID)/Adjunct Asst. Professor, Dept. of Agronomy, University of Arkansas, Fayetteville, AR.
- 1981-1988 Research and Teaching Assistant: Cornell University, Ithaca, NY.
- 1980-1981 Senior Research Assistant: Harvard Biological Laboratories, Harvard University, Cambridge, MA.
- 1977-1979 Peace Corps Volunteer Mathematics and Science Teacher: CollŠge de Boutilimit, Boutilimit, Mauritania. 1977-1979.

Experience Related to Proposed Program:

- As Research Agronomist and Acting/Assistant Chief of Party of the USAID-Burundi Small Farming Systems Research Project: designed, implemented, and analyzed: 1) on-farm research trials and demonstrations with fertilizers, IPM, and soil conservation for beans, corn, potato, wheat, sorghum, soybean, rice, coffee, cassava, forages, agroforestry; 2) rapid rural appraisals/diagnostic studies of farming system components: land-use, composting, cultural practices, integration of livestock and crop production. Integrated farming systems research and extension (FSRE), multidisciplinary research, and peer review within Burundi's national agricultural research institute (ISABU). Trained and supervised counterparts/technicians in FSRE, experimental design, statistical analysis. Designed agronomic/FSRE component of $4.5 million project renewal. Served as Chief of Party of a 6-person multidisciplinary technical assistance team in C.O.P.'s absence. Forged links between ISABU and CGIAR centers. Co-authored/edited project semiannual reports. Facilitated workshops in FSRE, statistics, statistics for intercropping, and geographic information systems.

- As a Post-Doctoral Associate: Analyzed the spatial variability of zinc and other micronutrients and heavy metals in U.S. soils, crops, and plants using geostatistics and geographic information systems. Developed maps illustrating the geographic distribution of zinc and other micronutrients and heavy metals in the conterminous U.S. Co-authored article on micronutrient mapping from field to global scales.

- As an Assistant Research Scientist: Conducted research characterizing soil spatial variability and its effect on sweetpotato production; studied N rate, timing, methods of application, and chlorophyll meter diagnosis for no-till and conventional corn; examined residual effects of poultry litter, fertilizer, and tillage on no-till corn. Developed cover crop soil conservation systems for sweetpotato. State Corn Fertility Research Leader and member of Mississippi Soil Testing Advisory Committee and Mississippi State University Nutrient Management and Water Quality Task Force.

- Current research examines the potential of a variety of remote sensing techniques to characterize soils for agricultural production and wetland restoration, and to develop strategies for site-specific fertilizer N management based on crop status, available soil moisture, and soil characteristics.

Pertinent Recent Publications:

White, J.G. and R.J. Zasoski. 1999. Mapping soil micronutrients. Field Crops Research 60:11-26.

White, J.G., W.B. Burdine, Jr., P.G. Thompson, and J.L. Main. 1999. Effects of soil spatial variability on sweetpotato yield and quality. P. 304-311. In 1998 Annual Research Report: North Mississippi Research and Extension Center. Mississippi Agric. and Forestry Exp. Stn. Bull. 347.

White, J.G., R.M. Welch, and W.A. Norvell. 1997. Soil zinc map of the USA using geostatistics and geographic information systems. Soil Sci. Soc. Am. J. 61:185-194.

Bangirinama, L., S. De Keyser, A. Drion, L. Rochette, and J. White. 1993. ProblŠmes li,s au d,veloppement agro-zootechnique dans la zone du Plateau Central. (Problems linked to agricultural, sylvicultural, and livestock development in the zone of the Central Plateau) Institut des Sciences Agronomiques du Burundi-ISABU, Bujumbura, Burundi.

White, J.G., S. Nkunzimana, and G. Mussche. 1993. Transfert et test d'une m,thode de lutte contre la mouche du haricot et les fontes de semis: r,sultats provisoires (Transfer and test of a method of combatting bean shoot fly and damping off: provisional results) In W. Godderis (ed.) La production du haricot au Burundi (Bean production in Burundi). Proc. Workshop ISABU-CIAT. May, 1993. ISABU-CIAT, Bujumbura, Burundi.

Michael G. Wagger
Associate Professor, Soil Management
Soil Science Department
North Carolina State University
Raleigh, North Carolina 27695

Education:

- B.S. 1977 Agronomy University of Kentucky
- M.S. 1979 Soil Science University of Kentucky
- Ph.D. 1983 Soil Fertility Kansas State University

Positions:

- 1991 - present Associate Professor of Soil Science, North Carolina State University
- 1989 - 1991 Assistant Professor of Soil Science, North Carolina State University
- 1985 - 1989 Assistant Professor of Crop Science, North Carolina State University
- 1983 - 1985 Extension Specialist/Researcher, Department of Crop Science, North Carolina State University

Experience Related to Proposed Program:

- Technical backstopping assistance in the design, implementation, analysis and interpretation of field trials on peach palm litter decomposition and nitrogen fertilizer requirements/management for mature stands in heart-of-palm production; Soil Management CRSP project on Decision Aids for Integrated Soil Nutrient Management in collaboration with University of Costa Rica investigators.
- Soil-plant-water relations in different tillage systems
- Nutrient cycling in cover crop based production systems
- Runoff and chemical transport in relation to tillage system
- Three visits to Bolivia in 1993-1997 were made to assess the progress of graduate students conducting field research in the Chapare region. These activities were a collaborative effort with IBTA Chapare that focused on nutrient cycling via tropical legume cover crops and their impact with regard to sustainable production systems.

Pertinent Recent Publications:

Glasener, K.M., M.G. Wagger, C.T. MacKown and R.J. Volk. 1998. Nitrogen-15 labeling effectiveness of two tropical legumes. Plant Soil 200:149-156.

Luna-Orea, P., M.G. Wagger and M.L. Gumpertz. 1996. Decomposition and nutrient release dynamics of two tropical legume cover crops. Agron. J. 88:758-764.

Luna-Orea, P. and M.G. Wagger. 1996. Management of tropical legume cover crops in the Bolivian Amazon to sustain crop yields and soil productivity. Agron. J. 88:765-776.

Tyler, D. D., M. G. Wagger, D. V. McCracken, and W. L. Hargrove. 1994. Role of conservation tillage in sustainable agriculture in the southern United States. p. 209-229. In M.R. Carter (ed.) Conservation tillage in temperate agroecosystems. CRC Press, Lewis Publishers.

Wagger, M. G., and D. K. Cassel. 1993. Corn yield and water-use efficiency as affected by tillage and irrigation. Soil Sci. Soc. Am. J. 57:229-234.

Literature Cited in Proposal:

Osmond, D.L., T. Metra-Corton, T.J. Smyth, R.S. Yost and W.S. Reid (eds.). 2000a. Decision processes for determining diagnostic and predictive criteria for soil nutrient management. Proceedings of a workshop on 6-10 September 1999 at PhilRice, Maligaya, Nueva Ecija, Philippines. U.S. Agency for International Development - Soil Management Collaborative Research Support Program (Cornell, Hawaii, N.C. State and Texas A&M universities). SM-CRSP Technical Bulletin 2000-03 and Philippine Rice Research Institute, Maligaya, Philippines. 132 pp.

Osmond, D.L., T.J. Smyth, W.S. Reid, R.S. Yost, W. Branch and X. Wang. 2000b. Nutrient management support system, NuMaSS (version 1.5). Soil Management Collaborative Research Support Program, North Carolina State University, Raleigh, NC.

Soil Management CRSP. 2001. Annual progress report: decision aids for integrated soil nutrient management. February 11, 1999 - February 10, 2000. (http://intdss.soil.ncsu.edu/sm-crsp/Download/Download.htm#2000 Documents/).125 pp.

Smyth, T.J., W.R. Raun and F. Bertsch (eds.). 1991. Manejo de Suelos Tropicales en LatinoAmerica. II Taller Latinoamericano de Manejo de Suelos Tropicales, San Jose, Costa Rica, 9-13 de julio, 1990. Soil Science Dept., N.C. State Unversity, Raleigh, NC. 310 pp.

Institutional Commitment from Collaborators

MIS

Tegucigalpa, 6 April 2001

Doctor Jot Smith
Department of Soil Science
North Carolina State University
Raleigh, N. C.
U.S.S.

Dear Jot.

The purpose of this communication is to express our support to the collaborative activities between your Program and the Consortium for the management of Fragile Soils in Central America (MIS) included within the proposal "Adoption of Improved Soil Management Technologies". These activities were discussed and approved by us during your last visit to our office in Tegucigalpa.

We consider this proposal as a valuable opportunity to put your decision support tool in the hands of people and institutions committed to promote sustainable agricultural development in Honduras and Nicaragua.

We are looking forward to a fruitful collaboration.

Sincerely,

Miguel Ayarza
Executive secretary of MIS

Lima, April 9 2001

Dr. T. Jot Smyth
Department of Soil Science
Box 7619
North Carolina State University
Raleigh, NC 27695-7619
USA

Dear Dr. Smyth,

We received through Walter Bowen your proposal for a potential collaboration with NC State on a nutrient management decision support system (NuMaSS) during the next 5-year phase of the Soil Management CRSP from February 2002 to February 2007.

The two major components to the "adoption" process of the improved soil management technologies,: 1) validation of the biophysical information base, and 2) local/regional use of the information base, fit very well with Papa Andina working strategy in Bolivia, Ecuador and Peru.

I have revised the possible steps for a collaboration between NuMaSS and PapaAndina including:

11. Hands-on exposure and training with NuMaSS
12. Validating nutrient diagnosis
13. Validating NuMaSS nutrient recommendations
14. P diagnosis
15. Adoption of NuMaSS information to local user needs

We agree with this proposal, which constitutes a good basis to start this collaborative project. At the initiation of the project, these steps should be revised and discussed with our national partners, and adapted if required, according to the national conditions and needs.

This collaboration looks promising and Papa Andina would be happy to play a supporting role and collaborate with the SM-CRSP Project in its implementation on adoption of improved soil management technologies in Bolivia, Ecuador and Peru.

Yours sincerely,

André, Devaux
Coordinador Proyecto Papa Andina (CIP-COSUDE)
International Potato Center - CIP - Centro Internacional de la Papa
Mailing Address: Apartado 1558, Lima 12, PERU
Phone: (51-1) 349 6017 Fax: (51-1) 3175326
E-mail: A.DEVAUX@CGIAR.ORG

From: "Manuel C. M. Macedo" <macedo@cnpgc.embrapa.br>
To: <Jot_Smyth@ncsu.edu>
Subject: NuMaSS 2002-2007
Date: Fri, 6 Apr 2001 17:43:05 -0300
X-MSMail-Priority: Normal
X-Mailer: Microsoft Outlook Express 5.50.4133.2400
X-MimeOLE: Produced By Microsoft MimeOLE V5.50.4133.2400
X-MIME-Autoconverted: from 8bit to quoted-printable by uni01mr.unity.ncsu.edu id RAA01330
X-SLUIDL: 2A65ED23-294C11D5-AA080020-AF0AE2FC

Prezado Professor Jot,

sobre sua consulta de validação dos coeficientes bio-físicos do software NuMaSS para adoção/utilização em forrageiras tropicais na América Latina, tenho a dizer o seguinte:

- temos interesse na Embrapa Gado de Corte de utilizar nos resultados já obtidos em experimentos e nos experimentos em andamento e testar o software NuMaSS;

- uma vez testado experimentalmente temos interesse em testarmos em propriedades agrícolas da região;

-temos relacionamento com duas Universidades locais que poderiam também participar da validação com o apoio de estudantes de graduação e pós-graduação;

- o pesquisador e professor de Fertilidade do Solo Eng. Agr. José Antonio Bono, da UNIDERP-MS, também tem interesse em participar como colaborador, já que trabalha também em nossos laboratórios conduzindo trabalhos de pesquisa em conjunto;

Estamos certos que poderemos estabelecer um trabalho que atenda os interesses das nossas instituições e preencher uma grande lacuna no processo de interpretação e recomendação de nutrientes para os agricultores e pecuaristas da América Latina.

Cordiais saudações,

Dr. Manuel Claudio Macedo
Pesquisador - Solos e Nutrição de Plantas Forrageiras
Embrapa Gado de Corte
Caixa Postal 154
79 002- 970 Campo Grande, MS
Brasil

From: "Ricardo Alem" <ricardoalemrojo@hotmail.com>
To: Jot_Smyth@ncsu.edu
Subject: Propuesta NuMaSS
Date: Thu, 05 Apr 2001 15:03:39
X-OriginalArrivalTime: 05 Apr 2001 15:03:39.0825 (UTC) FILETIME=[98FAFA10:01C0BDE1]
X-MIME-Autoconverted: from 8bit to quoted-printable by uni01mr.unity.ncsu.edu id LAA18049
X-SLUIDL: 2A65EBD8-294C11D5-AA080020-AF0AE2FC

Estimado Dr. Smyth:

Ha sido de mi conocimiento la propuesta de aplicación del software NuMaSS a ser desarrollada en nuestra área de trabajo en el Trópico de Cochabamba (Chapare). El contenido de la misma nos parece interesante y de uso pr ctico para su aplicación en los cultivos priorizados por el IBTA; por esta razón, nos agradará formar parte de este Proyecto si las condiciones de financiamiento y operación brindan esta posibilidad.

Atentos saludos,

Severo España

The Agriculture Program

THE TEXAS A&M UNIVERSITY SYSTEM
Jack K. Williams Administration Bldg., Suite 113
2142 TAMU College Station, Texas 77843-2142
Phone 979.845.4747 Fax 979.845.9938 http://agprogram.tamu.edu

Office of the Vice Chancellor for Agriculture and Life Sciences

April 11, 2001

Soil Management Collaborative Research Support Program
North Carolina State University
Raleigh, NC 27695-7619

The Texas A&M University System and The Texas Agricultural Experiment Station intend to enter into a subgranting contract with North Carolina State University on the project entitled "Transferal and Adoption of Decision Aids for Integrated Soil Nutrient Management" once the U.S. Agency for International Development awards the prime contract.

A 5-year budget agreed upon by the Texas Agricultural Experiment Station is attached.

Sincerely,

Edward A. Hiler

Edward A. Hiler
Vice Chancellor & Dean, College
of Agriculture and Life Sciences
Director, Texas Agricultural
Experiment Station and Texas
Agricultural Extension Service

EH:gf

Trade-Off Analysis

The Trade-Off Analysis Project Phase 2:
Scaling Up and Technology Transfer
to Address Poverty. Food Security
and Sustainability
of the Agro-Environment

Montana State University

Montana State University Proposal to the SM CRSP

The Tradeoff Analysis Project Phase 2:
Scaling Up and Technology Transfer to Address Poverty, Food Security and Sustainability of the Agro-Environment

Principal Investigator:
John M. Antle

Montana State University Proposal* to *the SM-CRSP for Phase 2 Funding

The Tradeoff Analysis Project Phase 2: Scaling Up and Technology Transfer to Address Poverty, Food Security and Sustainability of the Agro-Environment

Principal Investigator:

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Co-Investigators:

Walter Bowen, Soil Scientist, CIP/IFDC
Charles Crissman, Economist, CIP
International Potato Center
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Jetse Stoorvogel
Department of Soil Science and Geology
Wageningen University
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The Netherlands
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Principal Collaborators:

Miguel Ayarza, International Center for Tropical Agriculture, Honduras
Victor Barrera, Inst. Nac. Aut. De Investigaciones Agropecuarias, Ecuador
Susan Capalbo, Montana State University
Gerald Nielsen, Montana State University
Philip Thornton, International Livestock Research Institute, Kenya
Roberto Quiroz, International Potato Center

Amount Requested: $ 671,070 (2002-2003)
$3,377,307 (2002-2007)

Montana State University Proposal to the SM-CRSP for Phase 2 Funding

The Tradeoff Analysis Project Phase 2: Scaling Up and Technology Transfer to Address Poverty, Food Security and Sustainability of the Agro-Environment

Problem Statement and Objectives

To achieve the goals of the SM-CRSP, i.e., to enhance farm and rural incomes in the near term without compromising their long-term productivity and sustainability, there is a compelling need to provide decision makers - from the farm and community level to the national and international policy levels - with accurate information about the economic and environmental consequences of their decisions.

This research addresses the need in developing countries to generate the farm and regional-level information demanded by decision makers to assess: the sustainability of existing technologies; the potential for adoption of economically and environmentally sustainable technologies; and the economic and environmental consequences of policy decisions for poverty, food security, and sustainability of the agro-environment.

The first phase of the Tradeoffs Project developed *a policy decision support system* based on tradeoff analysis of agricultural production systems, and applied that system to two watersheds in Ecuador and Peru. The first phase emphasized the development of the Tradeoff Analysis (TOA) method, and analytical tools to implement it (data, models and software for their integration). A significant product of the first phase was the Tradeoff Analysis Model@, computer software that integrates disciplinary data into standard geo-referenced formats, and provides a modular capability to link existing disciplinary simulation models to support the TOA method.

The TOA method is a *process* based on collaboration between stakeholders and multidisciplinary research teams. The process begins with identification of *sustainability indicators* for a production system deemed relevant by the stakeholders, the formulation of hypotheses about their interrelationships *(tradeoffs),* and the development of *technology and policy scenarios* to be assessed. The research team generates suitable data and parameterizes models to quantify sustainability indicators. These models are simulated and to assess how tradeoffs among sustainability indicators respond to technology or policy scenarios. This information is used by stakeholders and researchers to assess impacts and design strategies to improve the economic viability and sustainability of production systems. For further details, see Stoorvogel, Antle, Crissman, and Bowen (200 I) and the various other reports and publications on TOA at *www.tradeoffs.montana.edu.*

In the first 5-year phase of this research project, the TOA method was implemented in Ecuador (in collaboration with the national agricultural research program, INIAP) and in Peru (in collaboration with the national soil conservation program, PRONAMACHS, and the national agricultural research program, INIA) to assess tradeoffs associated with pesticide leaching, water and tillage erosion, terracing, agro-forestry, and related soil management technologies.

These applications provided the first tests of the TOA method and TOA Model software. Based on lessons learned from our first phase of work, as well as comments from the SMCRSP External Review and from the Phase 2 pre-proposal review, we propose the following activities in the next 5-year phase:

- Further develop and refine the existing TOA method and TOA Model software, through applications with collaborating institutions in the Andes, Central America, and Africa.

- Develop methods to scale-up the analysis possible with the TOA method from single agro-ecozones (e.g., watershed scale) to larger regional (sub-national or national) scales. Important components of the research will be:
    - methods to assess impacts of soil management technologies and related policies on poverty and food security at regional scales
    - methods to scale-up results from participatory research and assess transferability of soil management technologies across agro-ecozones.

- Development of protocols and materials to transfer the TOA method and the TOA Model software to existing and future user groups.

Identification of *Objectives and Constraints*

This project will address the following SM-CRSP objectives and corresponding constraints:

1. ***Develop methodologies*** **to** ***scale up technology adoption from participatory scales*** **to** ***national and regional scales.*** The project will develop a new approach to assess the transferability of soil management technologies. We will extend the statistical methods for ex post assessment developed in earlier research (Winters, Espinosa, and Crissman, 1998) by linking these methods to biophysical and socioeconomic data to identify agroecozones with characteristics. associated with successful technology adoption in participatory research. We will also collaborate with scientists from the International Center for Tropical Agriculture (CIAT) who are developing related geo-statistical methods for scaling-up data and models. These methods will be applied to analysis of the technologies being developed in Ecuador, Peru, Honduras and Africa in participatory research programs.

2. ***Develop methodologies that enable households and institutions*** **to** ***assess and anticipate consequences*** **of** ***technology adoption****.* The TOA method is designed specifically to integrate biophysical and economic data and models, and to conduct scenario analysis of the economic and environmental tradeoffs associated with adoption of technologies. This information can then be communicated to decision makers at all levels, from the farm level to national policy makers. Phase 1 of the Tradeoffs Project demonstrated the effectiveness of this approach in the assessment of health impacts of technology adoption (pesticide use) in Ecuador, and assessment of soil erosion impacts and options in Ecuador and Peru. Our research in Phase 2 will investigate how the information generated by the TOA method can be integrated into the participatory research and training activities of CIP, CIAT and ILRI.

3. ***Develop methodologies that provide farmers, government agencies and the general public with information needed to design policies that encourage adoption of production practices that are compatible with the long-term conservation of agricultural resources.*** The TOA method is specifically designed to assess the impacts of alternative policies on the economic and environmental sustainability of agricultural production systems. In Phase 1 of the Tradeoff Project, the TOA method was adopted by the PRONOMACHCS program in Peru to assess the viability of its policy to subsidize investments in terracing as a means to combat soil erosion. In Phase 2, we will improve and apply the TOA method to support policy decision making through collaboration with PRONAMACHCS in Peru, with the national agricultural research program in Ecuador, with the CIA T Hillsides project and its partners in Honduras and Central America, and with the University of Florida-University of Hawaii-Cornell SM-CRSP carbon project in West Africa.

4. ***Accelerate technology transfer by applying existing methods to soil management products and practices.*** Application of the TOA method will provide decision makers with better information about where technology transfer is likely to be successful and where environmental impacts are likely to be positive or negative. Applications in the first 2-3 years of Phase 2 will include: soil fertility management, terracing and agroforestry technologies in Peru; technologies to increase productivity and sustainability of crop-livestock systems in Ecuador, including methods to improve soil fertility and reduce tillage erosion; and technologies being developed by CIA T to reduce soil degradation and increase agricultural productivity in the fragile hillside soils of Central America, and methods to improve soil fertility and sequester soil carbon in West Africa. Applications elsewhere are anticipated in years 4-5, implemented by institutions adopting the TOA method.

5. ***Apply multidisciplinary methodology to facilitate decision making at different levels in the agroecosystem.*** The TOA method provides a common language of *sustainability indicators, tradeoffs, and scenarios* to be used by stakeholders (ranging from farmer and community organizations to national policy makers) and scientists. The TOA method is premised on collaboration between stakeholders and the scientific team conducting the tradeoff analysis. Communication is fostered through the use of this common language, and through the process of discussing and identifying the set of sustainability indicators and policy and technology scenarios to be incorporated into the tradeoff analysis. Research in Phase 2 will further apply the TOA method in the Andes, Central America, and Africa. These applications will involve a wide range of stakeholders, including farmer organizations in the study sites, agricultural research organizations, and local and national governmental and non-governmental organizations involved with agricultural development.

6. ***Develop practical methods to measure gains and losses*** of ***soil organic carbon over time in spatially variable soils.*** Research conducted by project PIs has demonstrated that critical aspects of soil C measurement for use in carbon sequestration projects - e.g., the spatial scale over which measurements need to made, and the required accuracy of the measurements depends critically on the design of incentive mechanisms (policies or contracts) for soil C sequestration. Research in Phase 2 of the TOA project will further investigate these issues in relation to soil C sequestration projects designed to enhance adoption of improved soil management practices. In addition, Phase 2 of the TOA project will collaborate with ICASA (International Consortium for Agricultural Systems Applications) and the SM-CRSP project on soil C

sequestration measurement and modeling, to link the recently developed DSSA T-CENTURY soil C model with the TOA Model software. We will work with user groups to assess the impacts of soil management technologies (e.g., improved soil fertility management, improved forages, tillage practices, terracing) and policies (e.g., input and output price subsidies, market infrastructure development) on soil C.

Project Strategy

The strategy of the proposed Phase 2 Tradeoffs Project is to build on the success of the Phase 1 project. According to the External Evaluation Panel's (1999) review of Phase 1,

"The Tradeoffs Model is uniquely suited for global replication. We see an opportunity to use the conceptual framework of *the Tradeoffs Model to advance natural resources management research and development activities in multiple applications."*

The reviewers of our Phase 2 pre-proposal advised us to carry out an additional set of applications to further develop the TOA method and TOA Model software, before undertaking its global dissemination. Accordingly, Phase 2 will involve further applications with existing collaborators in Ecuador and Peru, and new applications working with CIAT in Honduras and the International Livestock Research Institute (ILRI) in Africa. We will use these collaborations to further test the existing TOA method and TOA Model software, and to make further advances as described below. While these further applications are being implemented, we will continue to present the TOA method as a viable analytical process in regional and international fora.

A key lesson learned from collaborations in Phase 1 was that the various national and international organizations that are potential users of the information produced by applications of the TOA method have different capabilities to use the TOA method and TOA Model. Some organizations, such as international agricultural research centers, have the scientific capability to build the multidisciplinary teams of scientists needed to implement a study using the TOA method and software. Other organizations, such as national agricultural research institutes or soil conservation agencies, need the information produced by the TOA method but may not have the scientific capability to adapt the simulation models for new applications. Therefore, in Phase 2 we will pursue a two-pronged strategy for direct collaborations. First, for institutions with the capability to build scientific teams that can use the TOA method independently (such as Ecuador's national agricultural research institute INIAP, and CIAT and ILRI), we will design collaborations to build teams within those institutions. Second, for institutions such as PRONAMACHCS in Peru that cannot build an in-house scientific team to support the implementation of the TOA Model, we will develop collaborations to train staff in the TOA method, but the project's scientific team will provide the support needed to implement the TOA Model.

There is already a remarkable level of interest in the TOA method and related quantitative approaches to integrated natural resource management (INRM). The Consultative Group for International Agricultural Research (CGIAR) has an INRM working group focused on research methods development. There are also system-wide programs of the CGIAR such as the Global Mountain Program and the System-wide Livestock Program that utilize integrated modeling approaches to agricultural and environmental problems. The integrated analysis done with a modeling focus that is the basis of the TOA Model also is a core interest of the International Consortium for Agricultural Systems Analysis (ICASA). The Tradeoffs Project research team is and will be actively participating in these scientific networking fora.

The target sites for applications of the TOA method are located in regions of widespread and extreme poverty. The rural agricultural regions of the central and northern Andes, the hillside agriculture zones of Central America, 'and marginal agricultural areas of West Africa are home to many millions of poor rural families that desperately need to intensify their farming practices while sustaining and enhancing the future productivity potential of fragile environments. The mixed crop-livestock agriculture practiced by these farmers is typical of most smallholders farming, and the environmental problems of hillside agriculture and the sub-Saharan region are of immediate concern to the SM-CRSP.

Work Plan

***Methodological Developments (Objectives* 1, 3, *and* 4)**

This component of the project will provide for: (1) further improvements in disciplinary data and models, including development of minimum data sets and simplified models, and methods to assess the effects of minimum data sets, simplified models, and up scaling on the accuracy of the information produced by the TOA method; (2) further development of linkages between crop, livestock, environmental, and economic models; (3) addressing the fundamental challenge of scaling-up site-specific data and models used in agricultural systems analysis from the field and farm scale to higher (i.e., regional and national) scales; (4) further developments in the TOA Model software.

1. *Improvements in disciplinary data and models.*

Biophysical Data and Models. Extension of research conducted in Phase 1, including:

- *Disaggregating soils and climate data.* In Phase 1 a cost-effective methodology for obtaining high-resolution soils data for model inputs was developed for the specific conditions of Ecuador, and was also applied in the Cajamarca site in Peru (Van Soest, 1998; Overmars, 1999). In Phase 2 we plan to standardize this methodology and further apply it and test it in other locations in Ecuador, Peru, Honduras, and Africa.

- *The development of data standards for the environmental process models.* The TOA Model software is based on the concept of modularity giving the software its generic character. As a result of the data standards developed by ICASA for data input and output for crop growth simulation models (Hunt and White, 2000), and the implementation of these standards in a large number of simulation models, it is possible to use any of these models with the TOA Model software. However, such standards have not been developed for environmental process models. One challenge of environmental models is that they are more varied in their data inputs and types of outputs. Our goal is to begin the process of developing ICASA-style standards for the environmental process models that we are using with the TOA Model, including leaching and erosion models. We will use our participation in the scientific networking fora mentioned above to introduce and promote this concept.

- *Procedures for the calibration and validation* of *crop growth simulation models (in collaboration with ICASA and other SM-CRSP projects that use crop models).* New applications of the TOA method require the use of crop growth simulation models from the suite of models in Decision Support System for Agricultural Technology Transfer (DSSAT; Jones et al., 1998). However, standard procedures for the calibration and validation of these models as they are applied to new sites are lacking. Our goal is to develop and document a set of cost effective procedures for calibrating and validating crop models.

Economic Data and Models. Extensions of topics investigated in Phase 1, and new topics, including:

- *Methods to parameterize economic models using minimum data sets and secondary data.* The applications of the TOA Model thus far have been based on the collection of field-scale and farm-scale data using dynamic surveys (surveys conducted through periodic collection of data from respondents). Such data are accurate but also costly and time-consuming to obtain. As part of our work to increase the efficiency of implementing the TOA method, one goal will be to use data collected in Phase 1 to assess the quality of analysis produced with less detailed secondary data. Research conducted as part of Phase 1, as well as research conducted by related projects of the PIs will be utilized here (Antle et al., 2000a).

- *Methods to analyze dynamic processes associated with land degradation and with investments in soil conservation technologies.* Land degradation introduces a dynamic aspect to the analysis of a production system that has implications for the design of economic models (Antle and Stoorvogel, 2001). Various soil conservation technologies have been developed such as terracing and agroforestry. Adoption of these technologies requires an investment in the near term that returns benefits over many years. Our research during Phase 2 will extend the work done in Phase 1 to further develop the capability of the economic models used in the TOA Model to address the dynamic interactions among crop and livestock productivity, land quality, and economic decision-making.

- *Models to analyze soil carbon sequestration.* To support our collaboration with the FHC carbon sequestration project in the SM-CRSP, we will incorporate recent developments in economic analysis of soil carbon sequestration into the economic models used in the TOA model (Antle et a12000c, 2000d, Antle and McCarl 2001). This will involve modifying the economic simulation models to input soil C rates from the DSSA T - Century model, and to incorporate this information into the land use and management decisions simulated in these models.

- *Development* of *data standards for economic models following the ICASA approach for crop models.* Research in Phase 1 developed a set of generic econometric production models for use in the econometric-process simulation model developed for the TOA Model. In Phase 2, our goal is to further standardize input and output data for these models, following the approach used by ICASA for crop models.

2. *Further development of linkages between crop models, livestock models, environmental models, and economic models.*

In the current version of the TOA Model, crop and livestock models are used to estimate site-specific inherent productivity. The estimates of inherent productivity are then passed to the economic models and used to help predict spatial variation in management. We refer to this type of model linkage as loose coupling of disciplinary models (Antle et al., 2000e). For some purposes, a closer coupling may be needed:

- To account for dynamic linkages between biophysical processes such as crop growth or pests and management decisions such as fertilizer and pesticide use, and the dynamics of land degradation processes.

- To account for spatial inter-relationships between land units (referred to recently in the literature as spatial externalities) caused by processes such as erosion and runoff.

- To link economic models to integrated crop-livestock models being developed in the Ecoregional Fund project at ILRI.

Research on the integration of biophysical and economic models is being funded at Montana State University by the USEP A (Antle et al., 2000b). These developments as well as additional developments by Tradeoffs Project PIs will be incorporated into the TOA Model framework in Phase 2.

3. ***Methods for Scaling Up TOA and Incorporation*** **of** ***Indicators for Poverty and Food Security.***

The application of tools for regional land use analysis is significantly constrained by the availability of reliable data. The TOA method also faces significant data needs to capture accurately the spatial variation in productivity caused by a high degree of spatial heterogeneity. Nevertheless, to make the TOA method widely applicable without large investments in data collection, we need to assess the effects of data aggregation and up-scaling of data and models, and we need to develop methods that can work reasonably well with less detailed data to the degree possible. It is therefore extremely important to define minimum data sets, develop cost-effective methods to obtain those data, adapt the methodology to fit better with available data sets, and develop methods to scale-up analysis.

Research conducted in Phase 1 established that when spatial heterogeneity is high, as it typically is in the environments of tropical hillside agriculture, estimates of the productivity impacts of resource degradation may be seriously downward biased if sufficiently disaggregate data are not used (Antle and Stoorvogel, 2001). In ongoing research by the project PI and collaborators funded by NSF (Antle, Capalbo, Mooney, and Paustian, 2001a), methods for assessing the benefits and costs of conducting analysis at alternative spatial scales are being developed in relation to the degree of spatial heterogeneity of the data. Related research on up-scaling data for quantitative analysis has been conducted by CIA T scientists (CIA T, 2000). These developments will be used to assess the loss of accuracy in the TOA Model associated with model simplification, aggregation and up-scaling. Based on these results, recommendations for minimum data needed for application of models used in the TOA Model will be developed to guide users.

In Phase 1, the sustainability indicators that were used were current and future agricultural production, pesticide leaching, human health risk, and soil erosion. To increase the usefulness of the TOA method for regional and national policy analysis of poverty and food security, work in Phase 2 will expand the sustainability indicator set to include broader social measures of well being, including measures of income, income risk, income distribution, and food security. This work is closely related to the methodological developments discussed above, but also goes beyond them in several critical respects. As noted earlier, a key challenge is to link the TOA method with broader data and tools that can support analysis not just of agricultural production, but analysis of farm households and of rural populations (both farm and non-farm rural households).

- *Incorporation of household decision making into the farm-level economic models.* A first step that can be taken within the existing modeling framework is to broaden the economic models beyond agricultural production to incorporate other household decisions and constraints. The existing body of literature on household production models could be utilized, but existing models have high data demands (e.g., see the various studies in Heerink, van Keulen, and Kuiper, 2001). The econometric-process simulation model methodology developed by the PI (Antle and Capalbo, 2001) is well suited to incorporate the effects of key household constraints on production decisions, such as family labor availability and financial constraints, without requiring the large amount of data needed to estimate complete structural household models.

- *Linkage of TOA Model software* to *census and other social and economic data.* Various census and other social and economic data are available in most regions of the world. Such data can be incorporated into the TOA Model software to facilitate spatial analysis of impacts of policy interventions on poverty, food security, and income distribution.

- *Linkage of TOA Model to data available at differing spatial scales and across large geographic regions.* Remotely sensed data on topography, land cover, and land use, as well as socioeconomic data from population and agricultural censuses, are available for large geographic regions. We will link our research on upscaling to these kinds of data in order to extrapolate the TOA method findings to regions that have similar biophysical and socioeconomic characteristics.

4. ***Further Developments* in *TOA Model Software***

With the adaptations of biophysical and economic data and models, continued improvements in the TOA Model software are anticipated. In addition, the software will undergo modifications and improvements through interactions between the project's research team and users of the software. Anticipated improvements include adaptations of the software to incorporate the methodological developments from this phase of work. Additionally, we intend to develop online documentation and a web page for interaction between project PIs and users.

***Applications* of *the TOA Method (Objectives* 5 *and* 6)**

The target groups for our work are farmer and community organizations, as well as sub national, national and international governmental and non-governmental organizations that have a responsibility to make decisions that impact the development and adoption of soil management technologies. The principal groups and locations for the first 2-3 years of the Phase 2 work are described below. During years 3-5 of the project, our plan is to disseminate the TOA method more widely, working through the regional and global networks of the international agricultural research centers.

- **INIAP (National Agricultural Research Institute), Ecuador.** Building on the long-standing and successful collaboration between CIP and INIAP researchers, our goal is to support the development of a research team within INIAP with the capability to apply the TOA method and tools to support decision-making by the Ministry of Agriculture in Ecuador. We will collaborate with two funded research projects that have adopted the TOA method:

    - *Eco-soils: Investigation for the ecological management and productivity* of *soils in the Ecuadorian Andean Eco-region.* This is a CIP-INIAP-IFDC-University of Guelph collaboration financed by the Competitive Grants for Research fund of the Agricultural Services Modernization Program (PROMSA) of the Ecuadorian Government. This project sought collaboration with the Tradeoffs Project to assess technology scenarios including the utilization of improved soil cover for erosion prevention, and improved soil organic matter management through soil amendments and use of cover crops.

    - *Strengthening research capacity for productivity improvement and sustain ability* of *mixed livestock-crop systems in the Andean eco-region.* This is a CIP-IFDC-ILRI-INIAP collaboration financed by the Strategic Alliance fund of PROMSA. This project sought collaboration with the Tradeoffs Project to examine scenarios of sustainability of mixed crop-livestock systems in four sites in the Ecuadorian Andes. These scenarios include rotations of pasture with different crops and increases in animal carrying capacity.

- **PRONAMACHCS (National Watershed Management and Soil Conservation Program), Peru.** PRONAMACHCS is a national institution that became a user of the TOA method in Phase 1 of the Tradeoffs Project, but lacks the in-house scientific capability to adapt the TOA Model to new applications. During the last year of our Phase 1 work, we are using the TOA method to conduct an assessment of the conservation technologies (e.g., terracing and agroforestry) being promoted by PRONAMACHCS in the Cajamarca region of Peru in collaboration with PRONAMACHCS staff. As a part of that collaboration, we are training PRONAMACHCS staff in the use of the TOA method and TOA Model. Our goal in Phase 2 is to extend this collaboration to evaluate the PRONAMACHCS conservation technologies in other regions of Peru, and to further develop the capability of PRONAMACHCS staff to use the TOA method. We also intend to work with PRONAMACHCS to investigate the potential for a soil carbon sequestration program in Peru, and if the potential is high, we intend to work with PRONAMACHCS to develop a pilot soil carbon sequestration program.

- **CIAT, Project on Community Management of Natural Resources in Hillside Agroecosystems of Latin America.** The Tradeoff Analysis project was invited by the SM-CRSP Phase 2 Pre-proposal Reviewers to develop a collaboration with the CIA T Hillsides project in Honduras. In January 2001, two Tradeoffs Project PIs (Antle and Stoorvogel) visited CIA T headquarters in Cali and the CIA T Hillsides project reference site in Honduras. Based on this visit and discussions with CIA T leadership, we are proposing in Phase 2 to initiate a new collaboration with the CIA T Hillsides project. The objectives of this collaboration are as follows:

- *Develop* a *multidisciplinary research team in Honduras with the capability to use the TOA method to support research and policy decision-making associated with the CIA T Hillsides project.* The CIA T Hillsides project is working at a watershed-scale reference site in the Yoro region of north-central Honduras. At this reference site, CIA T is developing technologies and agro enterprise strategies to address the problems of resource degradation and poverty. TO A will be used by the research team to assess the potential for CIA T technologies to increase incomes and reverse the widespread degradation of the fragile hillside soils, under various economic and policy scenarios. The research team will also work with the CIA T Hillsides project to communicate this information to regional and national stakeholder organizations (including NGOs and national government agencies) to support more informed decision-making by these organizations.

- *Collaborate with CIA T scientists in further development* of *scaling-up methods for the TOA method.* The Tradeoffs Project PIs will collaborate with the CIAT-TOA team and other CIA T scientists on the methodological developments outlined above.

- *Collaborate with research organizations and development organizations in Honduras and other Central American countries and disseminate the TOA method.* Miguel Ayarza, director of the CIA T Hillsides project in Honduras, recently organized the Integrated Soils Management (MIS) consortium. This consortium consists of 18 Central American and South American research organizations, universities, and NGOs working on integrated management of fragile soils throughout Central America. MIS is one of four consortia that comprise the CGIAR system-wide program on Soil, Water and Nutrient Management. The CIA T - TO A team will work through the MIS consortium to disseminate the results of the CIAT-TOA work and to identify other target groups for dissemination of the TO A method.

- International Livestock Research Institute. PI Crissman will relocate from Quito to Nairobi in June 2001. He will assume leadership to develop an application of the TOA method in collaboration with Philip Thornton at ILRI and the Florida-Hawaii-Cornell SM-CRSP carbon project. Crissman will collaborate with Thornton in the design of data collection in the FHC project and will train African collaborators in the use of TO A and the TOA Model. Our goal is to incorporate the DSSA T -Century and ILRI crop-livestock models into the TOA Model framework, and to use the TOA method in a manner that parallels the work with the CIAT Hillsides project in Honduras. We hope that these first applications of the TOA method in Africa will create interest among other potential user groups in Africa.

Dissemination* of *the TOA Method and Training* of *User Groups

A significant component of the work in years 4 and 5 of the project will be the production of scientific and popular publications derived from the methods developments and applications in years 1-3. In addition, a book-length manuscript composed of chapters written by the participants in the project will be a major product of years 4 and 5. This manuscript will be submitted to a commercial publisher.

Another major component of years 4 and 5 will be the development of training materials and workshops for dissemination of the TOA method and tools to other user groups. This activity will respond to the SM-CRSP External Review recommendation that the TOA be applied globally. Our goal is to work through the various networks of research organizations and development organizations. For example, in January 2001 Jetse Stoorvogel presented the TOA method and TOA Model in a regional training course on policy and institutional reform for sustainable rural development organized by the World Bank Institute in India. A similar training course is being organized by Stoorvogel (to be held February 2001) for the Graduate School of Production Ecology at Wageningen University and the Ecoregional Research Fund. We anticipate that continued involvement in these types of activities will generate a demand for the TOA products during the later years of this project.

The project will also develop a support site on the worldwide web for users of the TOA method and software. We are aware of other programs that have developed successful web sites for this purpose and plan to learn from those experiences in developing our web site.

Collaborative Relationships

Collaboration within the SM-CRSP. The Tradeoffs Phase 2 project will collaborate with two other proposed projects for Phase 2:

- **The University of Florida-University of Hawaii-Cornell University Carbon Project.** The goal of this collaboration is to incorporate the DSSA T -Century model developed by Jim Jones and collaborators into the suite of models that can be implemented within our Tradeoff Analysis Model software, and modify the economic models within the TOA framework so that they can be used for analysis of soil C sequestration. We will then implement this DSSA T -Century- TOA modeling system in a series of case studies:
    - We plan to implement a first pilot project for soil C sequestration as an extension of our analysis of terracing and agroforestry programs in Cajamarca, Peru. We plan to support the parameterization the DSSAT-Century model for the principal crops in the Cajamarca site (potatoes, grains, beans and peas, dairy) and link it to the Tradeoff Analysis Model. We will also use this modeling setup to incorporate a soil C analysis into our application of Tradeoff Analysis in Honduras.
    - We plan to collaborate with Philip Thornton at ILRI (who is also a collaborator in the FHC project) to include application of the DSSAT-Century-TOA modeling system to one or more of the sites in West Africa where the FHC carbon project will be working. Charles Crissman, working for CIP but based at ILRI in Nairobi, will lead our collaboration with Thornton. He will advise Thornton on data design to support application of the TOA modeling to the West African sites, and will assist with training of African collaborators in the use of the TOA approach and software.

- **The North Carolina State NuMaSS Project.** Our plan is to facilitate the dissemination of the NuMaSS decision support system in the Andean region, working with CIP's Papa Andina regional project in Ecuador, Peru and Bolivia, and with the MOSAndes consortium that Walter Bowen has helped create and lead. This collaboration would also provide the impetus for exploring possible synergies and linkages between the NuMass decision support system and the Tradeoff Analysis approach and software. Some specific points of collaboration will be: training user groups how to use NuMaSS; validating nutrient diagnosis and NuMass recommendations; and using the TOA Model to assess the economic and environmental implications of the NuMass recommendations in Ecuador, Honduras and Peru.

International Potato Center (CIP). The well-established relationship with the natural resource management program at CIP will continue, based at CIP's Quito facility. CIP staff involved will include Charles Crissman in Nairobi, Walter Bowen at CIP-Quito, Roberto Quiroz at CIP-Lima, and a jointly funded economist position based at CIP-Quito. The person in this jointly funded position will have responsibilities for research, project management, collaboration with established user groups, and dissemination of TO A to new users.

International Fertilizer Development Center (IFDC). Walter Bowen has a joint posting with CIP and IFDC. His presence on the Tradeoffs Project team provides a linkage to this center of expertise in soil fertility management.

International Center for Tropical Agriculture (CIA T). CIA T will support the TOA project's collaboration with its Hillsides project in Honduras and Central America through a significant commit of time of a senior scientist, support staff, vehicles, and joint support of an economist position similar to the arrangement with CIP. CIA T will catalyze the interaction of project staff with the systemwide Soil Water Nutrient Management program in both Central America and Africa.

International Livestock Research Center. Philip Thornton at ILRI has agreed to collaborate with the project as described above.

The Ecoregional Fund. In Phase I, the Ecoregional Research Fund supported various project activities related to methodological developments in collaboration with the Tradeoffs Project. The Fund has expressed interest in co-financing further development and application of the TOA method. However, the Fund could not make a commitment at the time this proposal was submitted.

INIAP (National Agricultural Research Institute), Ecuador. Victor Barrera, Head of the Department for Technology Validation and Transfer of INIAP in Ecuador, a collaborator in Phase 1, will be the leader of the TOA team that will be developed during Phase 2. He is also co-PI (with Walter Bowen) of the INIAP projects using TOA described above.

PRONAMACHCS (National Watershed Management and Soil Conservation Program), Peru. The group ofPRONAMACHCS staff that were trained in use of the TOA method in 2001 will provide the core group of collaborators in Phase 2.

MOSAndes (Consortium for Soil Management in the Andes). MOSAndes, a consortium representing a total of 51 investigators from six countries, has funding from the Ibero Americano Program on Science and Technology for Development (CYTED) to facilitate scientific exchanges and regional workshops for a four-year period beginning January 2001. Walter Bowen helped found this consortium which will be collaborating with the Tradeoffs Project in Phase 2.

SANREM and IPM CRSPs. We expect to continue to collaborate with the IPM CRSP in Ecuador. We expect that a collaboration with the SAMREM CRSP activities related to soil carbon sequestration will be initiated in 2001 after this proposal is submitted.

USAID Missions. The Honduras mission has expressed interest in SM-CRSP support for impact assessment, and we plan to pursue this opportunity to support USAID. We will continue to disseminate our findings through the USAID missions in the other countries where we are working.

Other Potential Collaborators. As noted earlier, collaboration will be sought with other institutions that are members of the Consortium for Integrated Soil Management in Central America, and with other governmental and non-governmental organizations in Africa. The Ministry of Agriculture in Panama has expressed interest in collaboration with the TOA project to assess environmental impacts of the Panama Canal watershed. Other potential collaborations we are exploring include EMBRAP A in Brazil, and CIP research programs in the Altiplano region of Bolivia. We expect other collaborations to develop from our networking activities detailed above.

Products to be Delivered

All written reports and presentations from project meetings and scientific conferences will continue to be made available on the project's web site at www.tradeoffs.montana.edu.

1. Project reports and publications that describe the methodological innovations described above, including a book-length manuscript summarizing the project's work.

2. Reports and publications documenting the use of the TOA method in the Andes, Central America, Africa, and other regions where adoption may occur during Phase 2. These reports will include summaries of policy analysis conducted using applications of TOA.

3. The TOA Model software and documentation developed during Phase 2.

4. The suite of biophysical and economic models that operate with the TOA Model software.

Results and Impacts

The impacts of Phase 2 of the Tradeoffs Project will come through successful application of the TOA method by user groups in various countries and institutions. It is difficult to quantify the impact of improved decision making. We will document impact by identifying the numbers of individuals trained, the institutions that adopt the TOA method, and by documenting changes in technologies or policies that are associated with adoption of the TOA method as a decision making aid.

This project also will have measurable impact on the state of science used to understand and predict the behavior of complex agricultural systems at farm and regional scales. These impacts will be measured through the conventional means of publications in peer-reviewed journals, presentations at scientific conferences and other scientific communication and dissemination methods.

Another measure of impact and success of the project is the ability to attract additional funding to leverage the SM-CRSP funding. The Phase 1 Tradeoffs Project was highly successful in leveraging SM-CRSP funding with grants from the Ecoregional Research Fund, IDRC, and other programs (as documented in Phase 1 annual reports). The PIs intend to continue to leverage SM-CRSP funds aggressively during Phase 2 as opportunities arise.

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Workplan and Schedule				
Objective/Task	**Activity**	**Investiator(s)**	**Year(s)**	**Cost**
Metodology Development, Objectives 1, 3, 4.			2002-2004	
1. Improvements in disciplinary data and models - biophysical				
	Disaggregating soils and climate data	Bowen, Stoorvogel	2002-2004	$51,028
	Development of data standards for environmental process models, including the WEPP soil erosion model and the DSSAT-Century soil C model	Bowen, Stoorvogel	2002-2004	$51,028
	Procedures for calibration and validation of crop models	Bowen, Stoorvogel	2002-2004	$51,028
Improvements in disciplinary data and models - economic				
	Methods to parameterize economic models using minimum data sets and secondary data • Assemble secondary data for study sites • Construct models based on secondary data • Simulate models based on primary and secondary data and compare quality of results	Antle, MSU post-doc, CIP Economist	2002-2004	$83,945
	Methods to incorporate risk and related social phenomena in economic models • Incorporate production risk into economic models • Identify data needs for transactions costs and financial constraints, collect data • Incorporate transactions costs and financial constraints into economic models	Antle, MSU post-doc, CIP Economist	2002-2004	$83,945
	Development of data standards for economic models	Antle, MSU post-doc, CIP Economist	2003	$18,137
2. Further development of linkages between crop models, livestock models, and economic models				

	• Investigate methods to link input use decisions from economic models to crop models • Investigate methods to account for spatial inter-relationships between land units • Integration of crop-livestock models with economic models	Antle, Bowen Stoorvogel Crissman, Thornton	2003 2003 2003	$21,658
3. Methods for Scaling Up TOA and Incorporation of Indicators for Poverty and Food Security				
	Incorporation of household decision making into the farm-level economic models • Review household decision model literature • Identify key issues for each study site • Incorporate key household constraints into econometric-process simulation models for each study site	Antle, MSU post-doc, CIP Economist	2002-2004 2002 2003 2003-2004	$83,945
	Linkage of TO A Model software to census and other social and economic data (Poverty and Food Security Indicators) • Identify available data in each region/country • Adapt TM to read and use data	Antle, MSU post-doc, CIAT economist, CIP Economist, Stoorvogel	2004	$29,159
	Linkage of Tradeoff Model to data available at differing spatial scales	Stoorvogel	2003	$3,521
	Methods for scaling up biophysical models and data	Stoorvogel, Quiroz, Peru student, Bowen, Nielsen	2002-2003	$34,374
	Methods for scaling up economic models and data	Antle, MSU post-doc, CIA T economist, CIP economist	2003-2004	$59,812
	Methods for extrapolating the TOA Model	Antle, Stoorvogel	2003-2004	$28,747

	Methods to extrapolate adoption models, define adoption domains	CIP economist, Quiroz, CIA T economist and collaborators	2002-2003	$61,539
4. Further developments in TOA Model Software	*Incorporation of methods developments*	All	2003-2005	$131,952
	Incorporation of improvements from experience with applications	All	2003-2006	$209,841
	On-line documentation	MSU post-doc, other Pis	2003-2006	$65,001
	Interactive web page for the TOA Model users	MSU post-doc	2003	$9,186
TOA Applications (Objectives 5, 6)				
INIAP (National Agricultural Research Institute), Ecuador				
	Eco-soils: Investigation for the ecological management and productivity of soils in the Ecuadorian Andean Eco-region	Barrera, Bowen	2002-2004	$35,642
	Strengthening research capacity for productivity improvement and sustainability of mixed livestock-crop systems in the Andean eco-region	Barrera, Bowen	2002-2004	$35,642
PRONAMACHCS (National Soil Conservation Program), Peru				
	Application of TO A to other PRONAMACHCS project sites in Peru	CIP economist, Bowen	2002-2004	$35,642
	Analysis of soil carbon in PRONAMACHCS projects	CIP economist, Bowen	2002-2004	$35,642
CIA T Hillsides Project, Honduras and Central America				

	Develop a multidisciplinary research team in Honduras with the capability to use TOA to support research and policy decision making associated with the CIAT Hillsides project • Recruit economist and soil student • Train CIAT Honduras staff in TOA and TM • Conduct TOA workshop with stakeholders to identify indicators and scenarios • Assemble existing secondary data and experimental data • Collect farm survey data and soils data • Parameterize models and conduct analysis • Disseminate findings in stakeholder workshops and publications	Ayarza, CIA T economist, soils student, CIA T staff, Antle, Stoorvogel, MSU post-doc	2002 2002-2003 2004	$113,480
	Collaborate with CIA T scientists in further development of scaling-up methods for TOA	Antle, Stoorvogel, CIAT economist, soils student, Ayarza, CIAT scientists	2003-2005	$81,525
	Collaborate with research organizations and development organizations in Honduras and other Central American countries and disseminate the TOA approach	Ayarza, CIAT economist, Antle, Stoorvogel	2004-2006	$99,853
International Livestock Research Institute and African Highlands Initiative, East Africa		Crissman, Thornton, Antle, Stoorvogel	2003-2005	$100,570
Dissemination of TOA and Training of User Groups (Objectives 5 and 6)				
	Scientific publications, participation in scientific meetings	All	2002-2006	$261,253
	Book-length manuscript on methods and applications of TOA	All	2005-2006	$112,131

	TOA training materials	All	2005-2006	$112,131
	TOA training workshops	All	2005-2006	$112, 131
Global Plan Activities				
Annual SM-CRSP workshop and planning meeting	PIs and selected collaborators participate in annual SM-CRSP program workshop and planning meeting	Antle, Ayarza, Bowen, Crissman, Stoorvogel, Yanggen, CIAT econ leader	2002-2007	$88,000
SM-CRSP training program	Develop and test training modules	PIs and post-docs	2002-2007	$58,500
SM-CRSP networking and web site	Develop enhanced web site Support marketing of SM-CRSP products	PIs, web administrator, marketing director	2002-2007	$304,014

Logical Framework for Impact Assessment			
Description	**Objectively Verifiable Indicators**	**Means of Verification**	**Assumptions**
Metodology Development, Objectives 1, 3, 4.			
1. Improvements in disciplinary data and models - biophysical			
	Reports on disaggregating soils and climate data	On website	Data are available
	Reports on development of data standards for environmental process models	On website	Standards are feasible
	Report on procedures for calibration and validation of crop models	On website	Procedures are useful
Improvements in disciplinary data and models - economic			
	Reports on methods to parameterize economic models using minimum data sets and secondary data	On website	Data are available
	Report on methods to incorporate risk and related social phenomena in economic models	On website	Methods are successful
	Report on data standards for economic models	On website	Standards are feasible
2. Further development of linkages between crop models, livestock models, and economic models			
	• Report on methods to link input use decisions from economic models to crop models • Report on methods to account for spatial inter-relationships between land units • Report on integration of crop-livestock models with economic models	On website	Research on each topic is successful

3. Methods for Scaling Up TOA and Incorporation of Indicators for Poverty and Food Security			
	Report on incorporation of household decision making into the farm-level economic models	On website	Data are available
	TOA Model software linked to census and other social and economic data (Poverty and Food Security Indicators)	Software modified	Data are available
	Linkage of TOA Model to data available at differing spatial scales	Software modified	Data are available
	Report on methods for scaling up biophysical models and data	On website	Methods are successful
	Report on methods for scaling up economic models and data	On website	Methods are successful
	Report on methods for extrapolating the TOA model	On website	Methods are successful
	Report on methods to extrapolate adoption models, define adoption domains	On website	Methods are successful
4. Further developments in TOA Model Software			
	Methodological developments incorporated into TOA Model software	Software modified	Methods are successful
	Incorporation of improvements from experience with applications	Software modified	Applications provide basis for improvements
	On-line documentation	On website	
	Interactive web site for the TOA Model users	Site exists	Interactive web site is useful
TOA Applications (Objectives 5, 6)			
INIAP (National Agricultural Research Institute), Ecuador			

	Report documenting results from the project, "Eco-soils: Investigation for the ecological management and productivity of soils in the Ecuadorian Andean Ecoregion"	On website	Project is successful
	Report documenting results from the project, "Strengthening research capacity for productivity improvement and sustainability of mixed livestock-crop systems in the Andean eco-region"	On website	Project is successful
PRONAMACHCS (National Soil Conservation Program), Peru			
	Report on application of TO A to other PRONAMACHCS project sites in Peru	On website	Applications are made
	Report on analysis of soil carbon in PRONAMACHCS projects	On website	Analysis is completed
CIAT Hillsides Project, Honduras and Central America			
	Reports documenting application of TO A in Honduras	On website	Project executed
	Report on collaboration with research organizations and development organizations in Honduras and other Central American countries	On website	Collaborations occur
International Livestock Research Institute and African Highlands Initiative, East Africa			
	Reports documenting application of TOA in East Africa	On website	Project executed
Dissemination of TO A and Training of User Groups (Objectives 5 and 6)			
	Publications in scientific journals, participation in scientific meetings	Publications, presentations	Work accepted for publication

	Book-length manuscript on methods and applications of TOA	On website	Publisher shows interest
	TOA training materials	On website	Demand for training exists
	TOA training workshops	Workshops done	Demand for workshops exists
Global Plan Activities			
PIs and selected collaborators participate in annual SM-CRSP program workshop and planning meeting	Attendance	Attendance	
Contribute to SM-CRSP training activities	Develop and test training modules	Modules completed	Demand for training exists
Contribute to SM-CRSP networking and web site	Develop enhanced web site	Web site completed	Demand exists
	Develop and implement marketing plan for SM-CRSP products	Marketing plan completed and implemented	

Montana State University SM-CRSP Budget Summary

	Year 1			Year 2	Year 3	Year 4	Year 5
	A	B	C				
Total Salaries & Wages	$143,000			$162,735	$169,970	$178,566	$187,074
Fringe Benefits (30% exc. Grad.)	$40,200			$43,421	$45,291	$47,870	$50,122
Other Direct Costs							
Subcontracts	$288,863			$297,216	$297,864	$279,792	$256,714
Consultants	$46,150			$46,950	$37,750	$38,450	$45,850
Equipment	$0			$0	$0	$0	$0
Supplies	$2,000			$2,000	$2,000	$2,000	$2,000
Travel (domestic U.S.)	$6,000			$6,000	$6,100	$6,400	$6,500
Travel (international)	$24,300			$24,700	$23,200	$19,400	$15,800
Other	$0			$0	$0	$0	$0
Indirect Costs (rate: 41.5%)	$120,558			$99,125	$102,447	$105,508	$105,178
Sub-Total	$671,070			$682,146	$684,922	$677,985	$661,184
Cost-sharing	$51,625			$55,214	$56,965	$58,809	$58,361
Total Estimated Costs	$722,695			$737,360	$741,887	$736,794	$719,545

Montana State U. Global Plan Sub-Budget

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Annual workshop	$16,000	$16,800	$17,600	$18,400	$19,200	$88,000
Training						
Travel (1 trip to collaborate)	$1,500	$1,600	$1,700	$1,800	$1,900	$8,500
Testing (1 workshop/yr)	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000
Network & Web Devel.						
Web Admin Salary	$13,500	$14,040	$14,040	$14,602	$15,186	$71,367
Software Administration	$30,000	$31,200	$32,448	$33,746	$35,096	$162,490
Benefits	13050	13572	13946.4	14504.26	15084.426	$70,157
Total	$84,050	$87,212	$89,734	$93,052	$96,466	$450,514

Budget Explanation

Salaries and Wages
(note: all salaries and wages assumed to increase 5% per year for inflation and merit adjustments)

Post-doctoral researcher, Ph.D. in agricultural economics, 1.0 FTE,
annual salary = $50,000/year.
Graduate scholarship, 1.0 FTE, $18,000/yr
Computer programmer, 0.5 FTE, wage rate = $15/hr.
Data analysis, 0.5 FTE, wage rate = *$15/hr.*
Web and software development, 0.25 FTE, wage rate = *$25/hr.*

Fringe Benefits
25% rate applied to salaries and wages excluding graduate scholarship

Other Direct Costs

CIP Subcontract

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
MSU/CIP Economics Leader (50%)	$31,250	$32,813	$34,453	$36,176	$37,985	$172,676
LA & EA collaborators	$30,000	$31,500	$33,075	$34,729	$36,465	$165,769
Field Experiments	$10,000	$10,000	$8,000	$8,000	$8,000	$44,000
Field Supplies & Gas	$10,000	$10,000	$10,000	$8,000	$8,000	$46,000
Data collection	$10,000	$10,000	$5,000	$5,000	---	$30,000
PI travel	$26,900	$27,200	$27,500	$24,800	$25,100	$131,500
Domestic travel & per diem	$15,000	$15,000	$30,000	$30,000	$10,000	$100,000
Stakeholder workshops	$3,000	$3,000	$3,000	$2,000	$2,000	$13,000
Project Training & Publications	$5,000	$5,000	$5,000	$8,000	$8,000	$31,000
Global Plan Training	$11,500	---	$11,700	---	$11,900	$35,100
Software	$1,000	$1,000	$1,000	$1,000	$1,000	$5,000
Computer for WA	$2,000	---	---	---	---	$2,000
Vehicle maint. & ins.	$8,000	$7,000	$5,000	$5,000	$5,000	$30,000
Total direct costs	$163,650	$152,513	$173,728	$162,705	$153,450	$806,045
Overhead	$40,913	$38,128	$43,432	$40,676	$38,362	$201,511
Total cost	$204,563	$190,641	$217,160	$203,381	$191,812	$1,007,556

Notes: Economics Leader position funded 50% by SM-CRSP and 50% by CIP.
LA & EA collaborators: funds to support participation of 1 senior collaborator in each region through salary supplement and domestic travel and per diem.

CIP PI Travel Budget:

MSU/CIP Econ Leader					
LA travel (60 days, 6 trips)	6000	6000	6000	6000	6000
1 conf in US (1 week)	2500	2500	2500	2500	2500
1 meeting @ Mont. State (1 week)	2500	2500	2500	2500	2500
1 SMCRSP meeting (5 days)	$2,000	$2,100	$2,200	$2,300	$2,400
Ecuador (8 trips, 3days)	1200	1200	1200	1200	1200
Bowen					
Peru 2 trips	1500	1500	1500	1500	1500
1 SMCRSP meeting (5 days)	$2,000	$2,100	$2,200	$2,300	$2,400
Ecuador (8 trips, 3days)	1200	1200	1200	1200	1200
Crissman					
1 trip LA (10 days)	3000	3000	3000	3000	3000
1 SMCRSP meeting (5 days)	$2,000	$2,100	$2,200	$2,300	$2,400
Africa travel (3 trips, 5 days)	3000	3000	3000	---	---
Total	26900	27200	27500	24800	25100

CIAT Subcontract

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
CRSP/CIAT Econ Leader (50%)	$31,250	$32,813	$34,453	$36,176	$37,985	$172,676
Field data collection (1 FTE)	$10,000	$10,000	---	---	---	$20,000
Soil testing	$5,000	$5,000	---	---	---	$10,000
Data analysis, GIS etc	---	$5,000	$5,000	---	---	$10,000
Travel to annual CRSP meeting	$4,000	$4,200	$4,400	$4,600	$4,800	$22,000
Travel to annual project meeting	$4,000	$4,200	$4,400	$4,600	$4,800	$22,000
Domestic travel & per diem	$5,000	$5,000	$3,000	---	---	$13,000
Global Plan Training	---	$11,600	---	$11,800	---	$23,400
Stakeholder workshops	$3,000	$3,000	$3,000	$3,500	$3,500	$16,000
Publications	---	$2,000	$2,000	$2,000	$2,000	$8,000
Software	$1,000	$1,000	$1,000	$1,000	$1,000	$5,000
Computer for reference site office	$2,000	---	---	---	---	$2,000
Field experiments	$5,000	$5,000	$10,000	---	---	$20,000
Total direct costs	$70,250	$88,813	$67,253	$63,676	$54,085	$344,076
Overhead	$14,050	$17,763	$13,451	$12,735	$10,817	$68,815
Total cost	$84,300	$106,575	$80,704	$76,411	$64,901	$412,891

Notes: Travel to annual CRSP and project meetings is for CIA T Soil Scientist and Economics Leader.

Wageningen Consultant Contract:

	Year 1	Year 2	Year 3	Year 4	Year 5
Grad scholarships (Peru&Hond.)	$20,000	$20,000	$10,000	$10,000	$20,000
Software and modeling support	$15,000	$15,500	$16,000	$16,500	$16,500
Travel					
1 trip to US (7 days)	$2,350	$2,350	$2,350	$2,350	$2,350
1 trip to LA (10 days)	$2,300	$2,300	$2,300	$2,300	$2,300
1 trip to WA (2 weeks)	$2,500	$2,600	$2,700	$2,800	---
1 SMCRSP meeting (5 days)	$2,000	$2,100	$2,200	$2,300	$2,400
1 trip to CA (10 days)	$2,000	$2,100	$2,200	$2,200	$2,300
Total Travel	$11,150	$11,450	$11,750	$11,950	$9,350
Total	$46,150	$46,950	$37,750	$38,450	$45,850

Notes: Consultancy is to fund the participation of Jetse Stoorvogel and one graduate student from Honduras to pursue a Ph.D. degree program at Wageningen University, as described in the proposal.

Supplies:
Miscellaneous supplies for staff use.

Montana State University Travel:

Antle - international	Year 1	Year 2	Year 3	Year 4	Year 5
1 CA meeting (10 days)	$2,500	$2,500	$2,600	$2,600	$2,700
1 WA meeting (2 wks)	$3,900	$4,000	$4,100	$4,200	---
1 LA meeting (10 days)	$2,500	$2,500	$2,700	$2,700	$2,800
1 SMCRSP meeting (5 days)	$2,000	$2,100	$2,200	$2,300	$2,400
1 intl. conference (1 week)	$2,500	$2,500	$2,600	$2,600	$2,700
Total intl. travel	$13,400	$13,600	$14,200	$14,400	$10,600

Antle - domestic	Year 1	Year 2	Year 3	Year 4	Year 5
1 CRSP meeting (4 days)	$1,500	$1,500	$1,600	$1,600	$1,700
1 cont in US (4 days)	$1,500	$1,500	$1,600	$1,600	$1,700
1 meeting w/carbon project (4 days)	$1,500	$1,500	$1,600	$1,600	$1,700
Total dom. travel	$4,500	$4,500	$4,800	$4,800	$5,100

MSU Postdoc - international	Year 1	Year 2	Year 3	Year 4	Year 5
1 CA meeting (10 days)	$2,500	$2,500	---	---	---
1 WA meeting (2 wks)	$3,900	$4,000	$4,100	---	---
1 SMCRSP meeting (5 days)	$2,000	$2,100	$2,200	$2,300	$2,400
1 LA meeting (10 days)	$2,500	$2,500	$2,700	$2,700	$2,800
Total intl.	$10,900	$11,100	$9,000	$5,000	$5,200

MSU Postdoc - domestic	Year 1	Year 2	Year 3	Year 4	Year 5
1 cont in US (4 days)	$1,500	$1,500	$1,600	$1,600	$1,700

Indirect Costs:

Montana State's IDC rate is 41.5%, applied to MSU direct costs and to the first $25,000 of subconracts and consultancies.

Actual Cost Sharing	Year 1	Year 2	Year 3	Year 4	Year 5
Antle (22%)	$27,693	$29,077	$30,531	$32,058	$33,661
Capalbo (5%)	$4,375	$4,594	$4,823	$5,065	$5,318
Nielsen (5%)	$4,688	$4,922	$5,168	$5,426	$5,698
Staff Support (50%)	$16,250	$16,900	$17,576	$18,279	$19,010
Total	$53,005	$55,493	$58,099	$60,828	$63,686

Required Cost Sharing	Year 1	Year 2	Year 3	Year 4	Year 5
MSU Direct Costs	$206,500	$220,856	$227,861	$235,236	$233,442
25% of MSU Direct Costs	$51,625	$55,214	$56,965	$58,809	$58,361
Cost Sharing					

Note: Required cost sharing is 25% of MSU Direct Costs excluding international student costs.

BIODATA FOR PRINCIPAL INVESTIGATOR AND CO-PIS:

John M. Antle
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Phone: (406) 994-3706
FAX: (406) 994-4838
E-Mail Address:*jantle@Jmontana.edu*

Time commitment: 25%

Education
- Ph.D., Economics, University of Chicago, 1980
- M.A., Economics, University of Chicago, 1979
- A.B., *summa cum laude,* Economics and Mathematics, Albion College, 1976

Professional and Public Service
- President, American Agricultural Economics Assn., 1999-2000
- Lead Author, IPCC Third Assessment Report, 1998-2001
- Member, Board on Agriculture, National Research Council, 1992-1997
- Member, Committee on the Human Dimensions of Global Change, National Research Council, 1997-1999
- Senior Economist, President's Council of Economic Advisors, 1989-1990

Related Research Experience
- Principal Investigator, SM-CRSP, 1996-2001
- Principal Investigator for various research projects on climate change, carbon sequestration, integration of biophysical and economic models, funded by DOE, EP A, NSF and USDA. Details available at www.climate.montana.edu.

Five Relevant Publications
- Antle, J.M. and S.M. Capalbo. (In Press 2001)."Econometric-Process Models for Integrated Assessment of Agricultural Production Systems." *American Journal of Agricultural Economics,* in press, May 2001.

- Antle, J. and J.J. Stoorvogel (2001). "Integrating Site-Specific Biophysical and Economic Models to Assess Trade-offs in Sustainable Land Use and Soil Quality." N. Heerink, H. van Keulen and M. Kuiper (eds.) *Economic Policy Reforms and Sustainable Land Use in LDCs - Recent Advances in Quantitative Analysis.* Physica-Verlag, Heidelberg. pp 169-184.

- Crissman, C.C., J.M. Antle, and S.M. Capalbo, eds. (1998) *Economic, Environment, and Health Tradeoffs in Agriculture: Pesticides and the Sustainability of Andean Potato Production.* Boston: Kluwer Academic Publishers, 12 chapters, 281 pp.

- Crissman, C.C., J.M. Antle, and J.J. Stoorvogel (2001). Tradeoffs in agriculture, the environment and human health: decision support for policy and technology managers. In: D.L. Lee and C.B. Barrett (eds.) *Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment.* CAB International, Wallingford, U.K. pp 135-150.

- Stoorvogel, J., J.M. Antle, C.C. Crissman, and W. Bowen. (In Press 2001). *The Tradeoff Model: A Policy Decision Support System for Agriculture.* Quantitative Approaches to Systems Analysis, Wageningen Agricultural University, The Netherlands.

Dr. Walter T. Bowen

Senior Scientist, joint appointment with the International Potato Center (CIP) and the International Fertilizer Development Center (IFDC)
CIP -Quito/IFDC
P.O. Box 17-21-1977
Quito, Ecuador

Time commitment: 40%

Relevant training:

- Ph.D. 1987 Cornell University (Agronomy/Soil Science)
- M.S. 1983 Cornell University (Agronomy/Soil Science)
- B.S. 1976 Clemson University (Agronomy)

Relevant experience:
A Systems Scientist with IFDC since 1992, Walter Bowen's research emphasizes the development, testing, and application of soil and crop growth simulation models. He has worked on collaborative research and model application projects, including training, in Albania, Bangladesh, Bolivia, Brazil, Colombia, Ecuador, India, Malaysia, Peru, Philippines, Romania, and Venezuela. In 1996 he moved to Peru where he has developed a successful collaboration with the International Potato Center (CIP) and IFDC focusing on integrated natural resource management research. He moved to Ecuador in 2000 where he continues to work with IFDC, CIP, and other collaborators on establishing a center of excellence for soil management research in the high Andes. Research and modeling activities are done together with regional and international collaborators through the Tradeoffs Project, the Management of Soils in the Andes (MOSAndes) consortium, and the International Consortium for Agricultural Systems Applications (ICASA). His work has contributed significantly to Phase 1 of the Tradeoffs Project.

Titles of 5 relevant publications:

- Quiroz, R., C. Leon-Velarde, and W. Bowen. 2000. Farming systems research from a modelling perspective: experiences in Latin America. p. 342-354. In M. Collinson (ed.) A history of farming systems research. CABI and F AO, Rome.

- Bowen, W., H. Cabrera, V. Barrera, and G. Baigorria. 1999. Simulating the response of potato to applied nitrogen. p. 381-386. CIP Program Report 1997-1998. International Potato Center, Lima, Peru.

- Bowen, W., G. Baigorria, V. Barrera, J. Cordova, P. Muck, and R. Pastor. 1999. A processbased model (WEPP) for simulating soil erosion in the Andes. p. 403-408. CIP Program Report 1997-1998. International Potato Center, Lima, Peru.

- Bowen, W.T. and W.E. Baethgen. 1998. Simulation as a tool for improving nitrogen management. p. 193-208. In G.Y. Tsuji, G. Hoogenboom, and P.K.Thornton (ed.) Understanding options for agricultural production. Kluwer Academic Publishers, Dordrecht, The Netherlands.

- Bowen, W.T., P.K. Thornton, and G. Hoogenboom. 1998. The simulation of cropping sequences using DSSAT. p. 317-331. In G.Y. Tsuji, G. Hoogenboom, and P.K.Thornton (ed.) Understanding options for agricultural production. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Charles Clinton Crissman
Economist
International Potato Center (CIP) Mail address: Box 17-21-1977
EE INIAP Santa Catalina
Km 17 Panamericana Sur
Quito, Ecuador
Work tel: 593-2-690-362/3
Work fax: 593-2-692-604
E-mail: c.crissman@cgiar.org

Time Commitment: 15%

Education:

- Ph.D. 1986 Agricultural Economics. University of California-Davis, Davis, CA, *USA*
- M.S. 1981 Agricultural Economics. University of Missouri-Columbia, Columbia, MO, USA
- BBA 1972 Business Administration. Wake Forest University, Winston Salem, NC, *USA*

Work Experience:

- 1997-present Scientist II *1* Country Representative, Quito Experiment Station, CIP, Ecuador
- 1994-1997 Scientist I *1* Country Representative, Quito Experiment Station, CIP, Ecuador
- 1993-1994 Visiting Professor, Montana State University, Bozeman, MT, *USA*
- 1989-1994 Scientist I, Quito Experiment Station, CIP, Ecuador
- 1987-1989 Scientist, CIP, Lima, Peru
- Post Doctoral Fellow, CIP, Lima, Peru

Recent Research Grants:

- Relaciones entre la pobreza rural y el deterioro ambiental en America Latina. IDB/FONT AGRO 1999-2000. $300,000.

- Health and Changes in Potato Production Technology in the Highland Ecuadorian Agro-Ecosystem. IDRCI Ecosystem Approaches to Human Health, 1998-2001. CAD$150,000.

- Regional Scaling offield-level economic-biophysical models. DGISI Ecoregional Fund to Support Methodological Advances, 1996-1998. $499,950.

- Tradeoffs in Sustainable Agriculture and the Environment in the Andes: A Decision Support System for Policy Makers. USAID/Soil Management Collaborative Research Support Program, 1996-2000. $988,118.

Recent Relevant Publications

- Crissman, e.e., D.e. Cole, and F. Carpio. "Pesticide *Use* and Farm Worker Health in Ecuadorian Potato Production" *American Journal of Agricultural Economics.* 76:(August 1994): 593-597.

- Antle, 1. M., e.e. Crissman, R.J. Wagenet and *J.L.* Hutson. "Empirical foundations for Environment Trade Linkages: Implications of an Andean Study". In M.E. Bredahl, N. Ballenger, *J.* Dunmore, and T.L. Roe (eds.) *Agriculture, Trade, and the Environment: Discovering and Measuring the Critical Linkages.* (Boulder, Col.: Westview Press) 1996. pp. 173-197.

- Crissman, e.e. and 1. M. Antle. "Physical and Economic Model Integration for the Measurement of Environmental Impacts of Farming." Chapter 22 in R. Lal (ed.) *Soil Quality and Agricultural Sustainability.* Chelsa, Michigan: Ann Arbor Press. 1998. Pp. 319-334.

- Antle, *J.M.,* D. e. Cole and C.e. Crissman (1998), "Further Evidence on Pesticides, Productivity, and Farmer Health: Potato Production in Ecuador." *Agricultural Economics:* An *International Journal2*(18): 199-208.

- C.c. Crissman, J.M. Antle, and S.M. Capalbo.(eds.) *Economic, Environmental and Health Tradeoffs in Agriculture: Pesticides and the Sustainability of Andean Potato Production.* (Boston: Kluwer Academic Press) 1998. 281p

Dr Jetse Jacob Stoorvogel
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Tel: +31.317.484043
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Time Commitment: 25%

Education
1983-1989: Wageningen Agricultural University (MSc.)
Major subjects:
- tropical, regional soil science
- tropical agronomy
- fieldwork: Costa Rica (1986)

1995: Wageningen Agricultural University (PhD.)
'Geographical Information systems as a tool to explore land characteristics and land use with reference to Costa Rica'

Journal editorship, other matters
- Nutrient Cycling in Agro-Ecosystems (Editorial Board)
- Member of the Educational Committee of the C.T. de Wit Graduate School for Production Ecology and Resource Conservation

Employment record
- 06/1996- present: Fellowship of the Royal Netherlands Academy of Sciences, Wageningen Agricultural University, The Netherlands *'The analysis of indicators governing sustainability for different land use systems under different agro-ecological conditions and at different scales and time horizons'*

- 11/1991-05/1996: Researcher at the multi-disciplinary research project of the Wageningen Agricultural University in co-operation with CA TIE and MAG. Emphasis on the development of a multi-disciplinary methodology for the analysis of agricultural land use scenarios and a regional geographical information system.

- 04/1990-11/1991: Researcher for the Wageningen Agricultural University in Ivory Coast with financial support of the Tropenbos foundation. Research on the gross inputs and outputs of an undisturbed rainforest in the south-west of Ivory Coast.

- 07/1989-04/1990: Researcher at the Winand Staring Centre for Integrated Land, Soil and Water Research, Wageningen, The Netherlands. A F AO financed project on the assessment of soil nutrient depletion in Sub-Sahara Africa.

Research projects

- Ecuador/Peru: Tradeoff analysis: support for policy making
- Costa Rica: Precision agriculture for banana plantations
- Burkina Faso/Kenya: Spatial and temporal variation of soil nutrient stocks and management in sub-Saharan African farming systems
- Egypt/Vietnam: Optimization of Nutrient Dynamics and Animals for Integrated Farming

Key publications

- Crissman, C.C., J.M. Antle, and J.J. Stoorvogel, 2001. Tradeoffs in agriculture, the environment and human health: decision support for policy and technology managers. In: D.L. Lee and C.B. Barrett (eds.) Tradeoffs or Synergies? Agricultural intensification, economic development and the environment. CAB International, Wallingford, U.K. pp 135-150.

- Antle, J. and J.J. Stoorvogel, 2000. Integrating Site-Specific Biophysical and Economic Models to Assess Trade-offs in Sustainable Land Use and Soil Quality. In: N. Heerink, H. van Keulen and M. Kuiper (eds.) Economic policy reforms and sustainable land use in LDCs - recent advances in quantitative analysis. Physica- Verlag, Heidelberg. pp 169-184.

- Antle, J.M., J.J. Stoorvogel, C.c. Crissman, W.T. Bowen, 2000. Tradeoffs: a new methodological approach for the integrated assessment of agriculture and the environment. Paper presented at the. 2000 Annual Meetings ASA-CSSA-SSSA. November 5-9 Minneapolis, USA.

- Stoorvogel, J.J., 1995. Integration of computer-based models and tools to evaluate alternative land-use scenarios as part of an agricultural systems analysis. *Agricultural Systems* 49: 353-367

- Stoorvogel, J.J., 1995. Linking GIS and models: structure and operationalization for a Costa Rican case study. *Netherlands Journal of Agricultural Science* 43: 19-29.

- Stoorvogel, J.J., R.A. Schipper, and D.M. Jansen, 1995. USTED: a methodology for a quantitative analysis of land use scenarios. *Netherlands Journal of Agricultural Science* 43: 5-18.

BIODATA FOR COLLABORATORS:

Miguel Angel Ayarza
Regional Coordinator, CIA T Hillsides Project, Honduras

Time commitment: 30%

Relevant training and experience:
- Development of Improved land use systems
- Development of biophysical impacts of land use on soil restructure, SOM, and biological activity.
- Nutrient cycling under pastures.

Education:
- 1988 Ph.D. Soil Science - North Carolina State University.
- 1980 MSc. Master of Agricultural Science - Universidad de Reading, England.
- 1975 B.Sc Agronomy Univ. Nacional de Colombia, 1975

Short training courses:
- 1997 Environmental Assessment and Management in Agricultural Development, Wye College, England.
- 1993 Use of simulation models for crop growth and nutrient use. International Fertilizer Development Center, IFDC, USA.

Publications 2000
- Lilienfein, J., Wilcke, W., Ayarza, M.A., Vilela, L., do Cormo Lima, S., Zech, W. 2000. Chemical fractionation of phosphorus, sulphur, and molybdenum in Brazilian savanna Oxisols under different land use. Geoderma, 96: 31-46.

- Lilienfein, J., Wilcke, W., Ayarza, M.A., Vilela, L., do Cormo Lima, S., Thomas, R., Zech, W. 2000. Effect of No-Tillage and Conventional Tillage Systems on the Chemical Composition of Soil Solid Phase and Soil Solution of Brazilian Savanna Oxisols. J. Plant Nutr. Soil Sci., 163: 411-419.

- Lilienfein, J., Wilcke, W., Ayarza, M.A., Vilela, L., do Carmo Lima, S., Zech, W. 2000. Soil Acidification in *Pinus caribaea* forests on Brazilian Savanna Oxisols. Forest Ecology and Management, 128: 145-157.

- Lilienfein, 1., Wilcke, W., Thomas, R., Vilela, L., do Carmo Lima, S., Zech, W. 2000. Nutrient concentrations in soil solution of some Brazilian Oxisols under conventional and no-tillage systems in the early part of the rainy season. Aust. J. Soil Res., 38: 851866.

- Zech, W., H, M, Morras., M. A. Ayarza, M, C, da Silva., S, C. Lima., C. da Silva., C. Valarezo and L. Vilela. Geoecological Studies in Selected Latin-American Ecosystems. In Zeitschrift fur Angewante Geology. 31 st International Geological Congress. Rio de Janeiro, 2000.

- Thesis 2000

- Zaconeta, F. 2000. Identificacion de Plantas locales como Indicadores de Calidad de Suelos en Parcelas Aghricolas en la Microcuenca de Luquigue, Yoro, Honduras. Tesis de grado. Escuela Agricola Panamericana el Zamorano. Honduras.

- Ruiz, D. 2000. Cuantificacion de Indicadores locales de calidad de suelo en la microcuenca de Luquigue, Yoro, Honduras. Tesis de grado. Escuela Agricola Panamericana el Zamorano, Honduras.

Ing. Victor Hugo Barrera Mosquera
Head, Department for Technology Validation and Transfer
Instituto Nacional Autonomo de Investigaciones Agropecuarias (INIAP) Santa Catalina Experiment Station
P.O. Box 17-012600
Quito, Ecuador

Time commitment: 20%

Relevant training:

- M.S. 1996. Pontificia Universidad Catolica de Chile (Agricultural Systems Analysis) Ing. Agr. Universidad Central del Ecuador (Agronomy)

Relevant experience:

- Current: Head of INIAP's Department for Technology Validation and Transfer since 1996. **PI** for two national projects with funding from the World Bank, and Co-PIon five international projects with the International Potato Center (CIP).

- 1989-1994 Head of INIAP's Department of Biometrics

Titles of 5 relevant publications:

- BARRERA, V. Y CRISSMAN, C. 1999. Estudios de caso del impacto economico de la tecnologia generada por el INIAP en el rubro papa. INIAP-CIP. Artes Gnificas Silva. QuitoEcuador. 72 pp.

- BARRERA, v.; UNDA, J.; ORTIZ, O. y NORTON, G. 1999. Manejo de las principales plagas y enfermedades en el cultivo de papa por los agricultores en la sierra ecuatoriana. INIAP-CIP-IPM-CRSP. Publicaciones INIAP. Quito, Ecuador. 120 p.

- BARRERA, V. 1996. Factores que afectan la sostenibilidad del sistema de produccion de pequefios productores de Carchi-Ecuador. Tesis de Maestro en Ciencias en Sistemas de Produccion Agropecuarios. Santiago de Chile. Pontificia Universidad Catolica. 190 p.

- BARRERA, V. 1995. Maximizacion de beneficios en el sistema de produccion de pequefios productores de Carchi-Ecuador. En Ciencia e Investigacion Agraria, Volumen 35. Santiago de Chile. Pontificia Universidad Catolica.

- BARRERA, V. y REINOSO, A. 1993. Manual de utilizacion del SPSS/PC+ para analizar informacion obtenida en la investigacion de sistemas agropecuarios. INIAP-FUNDAGRO. Quito, Ecuador. 80 p.

Susan M. Capalbo
Associate Professor
Agricultural Economics & Economics Department Montana State University
Bozeman, MT 59717-0292
PHONE: (406) 994-5619
FAX: (406) 994-4838
E-Mail Address: uaesc@montana.edu

Time Commitment: 5%

Relevant Training:

- 1982, Ph.D., Agricultural Economics, University of California-Davis,
- 1976, M.S., Resource Economics, University of Rhode Island
- 1974, B.A., Economics, University of Rhode Island

Relevant Experience:
Principal investigator and collaborator on various projects developing economic methods and models related to integrated assessment of agricultural production systems, including the project in Ecuador that developed the Tradeoff Analysis methodology.

Titles of five relevant publications:

- Antle, J.M., and S.M. Capalbo. (In Press 2001). "Econometric-Process Models for Integrated Assessment of Agricultural Production Systems." *American Journal of Agricultural Economics.*

- Antle, J.M., S.M. Capalbo, E. Elliott, W. Hunt, S. Mooney, and K. Paustian. (in press 2001) "Research Needs for Understanding and Predicting the Behavior of Managed Ecosystems: Lessons from Agroecosystem Research." *Ecosystems.*

- Crissman, C.C., 1.M. Antle, and S.M. Capalbo, eds. (1998). *Economic, Environment, and Health Tradeoffs in Agriculture: Pesticides and the Sustainability of Andean Potato Production.* Boston: Kluwer Academic Publishers, 12 chapters, 281 pp.

- Antle, 1.M., S.M. Capalbo, and C.C. Crissman. (1994). "Endogenous Timing of Decisions in Econometric Production Models." *Journal of Agricultural and Resource Economics* 19(1uly): 1-18.

- Antle, J.M. and S.M. Capalbo. (1994). "Pesticides, Productivity, and Farmer Health: Implications for Regulatory Policy and Agricultural Research." *American Journal of Agricultural Economics* 76(August):598-602.

Gerald A. Nielsen
Professor *of* Soil Science, Montana State University

Education:

- 1963, Ph.D., Soil Science, University *of* Wisconsin
- 1960, M.S., Soil Science, University *of* Wisconsin
- 1958, B.S., Agriculture & Education, University *of* Wisconsin

Relevant Experience:

- 1973-present: Professor, Montana State University
- 1995-present: *Co-PI,* Upper Midwest Aerospace Consortium
- 1997-present: *Co-PI,* Consortium for Site-specific Resource Management
- 1999: Chair National Research *Comm.* (NCR-180), Prec. Ag.
- 1992: Visiting Fellow Wageningen Agric. Univ., The Netherlands
- 1991-1992 : Visiting Fellow Australian National Univ.
- 1991: Visiting Professor Colorado State Univ.

Publications within past five years:

- Long, D.S., G.A. Nielsen, RE. Engel, M.P. Henry, B.J. Kozar, B. M. Maxwell, *A.J.* Bussan, and G.R Carlson. Precision nitrogen management in wheat: Lessons learned in multidisciplinary research. Precision Agriculture (accepted).

- M.P. Henry, G.A. Nielsen, R.L. Lawrence, R.E. Engel, and D.S. Long. Wheat yield estimates using multi-temporal NDVI satellite imagery. Int. 1. Remote Sens. (accepted).

- Thoma, D.P., D.W. Bailey, D.S. Long, G.A. Nielsen, C. Montagne, M.P. Henry, and M.C. Breneman. Potential for monitoring rangeland biomass and nitrogen content in Montana with A VHRR-NDVI. J. Range Manage. (submitted).

- Keck, T.J. M.J. Hansen, G.A. Nielsen. 1999. Pedological basis for revised soil mapping procedures. *In* 1999 Agronomy abstracts. Am. Soc. Agron., Madison, WI.

- Padbury, G.A., S.M. McGinn, G.M. Coen, S.M. Waltman, H.R Sinclair, G.A. Nielsen, J.M. Caprio, D.A. Mortensen. Agroecosystems and land resources *of* the Northern Great Plains. *In* 1999 Agronomy abstracts. Am. Soc. Agron., Madison, WI.

- Wilson, J.P., D.J. Spangrud, G.A. Nielsen, J.S. Jacobsen, and D.A. Tyler. 1998. Effects of sampling intensity and pattern on GPS-derived contour maps and estimated soil terrain attributes. Soil Sci. Soc. Am. (In press).

Roberto A. Quiroz
Land use systems specialist, International Potato Center

Time Commitment: 20%

Education:

- 1986, Ph.D. Nutrition and Crop Science (minor), North Carolina State University - Raleigh
- 1984, MS Nutrition and Crop Science (minor), North Carolina State University - Raleigh
- 1979, BS Chemistry, Universidad de Panama - Panama

Research Area and Experience:
Developing alternative land use strategies for sustainable agriculture in mountainous regions. Emphasis on combining process-based models and remote sensing for multi scaling analysis. Vast experience in farming systems research and systems analysis in the Andean region and Central America, as well as in developing and testing innovative technology transfer approaches for resource-limited farmers.

Relevant Publications:

- Quiroz, R. A., Estrada, R.D., Leon-Velarde, C. and Zandstra, H. 1995. Facing the challenge of the Andean zone: The role of modeling in developing sustainable management of natural resources. In: Eco-Regional Approaches to Develop Sustainable Land use and Food Production. Kluwer Academic Publishers, The Netherlands, pp. 13-31.

- Leon-Velarde, C. and Quiroz, R. 1999. Selecting Optimum Ranges of Technological Alternatives by Using Response Surface Designs in Systems Analysis. In: Impacting on a Changing World: CIP Program Report 1997-98 pp. 387-394.

- Quiroz, R. and Saatchi, S. 1999. Mapping Aquatic and Semiarid Vegetation in the Altiplano Using Multichannel Radar Imagery. In: Impacting on a Changing World: CIP Program Report 1997-98, pp. 395-402.

- Quiroz, R., Leon-Velarde, c., and Bowen, W. 2000. Farming Systems Research from a Modeling Perspective: Experiences in Latin America. In: M. Collinson (ed.). The History of Farming Systems. F AO and CAB!. Oxon, UK pp. 342-354

- Quiroz, R., Zorogastua, P.; Jongschaap, R., Ibarra, C., Leon-Velarde, C., and Cruz, M. 2001. Integrating Remote Sensing with Process-Based models to Assess Management Options for Grazing Lands in the Andes. GeoInfosystems (In Press)

Philip K Thornton

Scientist and Programme Coordinator, Systems Analysis and Impact Assessment, International Livestock Research Institute (ILRI), Old Naivasha Road
PO Box 30709, Nairobi, Kenya.
Tel +254 2630743, Fax +254 263 1499,
Email: p.thornton@cgnet.com,
Home tel +254 2 58 34 69 or +254 733 634 819

Time commitment: 10%

Education:

- 1979, BSc (Hons), Reading University (Agricultural Systems)
- 1983, PhD, Lincoln College, University of Canterbury, New Zealand (Farm Management and Agricultural Economics)

Areas of Special Competence and Current Research Interests
Systems analysis, *ex post* and *ex ante* impact assessment, decision making, risk analysis, socioeconomic modelling and biological simulation modelling, farming systems research, resource management, geographic information systems, land-use and spatial modelling.

Professional Experience:

- March 2000 - present: Programme Coordinator, Systems Analysis and Impact Assessment, International Livestock Research Institute, Nairobi, Kenya.

- July 1996 -February 2000: Scientist and Project Coordinator, Systems Analysis and Impact Assessment, International Livestock Research Institute, Nairobi, Kenya (project coordinator from July 1997).

- September 1990 - June 1996: Senior Scientist--Economist/Systems Modeller, International Fertilizer Development Center, Muscle Shoals, Alabama.

- June 1987 - August 1990: Research Fellowship, Division of Rural Resource Management, Edinburgh School of Agriculture, University of Edinburgh.

- June 1984 - April 1987: Post-doctoral Fellow in the Cattle Production Systems section of the Tropical Pastures Program, Centro Internacional de Agricultura Tropical (CIAT), Colombia.

Synergistic Activities

- July 1997 – present: Member of the Board of Directors, Soil Management Collaborative Research Support Program (SM-CRSP), US-AID
- March 1997 – present: Member of the Board of Directors, International Consortium for Agricultural Systems Applications (ICASA)
- January 1988 – present: Book review editor, Agricultural Systems (Elsevier).
- December 1999 – present: Editorial Board, Agricultural Systems (Elsevier).

Some Recent Publications

- Thornton P K, Galvin K A and Boone R B (2001). An agro-pastoral household model for the rangelands of East Africa *Agricultural Systems* (submitted).
- Thornton P K and Herrero M (2001). Integrated crop-livestock simulation models for scenario analysis and impact assessment. *Agricultural Systems* (in press). .
- Jones P G and Thornton P K (2001). Spatial modeling of risk in agriculture and natural resource management. *Conservation Ecology* (in press).
- McDermott J J, Kristjanson PM, Kruska R L, Reid R S, Robinson T P, Coleman P G, Jones P G and Thornton P K (2001). Effects of climate, human population and socio-economic changes on tsetse-transmitted trypanosomosis to 2050. In R Seed and S Black (eds), World Class Parasites - Vol. 1. The African Trypanosomes. In press.
- Thornton P K (2000). Simulation models for planning agricultural research. In: G Gijsbers, W Janssen, H Hambly Odame and G Meijerink (editors), *Planning agricultural research: a sourcebook.* CAB International and ISNAR, The Hague, The Netherlands.
- Jones P G and Thornton P K (2000). MarkSim: software to generate daily weather data for Latin America and Africa. *Agronomy Journal* 92, 445-453.

No. DG/2001/0035
15 January 2001

Dr John M. Antle
Department of Agricultural Economics & Economics
312 Linfield Hall, Montana State University
Bozeman, MT 59717
USA

Tel: 406-994-3706
FAX: 406-994-4838

Dear Dr Antle:

As Director General of INIAP, this letter is to certify institutional support for the project that you are submitting to the SM-CRSP, The Tradeoff Analysis Project Phase 2: Scaling Up and Technology Transfer to Address Soil Management CRSP Constraints and Objectives. We fully support the participation of Ing. MSc. Victor Barrera and his team in this project.

We have been full partners during Phase 1 of the Tradeoffs Project, contributing significantly to the development of a policy decision support system based on the tradeoff analysis approach. In Phase 2, we look forward to continuing our collaboration as we attempt to refine the tradeoff analysis tools and methods to improve their usefulness and applicability.

Sincerely yours,

Gustavo Enriquez
DIRECTOR GENERAL

INSTITUTO NACIONAL AUTONOMO DE INVESTIGACIONES AGROPECUARIAS

INTERNATIONAL POTATO CENTER (CIP)

Apartado 1558 - Lima 12, Peru
Phones: (51-1) 317-5301; Fax: (51-1) 317-5303
E-mail: cip-dg@cgiar.org - http:\\www.cipotato.org

Office of the Director General

L-004-DR-2001

January 22, 2001

Dr John M. Antle
Department of Agricultural Economics & Economics
312 Linfield Hall, Montana State University
Bozeman, MT 59717
<u>USA</u>

FAX: 406-994-4838

Dear Dr Antle: John

This letter is to confirm support from CIP for the project <u>The Tradeoff Analysis Project Phase 2: Scaling Up and Technology Transfer to Address Soil Management CRSP Constraints and Objectives</u>. We have been key partners in Phase 1 of the Tradeoffs Project, and we look forward to continuing our successful collaboration in Phase 2 as we work together to scale up the Tradeoff Analysis method and to develop a process for transfer of this method to users worldwide.

CIP will continue to support the active participation of Dr. Charles Crissman, Dr. Walter Bowen, Dr. Roberto Quiroz, and Dr. David Yanggen in this project.

Sincerely yours, Hubert

Hubert Zandstra
Director General

ILRI

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

International Livestock Research Institute

Consultative Group on International Agricultural Research

Nairobi, Kenya

Dr John M. Antle
Department of Agricultural Economics & Economics
312 Linfield Hall, Montana State University
Bozeman, MT 59717
USA

phone 406-994-3706
fax 406-994-4838

12 January 2001

Dear Dr Antle,

The Tradeoff Analysis Project Phase 2: Scaling Up and Technology Transfer to Address Soil Management CRSP Constraints and Objectives

This is to express ILRI's interest and support for this proposed research activity. Phase 1 of this project developed a framework for tradeoff analysis and for helping to supply decision makers with the information needed to make more informed decisions concerning the management of natural resources. Phase 2 is designed to scale up the methodology and develop a process for transferring this methodology. The focus of the project for Phase 1 was the Andean region, but there are clear opportunities for the adaptation and application of this methodology in regions of Africa and Asia.

One of ILRI's role in this project would be the further refinement and application of household models that take adequate account of the crop-livestock interactions in agricultural systems, as well as farmers' objectives and attitudes. Work in this area is already being undertaken by ILRI scientists based in Peru and Colombia as well as in Africa. ILRI will make direct and indirect contributions to the work, including an input of 0.10 FTE on crop-livestock modelling from scientists in the Systems Analysis and Impact Assessment Programme.

ILRI is well-placed to make a major contribution to the increasingly important area of natural resources management, and we welcome the opportunity to build on previous research with you and your collaborators, to assist in the cause of poverty alleviation.

Yours sincerely,

Brian S

for Dr Hank Fitzhugh
Director General

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WAGENINGEN UNIVERSITY
ENVIRONMENTAL SCIENCES

Fax message / Urgent

TO	FOR ATTENTION OF	FAX NUMBER
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FROM	**DIRECT TELEPHONE LINE**	**FAX NUMBER DIRECT**
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DATE	**SUBJECT**	
24 January 2001	SM-CRSP	

Dear prof Antle,

With great pleasure Wageningen University has co-operated with Montana State University and the International Potato Center in the first phase of the Soil Management Collaborative Research Support Program. It is therefore that we strongly support the initiative to continue this collaboration to further develop the Tradeoff Analysis methodology. Also in a second phase of the project I will reserve at least 25 % of my time to the project. Hopefully this will allow us to strengthen the co-operation, effectively improve the methods, and allow new research groups to use the methodologies under development.

With kind regards,

Stoorvogel

Dr Jetse J. Stoorvogel

Wageningen University
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Wageningen University and DLO have combined forces in Wageningen UR (Wageningen University and Research Centre).

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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Apartado Aéreo 6713, Cali, Colombia

John M. Antle
Professor, Dept. of Agricultural Economics
& Economics,
312 Linfield Hall
Montana State University
Bozeman, MT 59717
USA

Fax: 1-406-994-4838

January 26, 2001

To whom it may concern

The Centro Internacional de Agricultura Tropical (CIAT) hereby agrees to participate in the project entitled "The Tradeoff Analysis Project Phase 2: Scaling up and technology transfer to address poverty, food security and sustainability of the Agro-environment".

Staff from CIAT participated in the planning of this project during a meeting held both at CIAT headquarters Jan 9-10 and in Honduras with outposted staff on Jan 11, 2001. CIAT has agreed to provide input in terms of a soil scientist, a post-doctoral economist and a GIS specialist and other inputs as specified in the project proposal.

We look forward to a fruitful collaboration with other institutions named in the proposal.

Yours sincerely

Joachim Voss
Director General CIAT.

Rice-Wheat

Enhancing Technology Adoption
For the Rice-Wheat Cropping System
Of the Indo-Gangetic Plains

Cornell University

PROPOSAL

Enhancing Technology Adoption for the Rice-Wheat Cropping System of the Indo-Gangetic Plains

Submitted to the Soil Management CRSP
University of Hawaii

by

Cornell University

in collaboration with

The Rice-Wheat Consortium for the Indo-Gangetic Plains
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A. Problem Statement

1. *Justification*

The US-AID recognizes that economic growth and development in developing countries requires a shift from subsistence agriculture to market based agriculture. At the same time, agricultural productivity must advance so that overall production keeps pace with population growth while using natural resources in a sustainable manner. In developing countries, assuring food security commonly focuses on the production of staple crops, especially cereals. This narrow view of food security is inadequate as the desired outcome from the food system is a well nourished population. Therefore, agriculture should be thought of, and managed as, a nutrient delivery system to provide the appropriate amounts and balance of nutrients required by a country's population. Meeting this goal requires a paradigm shift in agricultural policy and a diversity in agricultural production that is not usually achieved. When the nutrient supply is deficient, malnutrition and poor health have negative impacts on economic growth through impaired mental and physical development of the population, increased health care costs and reduced worker productivity.

The rice-wheat cropping system is one of the world's major food production systems; it occupies 20 million ha and provides staples for over one billion people. Half of the land area in this system is found in the Indo-Gangetic plains (IGP) region of Pakistan, India, Nepal and Bangladesh and half is in China. With deep alluvial soils and widespread access to irrigation, agriculture in the IGP is not the risky venture that it is in many developing countries. Nevertheless, the rice-wheat, system is clearly under stress. Declining yields in long-term experiments (Duxbury et al., 2000), stagnating and possibly declining productivity of rice in NW India (Duxbury, 2000), and declining factor productivity (Hobbs and Morris, 1996) indicate that the sustainability of the rice-wheat system is questionable. Neither farmers nor researchers are really sure of the reasons for these alarming trends. Diagnostic research from our current project suggests that pressure from soil borne pathogens - or poor soil biological health - is a major underlying constraint that has received little attention. This fundamental constraint undoubtedly limits the effectiveness of many yield enhancing technologies such as improved nutrient management and improved crop establishment. Consequently, yields of rice, wheat and many other crops will always be sub-optimal until this major constraint is addressed. We have developed several technologies to assist with this issue (see technologies section) but it remains an area that needs research to characterize biological populations, to better define soil biological health and to learn how to manage soil biology for the benefit of crop production.

The sustainability of agriculture in the IGP is also affected by pressure on water resources as farmers increasingly access groundwater. Water tables are dropping by as much as 0.5 m/yr in NW India and irrigation waters in about half of the area of West Bengal (India) and Bangladesh are contaminated with geologically derived arsenic (McArthur et al., 2001), which can reduce both the yield and quality of rice (Woolson et al., 1971). Higher temperatures in the eastern part of the IGP allow rice to be grown in the dry winter season. Yields of this "boro" rice are higher than those obtained in the monsoon season but profitability is lower because of the high cost of irrigation (Baksh, 2000 Cornell SM-CRSP report). Soil and water management technologies that conserve water are therefore important across the IGP region. Contrary to traditional expectations, recent reports suggest that the productivity of rice is not reduced, and may even be increased, when it is grown with less water. Farmers in Haryana, India, were able to achieve the same yields as conventional practice when rice was grown on raised beds using half the water and at a savings of INR 4000/ha (~$90/ha) (R. Gupta, personal communication). One farmer in Punjab, India obtained a yield of 9 t/ha from beds, suggesting that the potential for "aerobic" rice culture is high. Similarly, substantial increases in yields of rice have been achieved in Madagascar using the so-called system of rice intensification (SRI), which uses single seedling transplants and avoids flooding of soil (Uphoff, 1999). And reports from China indicate higher yields when water is withdrawn from the paddy (R. Barker (IWMI) personal communication).

In practice, the rice-wheat system is more complex than the simple rotation of these two crops. It can include a third crop, such as summer mung bean after wheat. Alternatively, wheat is periodically replaced by grain legume, vegetable, oil seed, or fiber crops and replacement of both rice and wheat with a longer duration crop such as sugar cane also occurs. The cropping system has multiple constraints, so that a solution to one problem may create a tradeoff within the system. Therefore care must be exercised to ensure that technologies are successful within the context of the system.

The emphasis on cereal production has much reduced the diversity of agriculture in IGP countries, which has led to major health problems associated with micronutrient (vitamin and mineral) malnutrition (FAO, 2000) and with imbalances in essential amino acids. Consequently technologies that foster diversification of the rice-wheat cropping system, especially with respect to pulse (grain legume) and vegetable crops, will have substantial health and economic growth implications. Most likely, cropping systems diversification can also help to address some of the current constraints to rice and wheat productivity, creating a win-win situation.

Enhancing the adoption of technologies that address constraints to sustainability, productivity and diversification of the rice-wheat cropping system will address the EGAD Center strategic objective SO2 of improving food availability, economic growth, and conservation of natural resources through agricultural development, as well as AID's general goal of encouraging broad based economic growth and agricultural development. South Asia is a high priority area as it has the highest fraction (39%) of the world's extreme poor, yet at the same time Asia is the fastest growing market for US exports (US AID Asia/Near East web page). By developing and implementing methodologies to enhance technology adoption in a major cropping system the project will have an immediate and high impact.

2. ***Constraints Addressed***

The project that we propose will primarily addresses two constraints contained in the RFP, with emphasis in the order of presentation:

(i) "ineffective transfer of soil management technologies from research centers to decision makers at the farm and policy levels",

(ii) "availability and accessibility of information to support household decision making and adoption of sustainable production practices", and

Some technology adoption activities will also address:

(iii) "market constraints to farm profitability, adoption of inputs, and improved soil management practices", and

(iv) "availability and accessibility of information to support public policies that encourage adoption of sustainable production practices"

Our program in phase 1 of the SM-CRSP concentrated on diagnosis of technical and socio-economic constraints to crop productivity, research to better understand constraints, and identification/development of soil management practices to improve system output, resource quality, and sustainability of the agriculture. This work has been done primarily in Bangladesh and Nepal because of sanctions by the U.S. government against India and Pakistan.

The following broad constraints to increased productivity and sustainability in the rice-wheat system have been identified:

Technical

- High soil-borne pathogen pressure (poor soil biological health).
- Multiple macro- and micro-nutrient deficiencies and poor nutrient management practices.
- Traditional land preparation methods delay planting of wheat with consequent yield reductions.
- Poor stand establishment of upland crops caused by various combinations of high disease pressure, poor soil physical conditions, poor planting techniques and poor seed quality.
- Crop lodging at high fertilizer input levels which prevents crop yield potential from being achieved.
- Soil acidity (primarily in Bangladesh).

Socio-economic

- Farmers lack knowledge of technical constraints and potential solutions, especially with regard to soil biological constraints.
- The smallest farmers often lack access to credit.
- The high cost of fertilizers and other chemicals often limits inputs.
- Labor shortages at transplanting and harvest times, and high labor costs, are causing farmers to seek alternatives to labor intensive practices.
- Declining productivity of grain legumes and oil seed crops is causing farmers to switch to other crops, and to use minimum inputs in grain legume production.

Infrastructure

- Only limited fertilizer sources are available and quality is suspect, especially in Nepal.
- Seed of improved varieties of grain legumes is not widely available.
- Vitavax (seed fungicidal treatment) or equivalent material is poorly available or not available.

3. *Available Technologies*

Technologies that can increase crop productivity in the rice-wheat system, improve the efficiency of inputs, and/or conserve water resources are listed in Table 1. The sequence that we propose for adoption of these technologies is based on:

(i) the importance of the productivity constraint addressed,

(i) the projected impact of the technology,

(ii) the extent to which the technologies have been evaluated and adapted in on-farm trials or via farmer participatory research, and

(iii) providing a range of examples for technology adoption methodologies

Most of the technologies listed in Table1 have the potential to increase crop yields (principally rice, wheat and grain legumes) by at least 25% where the listed production constraint exists. Experience has shown that yield responses of this level are needed before farmers will consider technology adoption. In many cases a technology addresses more than one constraint to productivity. The same productivity constraint may also be addressed by different technologies, providing farmers with different options. The possibility of linking technologies to give additive or possibly synergistic effects is especially important. The impact of linking technologies will be a focus of study in the final year of our current project and the results of these studies may alter the sequence for technology adoption activities.

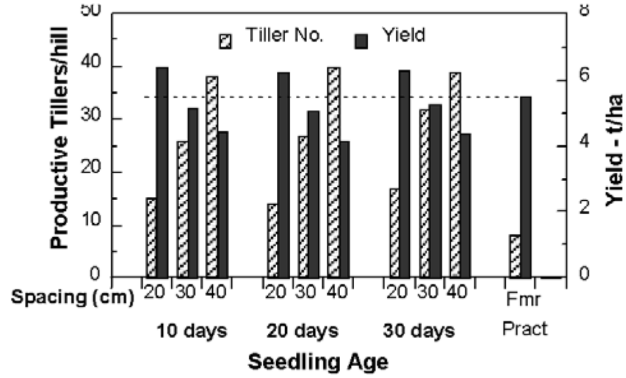
Table 1. Technologies for the rice-wheat cropping system

Management Area/ Technology	Productivity Constraint Addressed	Adoption Priority	Barriers to Technology Adoption
Soil-borne Pathogens Soil solarization - rice nurseries - home gardens - vegetable production	Soil borne diseases, poor soil biological health	1 2 2	Farmer knowledge, cost of plastic sheeting
Seed treatments - vitavax - bio-control fungi - seed priming	Seed borne diseases, seedling mortality	1 ? ?	Credit, Farmer knowledge, availability of materials
Tillage/Crop Estab. No-tillage drills	Late planting of wheat, labor shortages	3	Equipment, fragmented land holdings, and farmer knowledge
Manual surface seeding	Poor soil structure; late planting of wheat	1	Farmer knowledge
Direct seeded rice (earlier planting and maturity)	Late planting of wheat and labor shortages/costs	3	Farmer knowledge, greater weed and insect pressure on early maturing crops
Raised bed systems	Poor soil structure, weeds, low water and N use efficiencies, crop lodging	1-2	Equipment, new approach for rice, farmer knowledge
System of rice intensification (SRI)	Water availability, inter-plant competition, crop lodging	1	Seedling mortality, labor requirement, farmer knowledge
Nutr. Management Increased fertilizer inputs	Nutrient deficiencies	1	Credit, fertilizer quality, poor management/response
Straw mulches	Low N use efficiency in rice; water availability/cost, weeds and diseases	2	Other uses for straw, labor requirement, farmer knowledge
Micronutrient enriched seed	Micronutrient deficiencies, soil-borne pathogens, crop lodging	2	Annual purchase or prodn. of seeds, farmer knowledge
Soil Acidity Liming (Bangladesh)	Low soil pH	1	No existing infrastructure, may induce micronutrient deficiencies, credit, farmer knowledge.
Food Systems* Computer Decision Aids	Inadequate nutrient output from agriculture, tradeoffs between health and income generation	NA	No facilitating policy

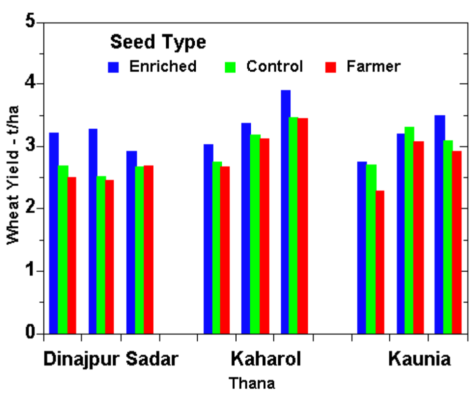
* This activity is not part of the current project due to funding limitations and the fact that it is not directly soil related. However, it is a very relevant, complementary activity that is included in a funding request to the Bangladesh AID mission. The proposed computer based decision tool will enable assessment of nutrient output from agricultural systems and provide the ability to evaluate the impacts of changing production systems in both nutrient and economic terms. It will have application across a range of scales from the household to policy makers, and from a farm to a country. It will build upon field based and modeling research that was carried out in phase 1 of the SM-CRSP.

The principles behind some technologies that may not be familiar, together with their impact, are briefly discussed and illustrated with results from our current project. One example of the benefits of linking technologies is also discussed.

The System of Rice Intensification (SRI) utilizes young (10-20 day old), single seedlings that are sometimes spaced more widely than normal (depending on the season). Tillering is high and soil is maintained more saturated than flooded. Yields of more than 10 t/ha are claimed (CIIFAD, 1999). Our experience in Nepal and that of the NGO, CARE in Bangladesh indicates that elements of the SRI method increase yields by at least 20% compared to conventional farmer practice. The single seedling gives a stronger plant that resists lodging. This is a major benefit because higher N inputs can be used to achieve crop yield potential, and the labor cost associated with erecting lodged plants is eliminated. In the figure, rice yield with farmer practice (3-5 seedlings per hill) was 20% less than the best yield achieved with the single seedling (20 cm spacing; no effect of seedling age). The potential of the method is perhaps only beginning to be tapped.



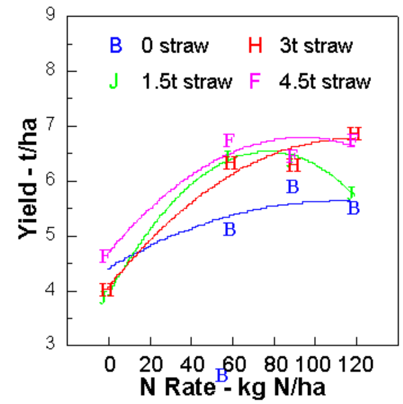
Micronutrient Enriched Seed provides the ability to overcome soil micronutrient deficiencies and increases resistance to soil borne pathogens, especially at the seedling stage. Our farmer trials in Bangladesh have shown an average yield response of 25% for both rice and wheat. The frequency of response was one in four with wheat and six out of ten with rice at sites that were selected at random. Either foliar or soil application of micronutrients can enrich seeds so both farmers and commercial seed suppliers could produce this seed.



Wheat yields were increased on five of nine farms by using micronutrient enriched seed. The mean yield on these farms was 3.4 t/ha compared to 2.8 t/ha from unenriched control seed and farmer seed. Farmer seed quality was noticeably poor on only one farm (first one in Kaunia).

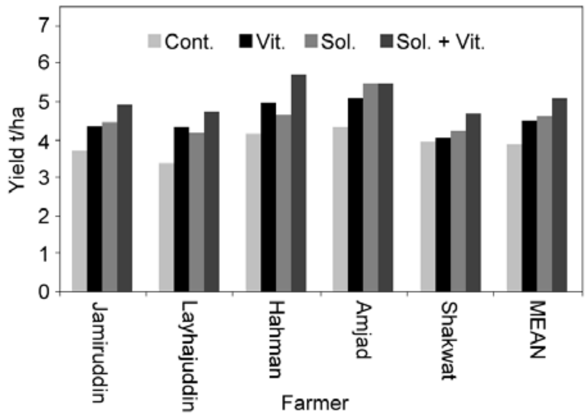
Each group of three pots in the photograph contains soil from a different farm. They were planted with micronutrient enriched seed (front), unenriched control seed (middle) and farmer seed (back). Seedling emergence from micronutrient enriched seed averaged 78% compared to 61 and 50% from control and farmer seed, respectively. This result, and the strikingly vigorous growth with micronutrient enriched seed, are attributed to the increased resistance to disease conferred by higher micronutrient content of seed.

Decomposing ***Straw Mulches*** lower the pH of floodwater in rice thereby reducing N losses via ammonia volatilization and increasing fertilizer N use efficiency. They also reduce weed pressure so that the labor cost associated with mulch application is offset by reduced weeding. The greatest benefit would be for small farmers who often put on low levels of N fertilizer. In the example shown, rice yield was increased by 1.2 t/ha when straw mulches were used and the maximum yield was achieved at a lower N input. The combination of low mulch and high N rate was ineffective due to rapid mulch decomposition.



Linking Technologies can be more effective than using technologies separately. An example is found with our concept that "healthy seedlings" lead to healthy rice plants and higher yields. Farmer participatory trials in Bangladesh have shown that solarization of soil in the rice nursery plus seed treatment with vitavax is usually more effective than either treatment alone. In the example shown both seedling size and crop yields were increased by vitavax or soil solarization but the combination was more effective than either alone. Yields were increased by 15% with vitavax treatment, by 17% with solarization of nursery soil and by 30% with the combined treatments.

Other technologies that can be linked with the "healthy seedling" concept are the single seedling of the SRI technology, micronutrient enriched seed and seed priming. ***Seed priming,*** by soaking seed in water for several hours to initiate germination prior to planting, increased production of chickpea by an average of 40% on 100 farms in Bangladesh (C. Johansen, personal communication). Linking technologies can lead to additive effects, synergistic effects, or no additional effect - or simply providing options by substitution of one technology for another.



Solarization has a major effect on the growth of rice and other crops. Soil was solarized for the six plots at the right but not for those on the left. The three nearest plots had untreated seed, while seed was treated with vitavax for the three in the back. Although solarization of large areas of land is not practical, the technology can have a large impact in home gardens and for high value vegetable crops. Our program continues to seek alternatives to solarization.

Identifying technologies such as those described in the previous pages, that have real potential to increase crop productivity, increase the efficiency of resource use etc., is an important first step in the technology adoption process. Understanding the scope for technology adoption and constraints to successful adoption are also key factors. Spatial analysis of biophsyical and/or socio-economic factors provides a mechanism to evaluate the scope of application for a particular technology. Examples from our current project that will also be included in this project are:

- Surface seeding of wheat was developed by CIMMYT-NARS collaboration in Nepal for heavy textured soils which remained fallow after rice because timely planting and obtaining adequate stands of wheat was too difficult. The technology is simple and has both biophysical and socio-economic spatial dependence. It involves surface broadcasting of manure dipped seed either prior to or after rice harvest when the soil is moist enough that one leaves a shallow footprint. It also targets small farmers who have difficulty preparing adequate seed beds and who do not have tractors and no-tillage drills. Further, the technology can be extended to lighter textured soils in unusually wet years or by using straw mulches to preserve surface moisture. Yields of 3-4 t/ha are easily achieved.

- Deficiencies of potassium (K) are now being observed in the terai zone of the IGP after many years of cropping with large negative balances in soil potassium. Zinc (Zn) deficiencies are also widespread. Evaluation of K and Zn responses on farms has revealed that K is most often deficient on light textured soils and Zn on heavy textured soils. Medium textured soils are often deficient in both nutrients and, not surprisingly, give double the yield response (1.1 t/ha versus 0.5 t/ha) compared to the other soils when nutrient deficiencies are corrected. This information, coupled with spatial analysis of soil texture, provides a way to target nutrient management programs to the highest return environments.

Understanding constraints to successful adoption of technologies is not generally considered by scientists. For example, we have worked with soil fertility specialists in Bangladesh to compare crop yields obtained with general farmer practice to those obtained with regional and soil test based nutrient recommendations. While improved nutrient management showed benefits on all farms, the most striking result of the research was large differences in yields amongst farms with the best nutrient management practice. Understanding and overcoming the reasons for these differences would give a greater return than improving nutrient management practices and is a focus in the last year of our current project. Spatial analysis of constraints, whether biophysical or socioeconomic, would again provide an increased understanding of the scope of a constraint and a means to target technologies and information to address a constraint.

B. Project Objectives

1. Develop methods to accelerate technology transfer of soil management products and practices.

    Output 1: Technology adoption process developed and verified
    Output 2: Identified technologies are adopted by farmers and benefits are documented

2. Develop methods to scale up technology adoption from participatory scales to national and regional scales.

   Output 1: Scaling protocol is developed and verified

3. Develop methodologies that provide farmers, government agencies and policy makers with information needed to design policies that encourage the adoption of production practices that are compatible with the long-term conservation of agricultural resources.

   Output 1: Information products are developed for selected technologies

4. Continue development of key technologies.

The primary outputs of the project will be *technology adoption protocols* for enhancing technology adoption at the farm level and for scaling up adoption to national and regional levels. A series of *information products* generated to support the technology adoption programs will also be available. The primary impact of the project will come through increased crop productivity and agricultural sustainability via the adoption of improved technologies.

We propose to continue to seek alternative technologies to soil solarization because this has a major effect on crop productivity but limited, although important, application. Plans for this activity will depend on the outcome from the next year of research under the current SM-CRSP program.

C. Project Strategy and Approach

1. *Guiding Principles*

Two guiding principles that underlie our general approach and specific workplans are:

- Use of geographic information systems (GIS) as the organizational framework within which technology transfer methodologies are developed, focused, and evaluated. This framework is chosen because different layers of information, both bio-physical and socio-economic, can be combined to ask and answer many questions relevant to technology adoption. GIS can be used at different scales and is likely to be an enduring framework. GIS derived outputs (e.g. maps and spatial model simulations) provide powerful tools to visualize and effectively convey information, especially at the policy level.

- Technology transfer is not a simple linear process. Experience with technologies and reasons for adoption or non-adoption often vary with biophysical and socio-economic conditions. Therefore, while the scientific principles behind technologies are widely transferable, the technologies themselves need to be adjusted/adapted to conditions at local and regional scales.

2. *General Approach/Target Groups*

The project will focus on the transfer of technologies and information to address identified constraints to productivity and sustainability of the rice-wheat cropping system. The constraints are grouped the into six areas shown in Table 2, which also indicates the target group (farmers, institutions and policy makers) and whether or not the problem has clear biophysical and/or socio-economic spatial dependence. Work plans are developed for technologies in each of these six areas.

Table 2. Technology Adoption Matrix

Constraints / Technology	**Target Audience**			**Bio-phys. Spatial Depend.**
	Policy	**Farm/ Extension**	**Other**	
1. Soil Biological Constraints:				
▪ vitavax seed treatment (L→ 3, 4, 5 & 6)	X	X		
▪ solarization				
- rice nurseries (L→ 3 & 5)		X		
- home gardens			X[1]	
- commercial vegetable production		X		X
▪ seed priming (L→ 3 & 6)		X		
▪ micronutrient seed enrich. (L→ 4, 5 & 6)		X	X[2]	
2. Soil Acidity:				
▪ lime (L→ 4)	X	X	X[3]	X
3. Crop Estab. and Soil Structure:				
▪ surface seeding for wheat (L→ 1 & 4)		X		X
▪ direct seeded rice (L→ 1 & 4)		X		
4. Nutrient Deficiencies:				
▪ targeting potassium and zinc inputs		X		X
▪ mulch to improve N efficiency (L→ 3 & 5)		X		
▪ micronutrient seed enrich. (L→ 1, 3 & 6)		X	X[2]	
5. New Technologies for Rice:				
▪ healthy, single rice seedlings (L→ 1 & 4)		X		
▪ permanent bed systems (L→ 1)		X		X
6. Constraints to Legume Production:				
▪ availability of improved varieties	X	X		
▪ seedling mortality (L→ 1 & 4)		X		X
▪ micronutrient deficiencies (L→ 1 & 4)		X	X[2]	X

X - major target or factor may become a factor as activity develops
(L→ 1) - linked activity to number 1 (soil biol. constraints)
[1] household home gardens
[2] seed producer groups, including village womens groups, government and private
[3] fertilizer industry

The first step in the technology adoption process will be to identify the potential audience, information needs, and associated land areas suitable for technology adoption. This spatial analysis process exercise will integrate known biophysical and socio-economic factors that are spatially dependent. The adoption process studies that target farmers will initially be carried out in selected villages or areas that are data rich so that any spatial dependence can be addressed during the technology implementation and evaluation process. Our strategy will be to develop the technology adoption process at farm scale in selected villages then to transfer this process to analogous locations at the same spatial scale. Our information technology and decision support framework is shown in Figure 1.

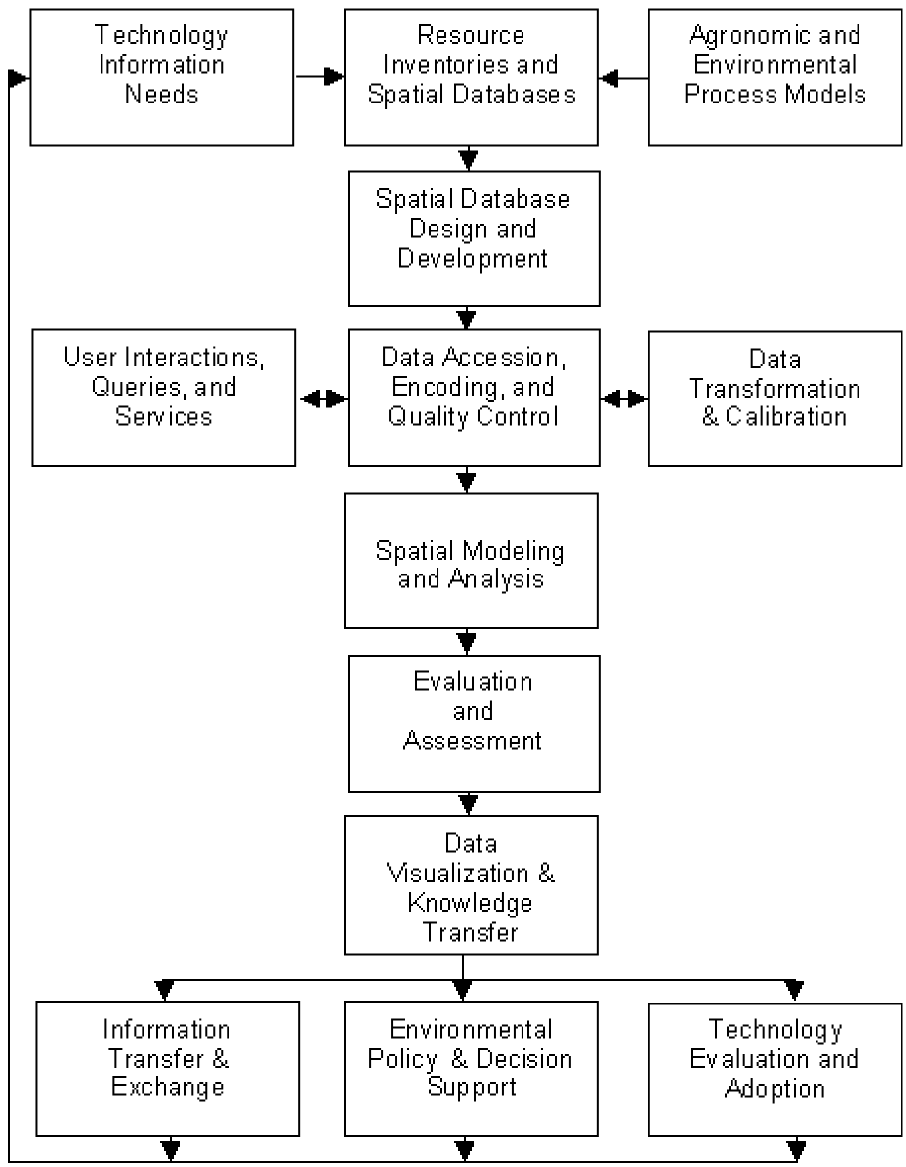


Figure 1. Information technology and decision support framework for the transfer and adoption of rice-wheat cropping system knowledge at farm and policy making levels (adapted from DeGloria and Wagenet 1996).

(i) Enhancing Technology Adoption on Farms:

The first step will be to identify villages where the technology transfer process will be implemented. We will utilize villages that are part of our current program wherever possible, i.e. where required spatial dependence factors are present or are not needed. Otherwise, villages that represent appropriate settings for the particular technology will be selected based on spatial analysis. We will use a whole family training approach to transfer technologies. This methodology has been used by CIMMYT to transfer technologies for wheat production in Bangladesh with funding from the AID mission. It has proven to be very successful, leading to an adoption rate of more than 90%. The process involves bringing groups of up to10 farm families together in an interactive setting to learn about and discuss technologies or production systems. It is led by a local extension or NGO partner, who uses a variety of information transfer tools, including demonstrations, pictographic/printed materials, and video to describe the technologies. We will also evaluate whether coupling the whole family training with more traditional ways of transferring technology, such as farmer field days and use of farmers to spread technology to other farmers, can be used to maximize the impact and limit the number of whole family training meetings.

A key part of the technology adoption process will be to provide ample opportunity for the identification of farmer and community experience and concerns. This information, which would include any farmer adaptations of the technology, will then feed back to the technology adoption process. Feedback from farmers will be obtained initially through the whole family training approach and subsequently through household surveys that are aimed at identifying biophysical and socio-economic factors that enhance or create barriers to adoption from adopting and non-adopting households. Survey results will be combined with community-level analysis in order to identify biophysical, spatial, institutional, and policy factors constraining adoption. Information on key biophysical and socio-economic factors influencing adoption will be utilized in two ways. First, it will be analyzed together with supporting data to revise the map of potential adoption areas. Second, the information provides "targeting criteria" which can be used by decision makers to create policies that enhance and promote future adoption of technologies.

(ii) Targeting Institutions and Policy Makers:

A different process will be used where policy makers and institutions, such as extension systems, are the target group(s). In this situation, the goal is to present a convincing case for creating or changing a policy, making a change in a recommendation, promoting a practice etc. This case will be made by broad based cost-benefit analyses that include productivity, production, environmental and socio-economic factors associated with adoption of a particular technology or suite of technologies. Farmer acceptance of the technology will be demonstrated and policy needs to enhance adoption will be identified. Tools that will be used to reach the institutional and policy levels include printed and video information materials, field visits and community meetings between the target (policy maker) and client groups (farmers).

(iii) Scaling Up Technology Adoption:

The scaling up process will extend successful methods for technology adoption at the farm/village level to larger geographic areas via a network of partners. A key element to successful networking is effective ways of sharing information and experience between partners. Our approach will be to:

- Create a network of partners across a country/region who will participate in the technology adoption program.

- Develop and implement technology adoption plans, and evaluate the adoption process as described for the farm/village level with the addition of strategies for exchanging information and experiences across networks and geographic locations.

A mixture of traditional and new networking methods will be used. Traditional methods include travelling workshops, which we have found to be successful, together with exchange visits amongst partners and farmer groups. The new method will utilize the internet to rapidly exchange text, still video images and video clips together with voice teleconferencing. This capacity is limited at present but is likely to become readily available as private providers are quickly improving internet systems within the region. Rapid improvements in web-based mapping, geodata processing, and spatial data base servicing will greatly facilitate information transfer and evaluation of field research knowledge (Lake 2001). We propose to create an Eastern Gangetic Plains technology transfer network between partners in Eastern India, Bangladesh and Nepal. This network will also link to the Rice-Wheat Consortium project information exchange network that is being established amongst rice-wheat research sites in the IGP.

3. *Target Geographic Locations and Transferability to Other Locations*

The geographic focus will be the Eastern Gangetic Plain region of South Asia, which includes Bangladesh, Nepal, and Eastern India.

The main product from the project will be a protocol for enhancing technology adoption. The protocol will, in principle, have wide transferability but may need adaptation when applied to other regions. The individual technologies will also be transferable. Those that are new technologies from our current project can be applied across the developing world as appropriate. The examples are many. Use of solarization in seedling production, home gardens and intensive vegetable production has widespread application, including in the US (as an alternative to methyl bromide, which is banned). The use of mulches to improve N use efficiency in paddy rice will have universal application for small farmers. The same can be said for "healthy seedlings". The use of micronutrient enriched seed to overcome soil micronutrient deficiencies has widespread application in the developing world,where it is difficult to identify specific nutrient deficiencies. Plants grown from enriched seed also have greater capacity to withstand disease and other stresses that inhibit growth and reduce yield.

4. *Collaborative Relationships*

Our primary linkage to the IGP comes through our continuing membership in the Rice-Wheat Consortium for the IGP (http://www.isnar.org/rwc/aro.htm), which provides the structure for regional studies. This group consists of five CGIAR Centers (CIMMYT; IRRI; ICRISAT; CIP; and IWMI) together with the NARS from the IGP countries and several IARC's (Cornell U.; Institute for Arable Crops research (IACR), Rothamsted); U. Melbourne; and CABI International). In addition to interactions within the rice-wheat consortium, we have developed formal collaborations with the Institute of Agriculture and Animal Science (IAAS), the agriculture component of Tribhuvan University in Nepal and the NGO, LI-BIRD (Local Initiatives for Biodiversity, Research and Development, also in Nepal. In our current program, collaborations with major NGO's, such as the Bangladesh Rural Advancement Committee (BRAC), CARE and

Helen Keller International are undertaken on the basis of mutual benefit. This approach has worked well for us, primarily in our project on Ca deficiency rickets that is funded by the Bangladesh AID Mission.

For the technology adoption program, collaborations with NARS extension systems and with NGO's involved in technology transfer will become more important. We will utilize a mix of small (LI-BIRD and PRADAN) and large NGO's (BRAC and CARE). The small NGO's require funding for their participation while the large ones do not. Both CARE and BRAC have agricultural technology transfer programs and have indicated a willingness to continue collaborations with us on a mutual benefit basis. We also propose to collaborate with the North Carolina led nutrient management program in the SM-CRSP, using NUMASS to help make the case for development of a liming program in Bangladesh. Another collaboration we propose in Bangladesh is with the IPM-CRSP, using soil solarization in commercial vegetable production.

The listing of collaborators by category is:

(i) U.S. Universities: None
(ii) National Agricultural Research Systems: Bangladesh, Nepal and India
(iii) IARC's: CIMMYT, IRRI, ICRISAT, IACR (Rothamsted), CABI International, IAEA (Vienna)
(iv) PVO's : none
(v) NGO's: Bangladesh - BRAC, CARE, Helen Keller
Nepal - LI-BIRD
India - PRADAN
(vi) Other CRSP's: NUMASS group in SM-CRSP for lime
IPM CRSP for solarization for vegetables in Bangladesh
(vii) Others: Institute of Agriculture and Animal Science (IAAS), Nepal

D. Annual Workplans

The technologies are divided into groups that will be used to advance methods development under our three objectives: accelerating adoption, scaling, and developing information products for policy makers etc. Scaling necessarily involves technology adoption and information products involve scaling analyses. Should time and resources permit, technologies used primarily for development of adoption methods could move to the scaling level. Similarly, if policy constraints to technology adoption are successfully overcome, technologies can be moved to the adoption and/or scaling levels. The groups of technologies, with technologies in each group listed in current order of priority, are:

1. <u>Accelerated Adoption</u>

- Solarization of rice nurseries (healthy seedlings)
- System of rice intensification (single seedlings)
- Solarization of home gardens and commercial vegetable operations
- Use of raised beds
- Mulch in rice paddies
- Micronutrient enrichment of seeds
- Direct seeded rice

2. <u>Scaling</u>

- Surface seeding of wheat
- Potassium and zinc fertilization
- No tillage drills for wheat

3. <u>Information Products/Policy</u>

- Lime availability
- Vitavax, or other chemicals for seed treatment

Technologies that are linked, such as healthy single seedlings for rice, will be combined in the technology adoption process.

Objective 1.
Develop methods to accelerate technology transfer of soil management products and practices

Output 1. Technology adoption process developed and verified.

Activity	Dates	Responsible Investigators (Lead investigator listed first)
General		
Collaboration meeting to finalize sites & work plans for top priority technologies	Feb '02	J. Duxbury, C. Meisner, P. Kataki, and NARS, NGO collaborators
Select sub-set of target areas for initial technology adoption ventures (see Objective 2, *Output 1*)	Feb '02 - '03	S. DeGloria, D. Paul, S. Pandey, K. Adhikari
Develop information materials for Whole Family Training (WFT) meetings	Feb ' 02 - as needed	J. Duxbury, C. Meisner, P. Kataki, and NARS, NGO collaborators
Training workshops on WFT techniques and evaluation for nodal NGO and ADO groups	April-May '02, Others as needed	C. Meisner, M.Sufian
Establish web-based network system and train NGOs, ADOs, and NARS working with technology adoption	Feb '02- Feb '03 Updates as needed	C.Meisner, P. Hobbs, R. Gupta
Train ADOs and NGOs about technologies as appropriate for the various selected target areas	Feb '02-'03 priority 1 technols.	P. Kataki, J. Tripathi, C. Meisner, N. Elahi
Incorporate appropriate technologies (as defined by target areas) into WFT or farmer groups; implement training	Nov '02 onwards	WFT coordinators, ADO, NGO groups in target areas
Solarization of rice nurseries, single rice seedlings, bed systems, DSR and straw mulching technologies:		
Undertake on-farm participatory trials with these technologies in selected/target areas	June '02 - May '05	N. Ehahi, P. Kataki, ADO, NGO groups in Bangadesh and Nepal

Surveys to identify farmer modifications and biophysical, economic, and social variables influencing adoption patterns	June '02 - May '05	D. Lee, E. Baksh, M. Mustafi, collaborators at Tribuvan University and IAAS
Utilize web network to communicate critical variables, adaptations or constraints	June '02 - May '05	N. Ehahi, P. Kataki, ADO, NGO groups in Bangadesh and Nepal
Incorporate technologies (along with critical variables and farmer adaptation) into Whole Family Training modules in target areas	June '02 - May '05	WFT coordinators, ADO, NGO groups in target areas
Identify and address constraints defined by farmers, ADOs, NGOs and NARS working with these technologies	As need arises	J. Duxbury, J. Lauren and NARS
Solarization in home gardens and commercial vegetable production		
Develop WFT materials with partners (HKI, BRAC, IPM-CRSP etc)	June '03 - Sep '03	C. Meisner, G. Abawi, J. Duxbury
Identify on-going programs where technology can be introduced and implement tech. adoption process	June '03 imp. Nov '03 on	C. Meisner, G. Abawi, J. Duxbury
Micronutrient seed enrichment:		
Develop promotional package for NGOs, ADOs, seed companies and farmer groups indicating target areas, potential for yield increases and seed supply requirements	Feb - March '03	J. Duxbury, C. Meisner, N. Elahi, M. Bodruzzaman,\
Train interested groups to generate micronutrient enriched seed of farmer preferred varieties through on farm participatory methods	June '03 - '05	P. Kataki, J. Tripathi, C. Meisner, N. Elahi
Verify enrichment, monitor modifications and biophysical, economic, and social variables influencing adoption of practice and sales of enriched seeds	June '03 - '05	D. Lee, E. Baksh, M. Mustafi, collaborators at Tribuvan University and IAAS

Output 2. Identified technologies are adopted by farmers, and benefits are documented.

Activity	**Dates**	**Responsible Investigators** (Lead investigator listed first)
Utilize remote sensing methodology from *Output1* to document adoption of surface seeding technology in Nepal Terai	Feb '02 -'07 annually	S.DeGloria, GIS Post Doc., P.Kataki, S.Pandey
Quantify area of adoption & productivity increases due to adopted technologies utilizing remote sensing, field and farmer survey, and district level agric. statistics as appropriate; display using GIS	Wheat: Feb '01 - '07 Rice: Sept. '01 - '07	S.DeGloria, GIS Post Doc., J.Lauren and collaborators

Objective 2.
Develop methods to scale up technology adoption from participatory scales to national and regional scales

Output 1. Scaling protocol developed, verified, and implemented

Activity	Dates	Responsible Investigators (Lead investigator listed first)
General		
Establish Eastern-Gangetic Plains network	Feb '02 - Apr '02 update as needed	J. Duxbury, R. Gupta
Measure and/or assemble geo-referenced soil, agronomic and socio-economic data and remotely sensed images at appropriate scales (1:50,000 or smaller for country level and farm units)	Begin Feb '02 and continue as needed	S. DeGloria, GIS Post Doc., J. Lauren, D. Paul, S. Pandey, K. Adhikari
Identify GIS extrapolation domains for technologies and target areas for scaling process	Feb '02-Dec '02	S. DeGloria, GIS Post Doc., J. Lauren, D. Paul, S. Pandey, K. Adhikari
Provide technology transfer information products and adoption potocols to collaborators in target areas	Dec '02 and as needed	P. Kataki, C. Meisner, J. Duxbury
Follow large scale technology adoption progress by monitoring and GIS; address collaborator issues	Initial and annually thereafter	S. DeGloria, GIS Post Doc., D. Lee, J. Duxbury
Workhops and travelling seminars; training and evaluation	As needed	P. Kataki, C. Meisner, J. Duxbury
Technology specific activities		
Develop and validate methodology, using remotely sensed images, to target fallow areas for surface seeding technology	Feb '02-Dec '02	S. DeGloria, GIS Post Doc., K. Adhikari, S. Pandey
Integrate yield response to K, Zn fertilizers and soil textures into GIS framework to identify target areas; validate approach from on-farm trial data '99-'02	Feb '02 - Nov '02	S. DeGloria, GIS Post Doc., J. Duxbury, J. Tripathi, S. Pandey, C. Adhikari, D. Paul, G. Panaullah
Identify target areas for adoption of K/Zn fertilizers, DSR, bed systems, micronutrient enriched seed based on spatial distribution of critical parameters such as: texture, soil pH, soil micronutrient levels	Throughout program	S. DeGloria, GIS Post Doc., D. Paul, S. Pandey, K. Adhikari
Derive and validate relationship between yield responses to lime and Bangladesh soil pH data using NuMASS	Feb '02 - Feb '03	J. Lauren, D. Osmond
Integrate lime-soil pH relationship with spatial data on soil pH, crop yields, cropping patterns to identify target areas for lime adoption	Dec '02 - May '03	S. DeGloria, D. Paul, A. Raman, G. Panaullah

Objective 3.
Develop methodologies that provide farmers, government agencies and policy makers with information needed to design policies that encourage the adoption of production practices that are compatible with long-term conservation of agricultural resources.

Output 1. Information products are developed for selected technologies.

Activity	Dates	Responsible Investigators (Lead investigator listed first)
Lime:		
GIS based modeling to calculate lime production needs and predict yield benefits	Dec '02 - May '03	D.Paul, A.Raman, G.Panaullah
Identify economic, farming system and social variables which might influence adoption of lime	Jan '03 - May '03	D.Lee, E.Baksh, M.Mustafi
Prepare GIS based promotional materials for policy and industrial sectors which quantify yield benefits (single crop, system-wide), land savings, required agric. lime resources, critical socioeconomic variables etc.	May '03 - July '03	D.Lee, J.Duxbury, C.Meisner, G.Panaullah
Prepare a video describing technology, potential impact (using GIS maps), farm level economic investment/impact	June '02 - July '03	C Meisner, A.Raman, D.Paul
Seed Treatments:		
Utilizing observed experimental increases and current yield estimates for rice and wheat, estimate range of yield increases possible with Vitavax seed treatments; and quantities required to meet treatment needs	June '02	C.Meisner, J.Lauren, PKataki
Identify constraints and possible solutions to material availability	June '02 - Dec'02	
Develop promotional materials for farmers, the policy and industrial sectors containing the information above as well as practical/appropriate information for farmers	Dec '02 - Feb '03	C.Meisner, S.Banu, N.Nahar E.Duveiller, S.Sharma, K.Gharti

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Logical Framework for Output Indicators

PROGRAM OUTPUTS/IMPACTS	MEASURABLE INDICATORS	MEANS OF VERIFICATION
Technology adoption process developed	• NGOs, ADOs and NARS establish target areas based on spatial protocol • NGOs, ADOs and NARS utilizing WFT techniques and on-farm participatory trials to transfer new technologies • web-based network with active participation by ADOs, NGOs and NARS working in technology adoption • modifications, critical biophysical economic and social variables incorporated into trainings and/or shared on network	A. more use of GIS databases by technology adoption workers; more data needs being requested of GIS repositories B. WFT and on-farm participatory trial approaches become institutional components of Extension agencies, agricultural NGOs and NARS farming systems programs C. web counter, usage monitoring D. more biophysical cum socioeconomic surveys conducted; monitoring network comments
Scaling protocol developed	• establish target areas for technology adoption based on spatial properties • web network for transferring technology beyond initial target areas • prediction of potential productivity increases in other project areas	• GIS suitability maps generated for various technologies • network used by different groups and across different areas • output from scaling-up analysis of remotely sensed images to other target areas
Technologies adopted by farmers and benefits documented	• productivity increases quantified in initial target areas • ready adoption, modification of technologies • increased yields and improved socioeconomic conditions on farms	• output from analysis of remotely sensed images, agricultural statistical data, etc. • 2,3 results from surveys of changes in farmer practice; participation in participatory on-farm trials
Information products for farm, policy and industrial sectors	Promotional packages developed for lime, solarization and micronutrient enriched seed	• white papers • videos

Cornell University Technology Adoption Budget Summary ($)	Year 1	Year 2	Year 3	Year 4	Year 5	Total
1. Salary and Wages	94,000	98,700	103,365	108,533	113,960	518,558
2. Fringe benefits (@32.91%)	13,262	13,925	14,621	15,353	16,120	73,281
3. Other direct costs:						
a. Subcontracts	72,300	87,300	87,300	87,300	87,300	421,500
b. Consultants	-	-	-	-	-	-
c. Equipment	-	-	-	-	-	-
d. Supplies	20,000	20,000	20,000	20,000	20,000	100,000
e. Travel						
Domestic	4,520	4,520	3,000	3,000	3,000	18,040
International	27,000	27,000	27,000	27,000	27,000	135,000
f. Other	91,225	75,000	70,000	65,000	60,000	361,225
4. Indirect Costs						
On Campus @ 59%	38,282	40,196	42,206	44,316	46,532	211,532
Off Campus @ 26%	52,103	44,575	44,575	41,475	38,337	221,065
5. Sub-Total	412,692	411,216	412,067	411,977	412,249	2,060,201
6. Cost-sharing @ 25%	103,173	102,804	103,017	102,994	103,062	515,050
7. Total Estimated Costs	515,865	514,020	515,084	514,971	515,311	2,575,251

Cost sharing calculation (annual)

0.45 FTE Cornell faculty at average salary of $93,500	42,075
Fringe benefits @ 32.91%	13,847
Sub-total	55,922
Indirect costs @ 59%	32,993
Indirect cost return from CALS	23,360
Annual Total	112,275
5 year Total	561,375

Cornell University Technology Adoption – 1 Year Budget

Personnel					Supplies Details			Notes
	FTE	On Campus	Off Campus			On Campus	Off Campus	
Research associate	0.5	23,350	-		Office	2,000	2,000	
Extension associate	0.5	-	16,950		Farmer trials	-	5,000	
Graduate students	3	26,850	26,850		Satellite maps	4,000	-	
Fringe benefits @32.91%, ex. Grad stud.		7,684	5,578		Fuel & oil etc.	-	5,000	
	Total	**57,884**	**49,378**		Video	1,000	1,000	
					Total	**7,000**	**13,000**	
Sub-Contracts								
	LI-BIRD		**25,000**		**Other Direct Costs**			
	IAAS		**15,000**			On Campus	Off Campus	
	CIMMYT (RW – consort)		**32,300**		Vehicle purchase	-	12,500	
					Vehicle rental	-	5,000	
Supplies		**7,000**	**13,000**		Vehicle repair/maintenance	-	2,500	
					Vehicle Insurance (2)	-	3,000	
Travel					Digital video camera	1,800	-	
	Domestic		**4,520**		Video production costs	-	6,000	
	International		**27,000**		Printed information materials	-	5,000	
					Motorcycles (2)	-	3,000	
Other Direct Costs		**24,225**	**67,000**		Computers (3)	9,000	-	
					Temporary labor	-	5,000	For whole family training
Total Direct Costs		**89,109**	**233,198**		Office labor	-	10,000	Bangladesh and Nepal
					Graduate student fees	10,425	-	
Indirect Costs		**38,282**	**52,103**		Graduate student health ins.	3,000	-	
59% on-campus, 26% off-campus,					Workshops	-	5,000	
less grad fees, equip. @ office rental					Socio-econ surveys	-	10,000	
Sub-contracts @ 26% up to $25,000					**Total**	**24,255**	**67,000**	
Total direct + indirect costs		**127,391**	**285,301**					
	Grand Total	**412,692**						

Travel Details			
Domestic: 3 scientific meetings (5 days) @ $1,000 (350 travel; 650 per diem)			
2 consultations (2 days) with N. Carolina NUMASS group @ $760 (500 travel; 260 per diem)			
International: 6 visits U.S. - S. Asia (2 weeks) @ $3,500 (2,200 travel; 1,300 per diem)			
Travel within region for nat. collaborators; variable cost as local to internat., est. total $6,000			
Indirect Cost Calculation			
	On Campus	Off Campus	
Total direct costs	**89,109**	**233,198**	
Exclusions:			
Computers + camera	**10,800**	**-**	
Grad. Fees + insurance	**13,425**	**-**	
CIMMYT sub-contract	**-**	**19,800**	Shared with carbon sequest. prop. - IDC
Office rental	**-**	**10,000**	
Motorcycles	**-**	**3,000**	
Indirect Costs	**38,282**	**52,103**	

Carbon Sequestration

Measuring and Assessing Soil
(Carbon Sequestration)
by Agricultural Systems
in Developing Countries

Cornell University
University of Florida
University of Hawaii

Measuring and Assessing Soil Carbon Sequestration By Agricultural Systems in Developing Countries

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Dollar Amount Requested: $1,374,717 (UF Portion of Budget)
Dollar Amount Requested: $1,375,000 (UH Portion of Budget)
Dollar Amount Requested: $1,364,765 (Cornell Portion of Budget)

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Problem Statement

RFP Constraint addressed and justification in terms of USAID/AFS goal

Declines in soil organic carbon (SOM) with cultivation of lands for agriculture are widepread and well established. The consequences of this trend are profound for the resource poor developing world where SOM plays an important role in nutrient supply, water holding capacity, and aggregation and tilth of soils. The degradation of soil that results from losses of SOM compromises food security through negative impacts on crop productivity and agricultural sustainability. In large parts of the developing world, insufficient productivity of agricultural land is a prime constraint for satisfying the most basic human need of all: adequate nutrition.

The present international interest in carbon sequestration to offset anthropogenic emissions of carbon dioxide offers an excellent opportunity to support a course of action for rebuilding soil carbon stocks with attendant multiple benefits to the environment and agricultural productivity and sustainability. The proposed program will focus on two regions of the world, West Africa and the Indo-Gangetic Plains (IGP) region of South Asia, which can be characterized as SOM challenged, but where technologies exist to rebuild SOM. The major driver of soil degradation in West Africa is poor utilization of limited resources, while it is deliberate destruction of soil aggregates by puddling for rice in South Asia.

The RFP constraint the proposal addresses is "lack of standard procedures to measure gains and losses of carbon (C) sequestered as soil organic matter." Overcoming this constraint supports USAID's goal or Strategic Objective of "Improved food availability, economic growth, and conservation of natural resources through agricultural development." Overcoming the RFP constraint can benefit food production, accelerate economic growth, and conserve natural resources in many ways. Two examples are:

- Losses of SOM and increased erosion associated with unsustainable farming practices in semi- arid zones bordering large deserts accelerates desertification through changes in the albedo of the land surface which lead to reduced rainfall (Charney et al., 1977; WMO, 1983; Schlesinger et al. 1990). There is potential for reversing this trend via increasing soil carbon content. However, the inability to accurately measure and predict soil C changes limits assessment of the potential impact of increasing soil C on desertification.

- Adoption of practices that would support gains in SOM, associated increases in agricultural productivity, and sustainable use of resources may be constrained by economic factors that can be addressed through appropriate policies. However, the inability to assess and predict soil C changes at large scales limits the effectiveness of the case that can be made to policy makers.

The factors involved in the measurement of soil organic carbon (SOC) include chemical determination of soil organic C at a field scale, the extrapolation of field measurements to large areas for policy and carbon trading level analyses, and the prediction of long term trends in soil organic C status.

Chemical assessment of soil organic C: Standard methods exist for measurement of total SOC. The standard chemical Walkley-Black procedure may not measure all of the soil organic C (McCarty and Reeves, 2000) and is being replaced by combustion methods which have auto analyzer features.

Extrapolation of field measurements: Even more challenging, however, is the need to scale up assessments of soil organic C for use by agricultural policy makers, in possible global carbon trading markets, and by other models, such as those that are used to study regional and global climate patterns. For example, the Kyoto Protocol suggests that carbon trading will be in lots of 100,000 tonnes of C (Tieszen, 2000). Estimating units of 100,000 t of C requires cautious extrapolation across spatial and temporal scales. Field level measurements of soil organic C will need to be extrapolated to regions of at least 4,000 to 10,000 hectares (an increase in SOC from 1 to 2% adds about 20 t C/ha). The results of C measurement on subgram quantities of soil must be extrapolated to the field and then to thousands of hectares. Techniques are needed not only for extrapolation but also to assess the loss of precision associated with extrapolation.

Prediction of long term trends in soil organic C: Changes in SOC levels in response to new land management practices are manifested over longer periods of time (up to 100 years in temperate regions but shorter time periods in the tropics) than can be experimentally determined, at least in many places. Therefore modeling of soil carbon dynamics is used to predict SOC dynamics over longer time scales.

Project Objectives:

Objective 1. Develop practical methods to measure gains and losses of soil organic C over time in spatially variable soils.

- Output 1. Integrated protocol for measuring the gains and losses of soil C under agricultural systems incorporating sampling, prediction and remote sensing technologies.
- Output 2. Predictive tools for evaluating options for soil C sequestration at both farm and cropping system scales, including the role of livestock on C and nutrient balances.

Objective 2. Apply the methods to assess the potential for soil C sequestration for selected sites in West Africa and South Asia.

- Output 1. A demonstrated capacity of land use-cropping systems for sequestering C in soils in West Africa and South Asia under different rainfall regimes.
- Output 2. Demonstrated capacity of reduced tillage management practices for sequestering carbon in soils of South Asia over soil texture gradients.
- Output 3. An assessment of the potential for soil C sequestration for the selected sites in West Africa and South Asia at scales necessary for C trading.

Structure of the proposed program: The program will have two groups, the universities of Hawaii and Florida will focus on West Africa and Cornell University will focus on South Asia. Both groups have the objectives and will achieve them in the same general way. Some specifics will differ as appropriate to the constraints and opportunities in each region. The programs are complementary and avoid duplication. Several points of interaction are identified and meetings between the Pis and key collaborators are planned for exchange of information and methodologies as the program progresses.

Project Strategy and Approach – West Africa

Our strategy is to develop and document a robust protocol that can be used to (i) identify practical options for farming systems that simultaneously increase food productivity, thereby reducing risk of food insecurity, and increase soil carbon stocks in degraded soils, and (ii) measure and monitor soil carbon sequestration in agricultural systems at scales from fields to areas large enough for C trading. Our approach is to conduct case studies in Sub-Saharan West Africa along a gradient of rainfall, soil types, and farming systems and research components of the protocol that are necessary for its development. A participatory research approach will be used by engaging researchers, farmers, and institutions in host countries in all aspects of the project. Our approach aims to facilitate joint learning by investigators, host country researchers, and others about management systems that both increase productivity and soil C sequestration.

Several factors affect the measurement of soil organic C. These include chemical assessment of soil organic C at a field scale, the extrapolation of field measurements to large areas and economically and internationally tradeable quantities of C, and the prediction of long term trends in soil organic C status.

Chemical assessment of soil organic C: The chemical assessment of soil organic C is problematic, in part, because the conventional measurement method, Walkley-Black, does not measure all of the soil organic C; rather it estimates only a fraction of the C (McCarty and Reeves, 2000). In addition, this method is environmentally pollutive because of the use of dichromate in the procedure. The major alternative, combustion, is not widely available in the Sub-Saharan tropics (Doumbia personal communication, 2000). Measurement is also problematic due to the distribution of soil C over depth and the expense and difficulty in sampling to depths greater than 20 or 30 cm.

Extrapolation of field measurements: More challenging, however, is the need to scale up assessments of soil organic C for possible use in global markets of C and by other models, such as those that are used to study regional and global climate patterns. Carbon trading, for example, tends to trade in lots of 100,000 tonnes of C sequestration as offsets of gaseous emissions according to drafts of the Kyoto Protocol (Tieszen, 2000). Estimating units of 100,000 tonnes of C requires cautious extrapolation across spatial and temporal scales. Field level measurements of soil organic C will need to be further extrapolated to regions of at least 4000 to 10000 hectares. The results of C measurement on subgram quantities of soil must be extrapolated to the field and then to thousands of hectares. Thus the concern about loss of precision associated with this extent of extrapolation. Techniques of measurement are needed to track the loss of precision in such extrapolations in support of accounting systems for the monitoring, exchange, or sale of units of soil C. We propose to use geostatistical methods developed for the spatial inference of soil properties with estimated variances (Yost et al., 1993). Landuse/cropping systems are expected to vary substantially depending on soils, topography, management, and other economic, social, and political factors (Nye and Greenland, 1960). A method or protocol is needed whereby estimates of soil organic C, measured on subgrams of soil, can be extrapolated to fields and units of landuse/cropping systems with a known level of precision. We propose to use remotely-sensed characterization of the regional landuse/cropping systems to assist in the upscaling of field and experiment estimates of soil organic C accretion (Doraiswamy et al., 2000).

Prediction of long term trends in soil organic C: Models of agricultural systems exist, but these have not been tailored or evaluated for predicting long-term trends in soil organic C in the cropping systems, soils, and climates of Western Africa. In addition to land management and residue input levels, soil temperature, soil moisture regime, soil texture, and clay mineralogy are likely to be the primary determinants of soil organic C levels (Parton et al., 1989). Recently, Gijsman et al. (submitted) have combined the widely used DSSAT suite of crop models (Tsuji et al.,1994; Jones et al., 1998) with the most widely used model for soil organic matter predictions (CENTURY; Parton et al., 1988, 1989, 1994). We expect that this model, hereafter referred to as DSSAT-CENTURY, will permit estimating the long term trends in soil organic matter under the candidate landuse/cropping systems as well as 'steady state soil organic C levels' for particular systems. These steady state values are important in predicting the effectiveness of candidate landuse/cropping systems in C accretion. If the current soil organic C levels are lower than the steady state level, we predict that the landuse/cropping system will successfully increase soil organic C levels. However if, at the time of implementation of the landuse/cropping system, the soil organic C level is above the 'steady state soil organic C levels', it is unlikely that additional C can be sequestered. Simulated results showed that C sequestration potential for Zaria, Nigeria (rainfall of 989 mm yr-1) varied from about 100 to about 700 kg ha-1 yr-1, and could double or triple soil C over one hundred years, depending on the crops grown and management of residue (Gijsman and Jones, unpublished). Techniques also exist for scaling up the DSSAT-CENTURY model to predict soil organic C sequestration at the farm scale, taking into account livestock management (Thorne, 1998; Thornton et al., 2000; Herrero, 1999), and for large areas by integrating it with spatial data bases on soils, land use and weather (Hansen and Jones, 2000; Jagtap and Jones, submitted; Doraiswamy et al., 2000). However, the proposed research is needed to adapt and evaluate the new model capabilities to the Western African conditions, to integrate it into an overall protocol for measuring and predicting changes in soil C, and to establish the levels of uncertainty associated with predictions at different scales, from field cropping systems to areas on the order of 10,000 ha.

Prediction also requires an understanding the role of livestock management in soil C sequestration. Livestock feed on grazing lands and crop residues that may otherwise increase soil C. Despite the use of manure as a soil amendment, many mixed farming systems have negative nutrient balances and soil carbon and nutrient depletion is a major concern (Stoorvogel and Smaling, 1990). Improved crop management leading to more crop residues may allow residues to be returned to fields and some used for feed without adversely affecting the soil environment. The growing of forages to substitute for crop residues, the partial rather than total removal of crop residues, rotational grazing of pasture land, and an improved balance between feed supplies and animal populations, will be crucial to sustainable improvements in agricultural production in particular places (Powell 1998; Savory and Butterfield, 1999; Bingham, 1997). An inability to accurately assess the impacts of livestock management in farming systems could lead to recommendations for soil C sequestration that are unrealistic and prevent our accurate assessment of the potential of different cropping systems to increase soil C.

Existing or Previously Developed Technologies

Candidate landuse/cropping systems: We propose to measure C accretion on several candidate landuse/cropping systems with known benefits for food production, income generation, and natural resource conservation. The proposed landuse/cropping systems comprise three approaches to increasing C accretion, through: 1) Improved water conservation with corresponding increases in biomass production and residue return to the soil, 2) Reversal of the nutrient mining and providing for the nutrient requirements of crops, and 3) Use of native species that tolerate the stress conditions prevalent in Sub-Saharan Africa.

Improved water conservation: The effects of improved water conservation will be evaluated through assessments of C accretion by ridge-tillage systems (courbe de niveau) as implemented by Gigou et al (1999) and Traore (2000). This system has been adopted by hundreds of farmers in central and southern Mali. Grain and stover increases in sorghum, millet, maize, and cotton range from 20 to 40%. The improved soil water conditions may lead to increases in SOM; the net long term result on soil C accretion will be analyzed by model predictions. Improved nutrient management. The West African Sahel is well-known for the extreme nutrient mining that has occurred there (Smaling et al., 1997; Doumbia et al., 2000, Duivenboden, 1992). This has occurred on already deficient soils (Doumbia, 1993; Bationo and Mokunye, 1991; Pieri, 1995). Reversing the mining of and loss of nutrients is an imperative for agricultural development in the region. Our hypothesis that the addition of nutrients through the detection and resolution of nutrient deficiencies is an important avenue to not only increase food production, but to increase C accretion as well. We propose to detect and resolve such nutrient deficiencies with the use of NuMaSS software, which has been developed by earlier components of the SM-CRSP. The DSSAT suite of models will also be used to assess impacts of improved nutrient management. There often is a positive interaction between the addition of nutrients and increased conservation and use of water (Gigou et al., 1999).

Use of native species to increase soil organic: C The Institut Senegelais de Recherche de Agricole (ISRA) has initiated studies on the accretion of C in soils of southern Senegal (Diack et al. 2000). Piliostigma reticulatum, widely distributed throughout the Sahel, is a native species that provides cover and is hypothesized to increase soil organic C (Diack et al. 2000a; Diack et al., 2000b). In Ghana, the use of a fast growing native leguminous shrub (Cassia) and leguminous cover crops (Mucuna and Calopogonium) have shown potential to almost double maize yield and biomass production (Adiku, personal communication).

Use of the DSSAT-Century Model: Site measurements and aspects of enhanced water, nutrient, and cover crop management will be used as inputs to the DSSAT-CENTURY model to predict C sequestration and biomass accumulation associated with the candidate land management systems. Modeling will provide the scientific information to inform localized farmer/herder and community-level land use decisions as well as the basis for scaling up estimates on a larger scale.

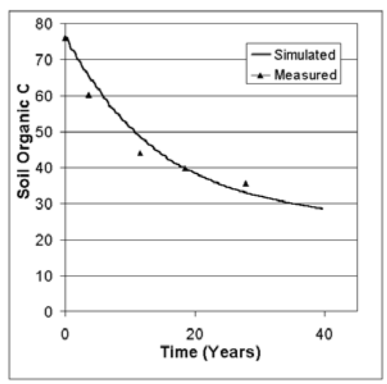

Figure 1. Comparison of DSSAT-Century predictions of changes in soil organic C with observed data from the Rothamsted long-term bare follow trials (from Gijsman et al., submitted).

The Decision Support System for Agrotechnology Transfer (DSSAT; Tsuji et al., 1994) forms a comprehensive model-based decision support system for assessing agricultural management options and is widely used in developed and developing countries (Algozin et al., 1988; Bowen and Wilkins, 1998; Jagtap et al., 1993; Lal et al., 1993; Singh et al. 1993; Thornton and Wilkins, 1998). DSSAT can simulate growth and development of 16 crops and can incorporate management events like fertilization, crop rotation, residue application, irrigation, tillage, and harvest. It includes consideration of greenhouse gas production (CO2, NOx) and nitrogen leaching. The impact of changing environmental conditions, such as increased carbon dioxide levels and changed climatic conditions, can also be analyzed.

To improve DSSAT's applicability to low-input systems and to more realistically simulate the soil organic matter (SOM) levels and greenhouse gas production under several agricultural systems, the SOM module of the CENTURY model has been incorporated into DSSAT. The CENTURY model is one of the most established and widely-used SOM models (Parton et al., 1988, 1994) and has proven valuable in both temperate and tropical systems (Carter et al. 1993; Cole et al., 1989; Kelly et al., 1997; Metherell et al. 1993; Parton et al., 1989, 1993, 1994; Paustian et al., 1992; Seastedt et al. 1992; Woomer, 1992, 1994). In a special issue of Geoderma 81 (1997), nine SOM models were evaluated with twelve long-term datasets, including inorganic fertilizer, organic manures and different rotations. Measured and simulated data were compared using an array of statistical analysis tools. Among the models that performed best, the CENTURY model produced consistently low errors for all datasets but one, showed the lowest overall bias, and was able to simulate both low-and high-N treatments (Smith et al., 1997).

The combination of the DSSAT crop models and the SOM module of CENTURY brings together the best in crop productivity models and SOM models. Figure 1 shows the initial validation of this new model using long-term bare fallow dataset from Rothamsted, UK (from Gijsman et al., submitted). Another important recent modifications to the DSSAT crop models is the addition of a new soil-phosphorus module built on experimental data from strong phosphorus-sorbing soils (Daroub et al., submitted), and work is under way to add a new, more detailed denitrification routine based upon earlier work of Del Grosso et al (submitted). These new additions are expected to provide the capabilities necessary for predicting soil C sequestration and productivity in cropping systems in west Africa.

Use of Remote sensing: Critical to measuring and monitoring improved land use practices that sequester carbon will be the use of fast, cost-effective and reliable measures land use and management practices associated with increasing soil carbon. Remote sensing technology is needed to make such estimates, when combined with measurements on the ground and biophysical crop-soil models. Considerable remote sensing work has been done in Africa, focusing on annual and inter-annual vegetation dynamics. NOAA developed the operational product of global vegetation index (Tarpley et al., 1984) and several uses of the data for large-area study were subsequently reported (Justice and Hiernaux, 1986; Tucker and Sellers, 1986). Prince and Justice (1991) monitored the grasslands of semi-arid Africa using NOAA-AVHRR data. Much of the recent work used time-series images to characterize changes in ecosystems, especially related to desertification. Temporal changes in the Normalized Difference Vegetation Index (NDVI) have been shown to relate to net primary production (Prince and Tucker, 1986; Goward et al., 1987). Tucker and Sellers (1986) provided a theoretical background to relate primary production estimates based on the absorption of photosynthetically active radiation (PAR) by the canopy. Studies have shown that the seasonal accumulated NDVI values under certain conditions can be correlated with the reported crop yields in semi-arid regions (Groten, 1993; Doraiswamy and Cook, 1995). The integration of crop-soil models with biophysical parameters derived from SPOT satellite (Moulin et al. 1995) and NOAA-AVHRR (Doraiswamy et al., 2000) data have been used successfully for mapping crop condition, leaf area index (LAI), biomass and yields at field and regional scales. By incorporating in situ measurements of biophysical conditions and crop-soil models, remote sensing technology could provide the means for researchers and decision-makers to associate an estimated level of carbon with a particular land use practice.

Development of Protocol

At the start of the project, an initial protocol will be presented to collaborators in a series of workshops so that refinements can be made and adopted by collaborators in each case study. The initial protocol is based on our current knowledge of the different components, and is outlined below:

1. Identify baseline conditions (farming systems, productivity, soil carbon, soils, weather).

2. Identify farming systems and land management practices that are candidates for increasing productivity and soil C (using workshops/focus groups, site visits, ex ante assessment of potential productivity and soil C benefits, risks and uncertainties associated with adoption).

3. Implement candidate systems, monitor, quantify impacts of changes in management systems, verifying that candidate systems sequester C as intended and predicted. Existing systems with long records will be monitored.

4. Scale up by (i) predicting potential changes in soil C over large areas and its uncertainty under different levels of adoption and (ii) refining techniques for large area monitoring to confirm the use of specified land management practices aimed at C sequestration.

The protocol will utilize tools and methodologies, such as soil and crop sampling, measurement of soil C, geostatistics, predictive biophysical models, and remote sensing. It integrates the various methodologies as a system that can be transferred to other regions. Several important questions must be answered for completing the protocol. Our approach will involve component research to answer these questions and develop the tools necessary for the protocol:

- What are the most effective landuse/cropping systems in terms of C accretion, increasing food security, reducing environmental degradation, and in providing income?

- How many samples are needed to quantify soil C at a specified level of uncertainty? Characterization of sources of variability in soil C assessment will be identified and quantified in order to recommend the most cost-effective assessment methods.

- Can the DSSAT-CENTURY biophysical model predict grain and biomass productivity for the farming systems, climates, and low phosphorus soils in Africa? Research will incorporate the soil phosphorus module developed by Daroub et al. (submitted) into the DSSAT-CENTURY model and evaluate it using existing data sets. If necessary, the DSSAT crop models will be modified to predict productivity under these environments.

- What is the effect of soil water potential on the SOM decomposition rates in soils of western Africa of different textures? Experiments will be conducted to quantify soil water potential effects on soil organic matter decomposition for sandy soils in Africa.

- How accurate are the predictions of soil C changes under the different farming systems, soils, and climates in Africa? *In situ* measurements will be used to adjust parameters, make modifications as needed, and verify that the models are tuned for the systems, soils, and climate of the areas selected. Methodology will be developed to quantify the uncertainty associated with predictions at field and area-wide scales.

- How realistic are assumptions about return of C to the soil considering animal grazing of residue, and how does livestock management affect soil C sequestration? An existing farming system model will be implemented for locations in West Africa, linked with the DSSAT-CENTURY model and used to assess livestock management effects on soil C sequestration in different farming systems.

- Can remote sensing technology monitor candidate landuse/cropping systems with sufficient accuracy? Remote sensing images of candidate systems will be used, along with ground measurements, to determine the accuracy with which management systems and residue return to the soil can be estimated.

- How can remote sensing of soils and agricultural systems be combined with geostatistics and modeling to scale up predictions of soil C sequestration to large areas in a simple protocol? High resolution and hyper spectral images of the farming systems being studied will be analyzed using spatial and temporal characteristics to develop methods for estimating management system inputs to the DSSAT-CENTURY model for predictions over large areas. The methods will be evaluated using measurements made in the case studies.

The protocol will be refined over the duration of the project using results from these component studies and using knowledge gained in case studies. Finally, the protocol will be published, with detailed procedures for all components to facilitate its use in other regions.

Case Studies

Our approach will use case studies at locations varying in rainfall regimes (from about 600 to 1500 mm per year), and in farming systems and soil types representative of West Africa and Sub-Saharan Africa. These locations (described below) were selected not only to create a wide range of conditions for developing and testing our protocol, but also to take advantage of relationships that have already been established between investigators of this project and highly competent collaborators, ongoing studies, and institutions in this region. The case studies will be used as a tool for refining and evaluating the protocol as well as for characterizing the potential for soil C sequestration in the selected regions. A comparative study across locations will also provide information on the effects of rainfall, soils, and farming systems that can be used to estimate the potential for C sequestration in other regions.

The case studies will involve initial planning workshops to review the protocol, refine it, and establish detailed workplans and timetables for the carrying out the protocol. Our approach calls for each case study to carry out the four overall steps in the protocol (see above), collect a minimum set of data needed for testing the protocol and making predictions, and to share these data among all participants in the project. An outline of reporting requirements will be developed at the initial workshops to ensure that all collaborators collect and report information that are needed for comparative analysis and for evaluating the protocol across locations. A database will be established to integrate the different types of data needed for geostatistical analysis, model predictions, and scaling up. The use of the DSSAT-CENTURY model for predictions of C sequestration and productivity in the case studies will be developed in conjunction with scientists in host countries and conveyed to local end-users and institutional decision-makers involved in dissemination of agricultural information on a larger scale. This information will result in an improved ability to make localized estimates of soil C and crop biomass resulting from improved land use practices.

Comparative Assessment

By adhering to the protocol across case studies, we will be able to use the compatible data to compare the effects of rainfall, soils, and management systems on soil C sequestration. This comparative assessment will be made to gain insight about characteristics that would need to be considered in efforts to extrapolate results or to transfer the protocol to other regions.

Target Groups (end users) – West Africa

- *Farmers* - by providing practical options for increasing soil C while increasing or maintaining productivity, empowering them to participate in C markets
- *Host country scientists* - by increasing their capabilities for measuring and predicting soil C sequestration in their current and proposed farming systems
- *International, regional, national agricultural development/environmental agencies* - by providing information on potential impacts of changes in practices aimed at increasing soil C
- *Carbon traders* - by providing a protocol for measuring and verifying soil C accretion in agricultural systems at scales necessary for carbon trading

Target Geographic Locations – West Africa

The case studies in West Africa will be conducted at eight locations in five countries:

Wa, Ghana

Wa is in the Upper West Region of Ghana, latitude 10^{o} 5' to 10^{o} 7' N, and longitude 2^{o} 33' to 2^{o} 35' W. The area is in transition from Guinea to Sudan savanna due to the southward expansion of the Sahara desert. The area has one rainy season (May to October) and a mean annual rainfall of 1026 mm. During the dry season, vegetation is almost non-existent and river channels are dry. The soils, mainly Ferric Lixisols or Chromic Luvisols in the FAO system, vary from those that are shallow loamy sands to deep, poorly drained alluvial clays in valley bottoms. This region is an important producer of cereals (sorghum, millet, maize and to a lesser extent, rice) and legumes (groundnut, cowpea and soybean). The predominant agricultural systems include compound farming or continuous cropping, shifting cultivation and livestock production.

Kpeve, Ghana

Kpeve is in the Volta Region of Ghana, latitude 6^{o} 40' to 6^{o} 42' N, and longitude 0^{o} 17' to 0^{o} 19' E. It is a typical sub-humid forest-savanna transition ecological zone. Annual rainfall is bi-modally distributed, averaging 1400 to 1600 mm; 60% falls from April to July and the rest from September to October. Kpeve soils are mainly Dystric Planosols, Umbric Leptosols, and Haplic Acrisols. About 70% of the land is in various types of arable farming. Major crops are maize and cassava monocropped or intercropped with legumes. Although slash and burn is practiced, shifting cultivation is shifting to more sedentary farming due to population growth. Conventional tillage is limited (< 10 %) apparently due to hilly landscapes and high tractor hiring costs.

Nioro, Senegal

Nioro is the site of long term studies of water and soil conservation conducted by ISRA and ORSTOM (France). Rainfall is about 1000mm annually. This zone of intensive agriculture is at the southern edge of the "peanut basin" of Senegal. Soils are psamments, many of which contain less than 5% clay + silt. Initial tests of the KINEROS model have predicted water runoff from experimental watersheds of ORSTOM conducted in this region. Current InterCRSP experiments in their last seasons are on-farm tests of Piliostigma reticulata in farming systems, use of phosphogypsum on peanut, and tests of water conservation methods.

Ribeira Seca, Cabo Verde

The Ribeira Seca watershed is one of the most important valleys in Cabo Verde, Island of Santiago. It is affected by salt intrusion exacerbated by over-pumping of the small stores of fresh water for irrigation. The watershed characterized by extreme slopes, some of which exceed 60%, intensive agriculture, and periodic very short rainy seasons. Water and soil conservation measures to be tested for C sequestration potential include pigeon-pea vegetated barriers and testing / validation of the KINEROS water and soil conservation model.

Basse, The Gambia

Basse, in Eastern Gambia, is one of the most sloping landscapes of The Gambia, yet the slopes seldom exceed 10%. Rainfall is about 1000mm annually. Local farmers have disastrous stories relating to lost crops, lost buildings due to inadequate water control. Technologies proposed for testing for C accretion include ridge-tillage, improved fertility such as improved phosphorus / manure combinations, and the use of phosphogypsum.

Konobougou, Zamblala, and Sikasso, Mali

These regions of Mali, from north to south, and from rainfall amounts of 800, 1000, to 1200 represent some of the most productive, yet most nutrient mined soils of Mali. Technologies of ridge-tillage have been adopted by farmers in each of the three regions, yet the carbon sequestration potential of each has yet to be determined. Soils are highly sandy as in the case of Nioro du Rip, and Basse, The Gambia, usually in the Ustult suborder and some with plinthic properties that have resulted in hard rocky surfaces further exacerbating runoff and soil loss. Cropping systems that have been tested with the ridge-tillage include millet, sorghum, maize, and cotton. All have shown substantial yield increases.

Contributions to the SM-CRSP Global Plan

Activities will not only address objectives described above, but will contribute to the SM-CRSP Global Plan (Uehara, 2001). Specific activities include:

1. Annual technical workshops for US and Collaborating institution scientists of all SM-CRSP Projects will be conducted to encourage joint interpretation of results and to increase awareness of opportunities for collaboration.

2. We will invite members of other SM-CRSP Projects to participate in our project workshops.

3. We will seek to coordinate project travel so that opportunities for collaboration are apparent.

4. We will join other SM-CRSP Projects in seeking alliances with other programs, projects, and joint efforts. We also propose joint visits to missions and local governments.

Collaborative Relationships – West Africa

Collaborators in Mali, Ghana, Senegal, Cabo Verde, The Gambia and ILRI will be responsible for carrying out the studies on agricultural systems in their countries and for some component research. Funds will be provided by the project for their activities as indicated in the Plan of Work below. Subcontracts will be provided (see budget) for these activities.

Type	Institutions	Description
National Agricultural Research Systems	Savanna Agricultural Res. Inst., Wa, Ghana	Jesse Naab will conduct the case study in Northern Ghana (subcontract)
	University of Ghana, Accra, Ghana	Samuel Adiku will conduct the case study in Kpeve, Ghana (subcontract)
	Le Institut d'Economie Rurale, Bamako, Mali	Mamadou Doumbia: sampling, lab. analysis, GIS, GPS and the InterCRSP/West project, Abou Berthe: native plants, manures
	Institut Senegalese de Recherche de Agricole	Aminata Badiane and Modou Sene: water and soil conservation, improved nutrient mgmt, and native plants
	National Agricultural Research Institue	Babou Jobe and Alieu Bittaye: ridge-tillage and improved nutrient management in Basse, Eastern Gambia
	Instituto Nacional de Desenvolimento Agricultura	Isaurinda Baptista and Antonio Querido: C gains with agroforestry, water and soil conservation, using KINEROS modeling, and improved nutrient management
Int. Agric. Research Centers	International Livestock Research Institute (ILRI)	Philip Thornton will be responsible for the farming system studies of effects of livestock on C sequestration (subcontract)

	Intern. Fertilizer Dev. Center (IFDC), Togo	U. Singh will help evaluate the biophysical models for cropping systems in West Africa
	(ICRISAT)	Sibiry Traore: remotely-sensed data.
CRSP	InterCRSP	Collaboration InterCRSP/West project & UH
	Peanut CRSP	A current experiment will provide data on effects of soil P on production of biomass and grain yield of peanut
University	University of Georgia	Gerrit Hoogenboom will assist in obtaining weather data for the regions.

Project Strategy and Approach - South Asia:

General Concepts Underlying Program

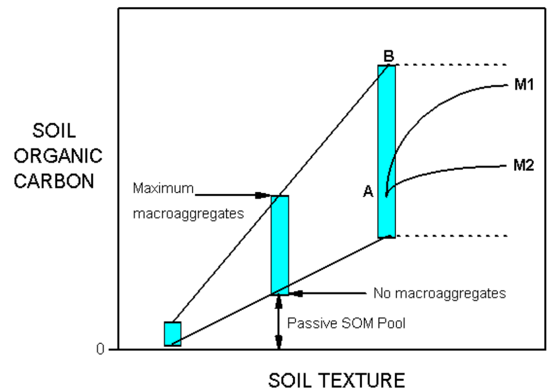

Figure 2. Concepts behind the measurement of soil organic carbon.

Our approach to measurement and assessment of carbon sequestration in soils is based on the concept that soil aggregation is the primary variable controlling SOC content in tropical soils. The concepts behind our approach are illustrated in the Figure 1. Sandy soils with little or no micro- or macro-aggregates have low SOM contents that vary little with cultivation. Finer textured soils have higher SOM contents that are reduced by tillage induced destruction of macro-aggregates. The upper and lower lines show the range in the maximum and minimum SOM contents, respectively, as a function of soil texture. The difference between the two lines is the SOM protected within macro-aggregates. The minimum SOM content is associated with a passive or stable SOM pool that is protected by molecular scale interactions within micro-aggregates. The passive pool is not affected by soil management practices or by wetting and drying events. For a clay soil with an initial carbon content at point A, the sequestration potential is the difference between the maximum value and the initial value, i.e. B-A. The equilibrium carbon content that can be achieved by a given carbon sequestration practice may be less than the maximum or saturation carbon content of a soil. Carbon sequestration management regime M1 gives a different pattern of carbon accumulation and a higher final or equilibrium SOM level than regime M2.

Feller et al. (1995) demonstrated a good linear relationship between soil organic carbon and soil texture which held for all mineralogies, except allophanic, for soils from West Africa, South India, Brazil and the Antilles. Feller and Beare (1997) found that SOC contents from cultivated and uncultivated soils were categorized according to our conceptual scheme.

Tillage will be the primary variable investigated in our project with residue placement, residue quality and soil fertility as secondary variables. Tillage practice is the ultimate control on soil carbon content and therefore the amount of carbon that can be sequestered. Residue management, residue quality and soil fertility are expected to affect the rate of carbon sequestration by influencing the rebuilding of soil macro-aggregates. Both the potential and rate of carbon sequestration are important factors for carbon trading considerations.

Much research in temperate regions has established the negative effects of tillage on SOC contents (e,g, Angers et al, 1997; Paustian et al., 1997: Unger, 1997). Some recent evaluations of tillage effects in tropical environment have been reported for Australia, Nigeria and Brazil (Cogle et al., 1995; Standley et al, 1990; Ohiri and Ezumah, 1990; Bayer et al, 2000), but not for South Asia.

Strategy and Approach

Our overall strategy is to couple a soil carbon model that predicts carbon sequestration dynamics in soil at a specific site (field) with GIS based extrapolation techniques to provide a protocol for assessment of C sequestration at different scales.

We propose to use the Century soil carbon model because this explicitly includes soil texture, residue placement and residue quality as variables. However, information on the recovery of SOC following a switch from long-term tillage to reduced tillage is very limited, and we propose to evaluate model capacity to predict this type of change. We believe that a combination of soil texture and soil mineralogy may be necessary to accurately describe C accretion in different soils. Few soils with high activity clays (smectites) were found in the study by Feller and Beare (1997) and such mineralogies are found in the IGP. We are also believe that tillage x residue placement (and role of root versus shoot inputs) x residue quality x soil fertility interactions require further investigation for agricultural soils under conditions of carbon accretion. We will explore aspects of these interactions with the goal of improving model performance.

We propose to develop algorithms to predict the maximum carbon content that a soil can contain based on soil texture and mineralogy. The algorithms can be coupled with general (or specific) knowledge of soil carbon status and GIS techniques to assess C sequestration potential at different scales without having to use a soil carbon model. This would provide a simple tool to assess soil carbon sequestration potential at a national scale for the many developing countries that now use GIS.

Conceptually, the South Asia group will follow Figure 2, below (adapted from Paustian et al., 1997). The South Asia group will not use the crop production models. The diagram also shows components of our program. We will combine literature data, new data that will be collected from existing experiments and data generated in new experiments to improve our understanding of processes and to refine the Century model. Model output will then be coupled with GIS based information on soil properties (texture and mineralogy) for extrapolation to larger scales. The final phase of the project will utilize the model to evaluate questions relevant to adoption of carbon sequestration technologies at both farmer and policy maker levels.

Target Groups - South Asia

The project targets (i) farmers as principal beneficiaries of the adoption of practices that increase both productivity and carbon sequestration, and (ii) policy makers who need information on carbon sequestration potential in soils, verified carbon sequestration practices, and the ability to carry out carbon sequestration assessments at different scales.

Target Geographic Locations - South Asia

The major target geographic location is the Indo-Gangetic Plains region of South Asia. The results of the work have direct application to the rice-wheat system in China. Interactions with the West African project will ensure that some of the process elements of the protocol being developed will be evaluated in that setting. The protocol itself will have broad application to all developing countries.

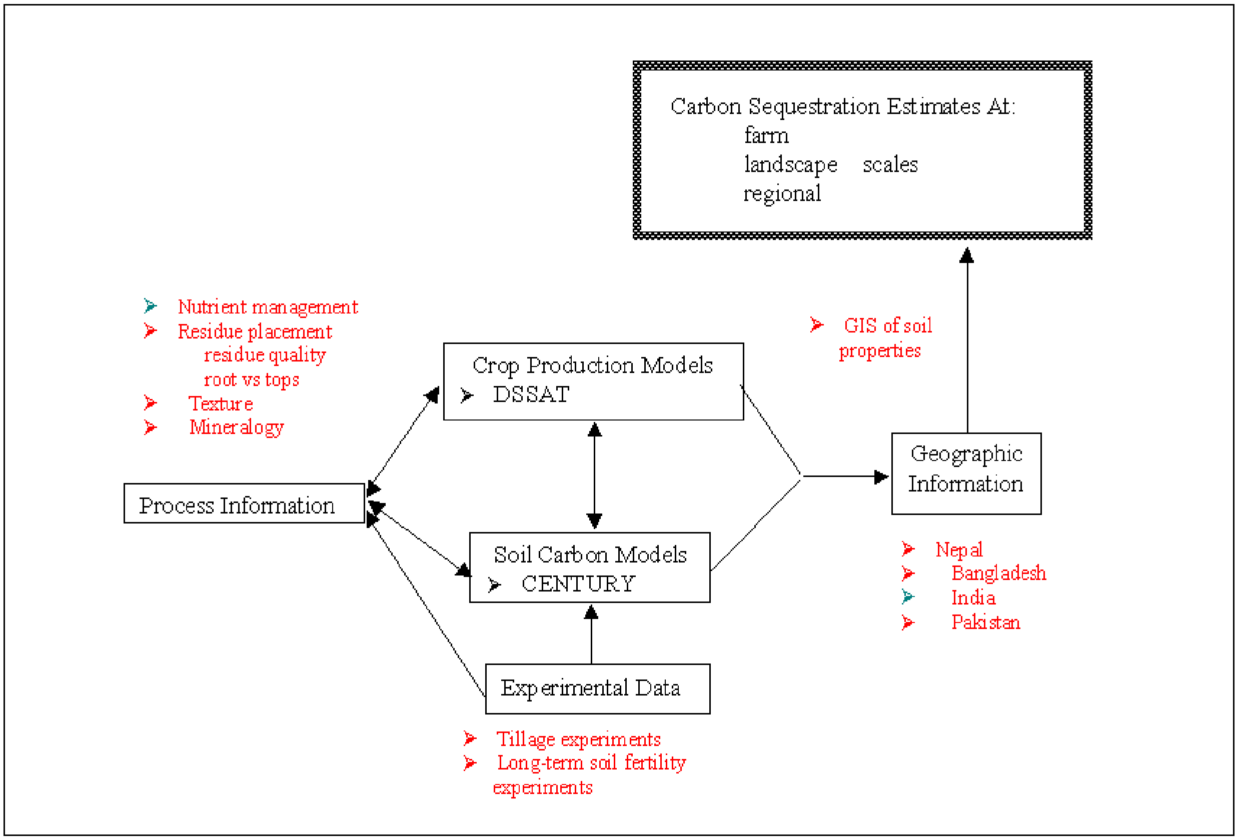

Figure 3. Overall representation of the strategy for the South Asia component.

The rice-wheat system of S. Asia is targeted because:

- it is one of the world's major cropping systems; it occupies 20 million ha of land and provides staple grains for 20% of the global population,
- carbon sequestration potentials are high because puddling of soil for rice has destroyed soil macro-aggregates and severely depleted soil carbon contents. Also many soils are medium to fine in texture with a range of mineralogies,
- management trends in the region are moving rapidly towards reduced tillage practices as these improve crop productivity, and
- increased residue return is becoming more feasible as animal power is being replaced by tractors - rice and/or wheat straws have been the major animal feed.

Collaborative Relationships – South Asia

Cornell's primary linkage to the IGP comes through our membership in the Rice-Wheat Consortium for the IGP (http://www.isnar.org/rwc/aro.htm). This group consists of five CGIAR Centers (CIMMYT, IRRI, ICRISAT, CIP, and IWMI) together with the NARS from the IGP countries and several IARCs (Cornell U.; Institute for Arable Crops Research (IACR), Rothamsted); U. Melbourne; and CABI International). CG Center collaborators (Drs. Peter Hobbs, Craig Meisner and Raj Gupta from CIMMYT and Dr. J.K. Ladha from IRRI will provide in country leadership for parts of the program as identified in the workplans. Collaborators from the national agricultural research systems, together with graduate students, and Cornell country-based coordinators (Drs. P. Kataki and Craig Meisner [shared with CIMMYT] and will carry out the research as indicated in the workplans.

Activities

1. <u>Process</u>

The process level studies are designed to assist quantitative assessment of the impact of various carbon sequestration practices and to improve the modeling process which necessarily has to carry predictions beyond the short-term measurements that can be made during the project.

a. *<u>Tillage Practices</u>* selected for study are shown in the table. They represent the range of practices that are realistic. Conventional tillage without puddling is the practice used with

Table 1. Tillage practices in the rice-wheat system

Rice	Wheat
1. Conv. tillage with puddling	1. No tillage or Conv.tillage
2. Conv. tillage without puddling	2. No tillage or Conv. tillage
3.Permanent beds (reduced tillage)	3. Permanent beds (reduced tillage)

direct seeded rice, which is likely to increase in popularity because of labor shortages for transplanting. It also allows earlier planting and maturity of rice which leads to timely planting of the wheat crop. No tillage practices for wheat are spreading rapidly with drills being used in NW India and Pakistan and manual surface seeding being use by small farmers in the Eastern IGP. Surface seeding of wheat is being promoted for lands that otherwise would be fallow after rice so change could greatly influence carbon sequestration. The permanent bed system represents an exciting new technology for the IGP region. It is well established that beds are a resource conserving technology reduce water use, eliminate herbicide use, and increase N use efficiency) that increases wheat yields (Limon-Ortega et al., 2000) and they are used extensively in Mexico. The introduction of beds to the IGP is recent. There is only one season of experience with rice on 9 farms, where yields were comparable to or better than conventional practice. The bed system used half the normal irrigation water with a cost savings of about $100 per acre (R. Gupta, personal communication). The beds are a reduced tillage option because of some reforming and cultivation for weed control. Transfer of surface seeding and bed technologies are included in Cornell's technology adoption proposal.

b. *Residue placement* options are surface mulch or incorporation into soils. Strong effects of placement on residue decomposition have been reported in temperate environments (Schomberg et al.,1994) and surface mulches increase SOC compared to no mulch in tropical environments (Blair, 2000; Juo et al, 1996; Yadav et al., 1995). Residue placement practices will be superimposed on tillage experiments and in selected farmer fields to extend the range of environments. The studies will utilize a natural abundance $^{13}C^{13}C$ approach to trace the fate of added carbon. We have considerable experience with this type of study. Labeled straws will be prepared in greenhouses using fossil fuel carbon dioxide sources to create a different M ^{13}C value than that in field grown plants. This is a low cost way of producing large quantities of labeled straw for field studies.

c. The effect of residue quality on carbon sequestration and interactions with residue placement will initially be investigated in controlled environment pot experiments so that straws from many modern and traditional varieties of rice and wheat can be studied. Villegas-Pangga et al. (2000) found a two-fold difference in decomposition rates of rice straws from different varieties and we have observed that wheat straw mulches persist much longer than rice straw mulches. Schomberg et al. (1994) found strong interactions between residue placement and residue quality. Our experiments will use ^{13}C labeled residues. If marked differences are observed between varieties, selected varieties will be evaluated in microplot field experiments across a range of soil textures to address residue placement x residue quality x environment interactions.

d. Root versus shoot residue contributions to SOC will be evaluated because our studies with maize in New York have shown that, on an equal mass basis, root residues contribute 4x the amount of carbon to SOC than do stover residues. Recent work by Gale and Cambardella (2000) and Gale et al., (2000) has confirmed that root derived carbon is a major source of SOC. The contributions of root and straw residues from rice and wheat to SOC will be evaluated using in situ ^{13}C labeled plants in1m2 microplots that are maintained over several years. Crops will be pulse labeled at 3 times during their growth by covering the microplots with a plastic tent for 24 hours and releasing ^{13}C enriched CO_2 into the tent. Straw residues from labeled and unlabeled treatment plots will be exchanged to enable study of root and top decomposition patterns over time. One site for this study will be a tillage experiment at Bhairahawa, Nepal which is part of our current CRSP project. It has all combinations of tillage practices 1 and 2 for rice and wheat (see tillage table). A second site will be determined in consultation with collaborators.

e. The impact of nutrient management on carbon sequestration is associated with increased biomass production and therefore greater residue return rates. Although increased crop productivity is known to increase SOC content in temperate environments (Halvorson and Reule, 1999; Halvorson et al, 1999; Duiker and Lal, 1999), we hypothesize that the impact of nutrient inputs will not be a major factor in the IGP setting. This is partly because of the very low size of the labile pool of carbon in tropical soils and partly because we believe that root contributions will prove to be more important than top residues to carbon sequestration. Increased nutrient inputs have a much smaller effect on root biomass than on top biomass. Further, plant stands in the IGP are generally acceptable and are not much affected by fertility. Nutrient effects on SOC content will be assessed by:

   - collection and analysis of soil samples from 15 existing long-term soil fertility experiments in the IGP with variations in nutrient and residue inputs.

- by evaluating root and shoot contributions to SOC using ^{13}C labeled plants as described in section d) at two different fertility levels in 3 long-term soil fertility experiments in the IGP that differ in soil texture. Candidate sites are located at Bhairahawa in the Nepal Terai, which has a silt loam soil; Ludhiana, India or Nashipur in, NW Bangladesh which have sandy loam soils; and Pantanagar or Jabalpur, India, or Tarahara, Nepal which have clay loam soils.

2. <u>Modeling</u>

a. Data from the process experiments will be utilized as appropriate to adjust the Century model for the parameters evaluated.

b. Validation of model predictions will be done in several ways:

   - data from 13C studies on tillage experiments will be used to refine the CENTURY model without actually using the total SOC content of these experiments. They can therefore be used to validate model predictions. The experiments will have run for time periods of 9 and 15 years at Bhairahawa, Nepal and Nashipur, Bangladesh, respectively by 2007.

   - data (literature and measurement as needed) on other tillage experiments in the tropics.

c. Algorithms describing the dependence of SOC content on soil texture, mineralogy and aggregation will be developed for soils from the tropics using a combination of literature data and experimental measurements designed to fill gaps. Soils will be collected from countries where the SM-CRSP and Cornell have existing projects. Where possible, soils will be collected from both agricultural and natural ecosystems; the latter will, for the most part, represent the highest level of aggregation and SOC content. Aggregation will be determined as the mean weight diameter (MWD) of aggregates isolated following wet sieving or as the proportion of aggregates > 50 μm.

   The algorithms will be evaluated to see whether they improve the predictive capacity of the Century model using data sets from long-term experiments.

3. <u>Scaling</u>

The carbon sequestration model will be coupled with GIS based extrapolation domains to assess the potential impact of using various carbon sequestration technologies. Discrete steps in the process will be to go from farm to landscape to regional scales.

We will assess uncertainty of model predictions as information is upscaled. Uncertainties result from model errors, measurement errors, and error propagation (Corwin 1996). Model errors generally result from biophysical processes being poorly represented, or overly simplified, in model algorithms due to lack of appropriate data of suitable resolution at the scale of application. Measurement errors are a result of poor, or highly variable, field- or laboratory-based techniques or from generalization procedures used to re-scale input or validation data to the scale at which the modeling is conducted. Both model and measurement errors tend to propagate through the modeling process and can be assessed using sensitivity analysis in most case though other, more robust, methods are available (Loague and Corwin 1996). We will address scale-related factors in our evaluation of model performance and uncertainty by ensuring, to the degree possible: (1) consistency in our sampling and measurement of input and validation data, (2) close correspondence of model typology, model application, and nature and quality of field- and almanac-based data, and (3) appropriateness of measurements and monitoring methods at the given spatial and temporal scales of model application.

4. Large Scale Assessments

Country and regional (IGP) level analyses will be run purely on the biophysical basis to characterize the potential for carbon sequestration. This analysis will identify high return situations in terms of soils, technologies and geographic locations. We will then incorporate socio-economic factors into carbon sequestration projections because not all farmers will have the capacity or the desire to adopt these practices. Therefore, economic analyses of alternative C sequestration practices will be undertaken to identify cost/benefit ratios and economic constraints to adoption when agronomic, market, and carbon sequestration factors are included. These studies will be coupled with information from our technology adoption project where the reasons for adoption or non-adoption of different tillage practices will be explored. The most likely adoption scenario(s) can then be incorporated into larger scale assessments of carbon sequestration for use by policy makers.

Work Plans - West Africa

Russell Yost of the University of Hawaii will be responsible for the case studies in Mali, Senegal, The Gambia, and Cabo Verde. In addition, he will be responsible for the activities involving sampling and measurement of soil C across all sites in the proposed project. James W. Jones of the University of Florida will be responsible for the two case studies in Ghana and for the modeling activities across all sites. Yost and Jones will share responsibilities for the remaining activities, such as use of remote sensing for classification of management systems and scaling up predictions for each site. The tables below provide a list of activities with specific investigator responsibilities. The overall plan of work for the West African studies is based on close cooperation between investigators at UH and UF.

Objective 1.
Develop practical methods to measure gains and losses of soil organic C over time in spatially variable soils.

Output 1. Integrated protocol for measuring the gains and losses of soil C under agricultural systems incorporating sampling, prediction and remote sensing technologies.

Activity	When (Begin and End)	Responsible Investigator(s)
Travel to sites, meet collaborators, visit and consider sites	Feb – July '02	J.Jones, R. Yost
Survey, using remote sensing imagery. Identify landuse / cropping systems (Ghana-2, Mali-3, Senegal-1)	Aug - Oct '02	Collaborators, J. Jones, R. Yost
Workshops (5 countries); Planning ('02), Analysis ('04), Assessment ('06)	Nov '02 – Nov '06	Collaborators, J. Jones, R. Yost
Initial sampling of soils and biomass (5 countries)	Dec '02 – Feb '03	Collaborators, R. Yost
Laboratory analysis	Feb - Jun '03	Collaborators, R. Yost
Statistical analysis	Jul - Nov '03	Collaborators, R. Yost
Local workshops in 3 countries (Ghana, Mali, Senegal)	Feb '02	Collaborators, R. Yost, J. Jones

Output 2. Predictive tools for evaluating options for soil C sequestration at both farm and cropping system scales, including the role of livestock on C and nutrient balances.

Activity	When (Begin and End)	Responsible Investigator(s)
Incorporate soil phosphorus module into DSSAT crop models	Feb '02 - Feb '04	S. Daroub, R. Yost, K. Boote, A. J. Gijsman
Evaluate crop models under conditions of low soil P in African cropping systems	Jul '03 - Jul '06	Collaborators, K. Boote, J. Jones, S. Daroub, R. Yost
Experiments to quantify effects of soil water potential on soil organic matter decomposition, using soils in West Africa	Jul '02 - Jul '04	J. Scholberg, S. Adiku, A. Gijsman, J. Naab
Evaluate the DSSAT-CENTURY model to predict biomass, yield, and changes in soil C using long-term data sets	Jul '02 - Jul '05	Collaborators, A. Gijsman, C. Hiebsch, J. Jones, R. Yost
Combine cereal crops with the DSSAT-CENTURY to allow simulation of crop rotations, management in West Africa	Feb '02 - Jul '03	A. Gijsman, J. Jones, K. Boote
Develop methods to assess uncertainty in soil C acrretion, including effects of non-compliance and abandonment	Feb '05 - Dec '06	J. Jones, R. Yost, A. J. Gijsman

Objective 2.
Apply the methods to assess the potential for soil C sequestration for selected sites in West Africa.

Output 1. Land use-cropping systems with demonstrated capacity for sequestering C in soils in West Africa under different rainfall regimes

Activity	When (Begin and End)	Responsible Investigator(s)
Select farms for comparing C sequestration, two systems per site vs. traditional systems, obtain GPS coordinates	Feb '02 - Jun '02	Collaborators, R. Yost, J. Jones
Measure soil properties (texture, C, nutrients) for each field in the study prior to first growing season, each field and site	Mar '02 - Dec '02	Collaborators, R. Yost, J. Jones
Measure biomass production, yield, residue and lignin, P, and N in residue for each system each year; record rainfall at each field (annually), management details	Feb '03 – Dec '06	Collaborators, J. Jones, R. Yost
Obtain daily weather records for the nearest station for the years of the study as well as for at least the last 10 years	Feb '02 - Dec '06	Collaborators, J. Jones, R. Yost
Computerize soil, weather, and system data, perform simple statistical analyses on data	Feb '03 - Dec '06	Collaborators, J. Jones, R. Yost
Perform simulation analyses; first, evaluate predictions using data from each system, second, projecting changes in soil C over the next 5, 10, 20, and 50 years for each system	Feb '03 - Dec '06	Collaborators, J. Jones, R. Yost
Perform comparative analysis across locations on effects of soils, systems, rainfall on potential for soil C sequestration	Jul '04 - Dec '06	Collaborators, C. Hiebsch, J. Jones, R. Yost, A. Gijsman
Assemble farming system data for mixed crop-livestock systems for three of the sites	Jul '02 - Jul '04	P. Thornton, C. Hiebsch, J. Jones
Adapt and evaluate farming system model for the three sites	Feb '03 - Dec '04	P. Thornton, C. Hiebsch, J. Jones
Integrate DSSAT-CENTURY on soil C sequestration for different land use systems into farming system model	Jul '04 - Jul '05	P. Thornton, C. Hiebsch, A.Gijsman
Assess impacts of livestock management on soil C for the different systems; project impact over 5, 10, 20, and 50 years	Jul '05 - Dec '06	A. Gijsman, P. Thornton, C. Hiebsch, R. Yost

Output 2. An assessment of the potential for soil C sequestration for the selected sites in West Africa at scales necessary for C trading

Activity	When (Begin and End)	Responsible Investigator(s)
Evaluate the potential of remote sensing to classify management systems, monitor adherence to C seq. practices	Feb '02 - Dec'04	R. Yost, J. Jones
Develop methods for using remote sensing to estimate residue added to soil each year based on remote sensing	Feb '03 - Dec '04	R. Yost, J. Jones
Develop methods for remote sensing to provide inputs for DSSAT-CENTURY model for predicting C sequestration; verify them in study fields at each site	Feb '03 - Dec '05	J. Jones, R. Yost
Scale up predictions of soil C sequestration for each study region; produce maps showing potential under different scenarios	Feb '05 - Dec '06	R. Yost, C. Hiebsch, J. Jones, A. Gijsman

Schedule of Milestones, Completion Times – West Africa

Objective -Output	Milestone	Date to achieve
1-1	All fields and candidate systems are identified for each site	Jul '02
	Analyses of remote sensing images, identification of cropping systems are complete	Oct '02
	Organizing/planning meeting is completed; project protocol is refined and adopted by all collaborators via local workshops	Nov '02
	Sampling protocol for soil C is refined	Nov '03
	Protocol for measuring and verifying soil C sequestration is published along with detailed procedures for its essential components	Dec '05
1-1	All fields and candidate systems are identified for each site	Jul '02
1-2	Soil phosphorus module is incorporated in all crop models, providing capability to simulate low input cropping systems in P-limited soils of west Africa	Sep '03
	Calibrate and adapt crop models for the target crops, soils, management systems at all sites	Mar '04
	Newly derived relationships between soil water potential and organic matter decomposition is developed and incorporated into DSSAT-CENTURY model, for African soils	Jul '04
	The tool for predicting soil C sequestration under a wide range of cropping systems and environments in Africa, DSSAT-CENTURY, is completed for all crops in DSSAT	Jul '05
	Uncertainty of predictions are known for all candidate systems in each site	Jul '06
2-1	Initial soil organic C and N are known for different soils, climates and management systems across sites	Dec '02
	Data bases for organizing and integrating all data (historical and those data to be collected during project) for access by investigators/collaborators	Jul '03
	Predictions for potential soil C sequestration for all candidate systems are completed, including how time affects them	Jul '05
	Comparative assessment of soil C sequestration potential across sites, soils, climate, systems is completed	Dec '06
	Farming systems for three sites are characterized for assessing impacts of livestock on soil C sequestration in west Africa	Dec '03
	Farm scale assessment model linked with DSSAT-CENTURY	Jul '05
	Assessment of impacts of livestock on soil C sequestration; recommendations for incorporation of livestock management into protocol	Dec '06
2-2	Techniques are available for classifying management systems using remote sensing with known levels of precision	Dec '03
	Procedures are completed for linking predictive models with remote sensing for scaling up predictions for C sequestration	Jul '05
	Potential for soil C sequestration is scaled up for each site and maps are produced for all candidate system potentials	Sep '06

Work Plans – South Asia

Objective 1.
Develop practical methods to measure gains and losses of soil organic C over time in spatially variable soils

Output 1. Integrated protocol for measuring gains and losses of soil C under agricultural systems incorporating sampling, prediction and GIS technologies.

Activity	When (Begin and End)	Responsible Investigator(s) (first person is lead investigator)
Measure and/or assemble data on current soil carbon status at appropriate scales (1:50,000 or smaller for country level and for farm units in minimum area for C trading)	Continuous as needed through project	J. Lauren and collaborators
Use modified and validated CENTURY model to predict SOC dynamics with C sequestration practices at field scale	From output 2	J. Lauren, S. DeGloria, J. Duxbury
GIS based protocol developed for scaling from field to landscape to country - Compile/update geo-referenced soil texture/mineralogy and available SOC data in the IGP at 1:50,000 or smaller scale - Generate country-level prediction tool of C sequestration potential from soil texture/mineralogy-GIS data - Establish interface between GIS databases of soil texture and modified CENTURY model - Assess precision/errors of GIS based predictions at various scales - Predict amount and temporal pattern of C sequestration for various reduced tillage practices	 Feb '02- Feb '03 Mar' 03- Mar '04 Mar '04- Mar '05 Mar '05- Mar'06 July '05- Feb '07	 S. DeGloria,, GIS post doc S. DeGloria,, GIS post doc, R. Gupta S. DeGloria,, GIS post doc, J. Lauren S. DeGloria, GIS post doc J. Duxbury, P. Hobbs, R. Gupta
Apply protocol to example scenarios	As in Obj.2, output 2	S. DeGloria and collaborators

Output 2. Predictive tools for evaluating options for soil C sequestration at farm scale

Activity	When (Begin and End)	Responsible Investigator(s) (first person is lead investigator)
Development of texture/mineralogy-SOC algorithms using literature and experimental measurements	Feb '02-Feb '03	J. Lauren
Collaboration meeting to finalize sites & process level work plans	Feb '02	J. Duxbury, J. Lauren, collaborators
Characterization of C gains from sequestration practices:		
Tillage Experiments - India -Bangladesh - Nepal	 June '02 - May '06 June '02 - May '06 June '02- May '06	 R. Gupta, J.K. Ladha C. Meisner, J.K. Ladha P. Hobbs, P. Kataki, J. Tripathi, G. Sah

Residue Placement Experiments - farmer fields in Haryana, India - Kustia or Gazipur Bangladesh - Bhairahawa, Nepal	 June '03- May '05 June '03- May '05 June '03- May '05	 R. Gupta, P. Hobbs, J.K. Ladha C. Meisner, J.K.Ladha, N. Elahi, G. Panaullah P. Kataki, J. Tripathi, J. Duxbury
Residue Quality Experiments - Ithaca, NY greenhouse - fields TBD	 Feb '02- Feb '03 June '03- May '04	 S. Gami, J. Lauren, J. Duxbury Investigator depends on locations-TBD
Roots vs.Shoot Experiments Bhairahawa Tillage, Nepal Dinajpur Tillage, Bangladesh	 June '02- May '06 June '02- May '06	 P. Kataki, J. Tripathi, J. Duxbury C. Meisner, R.Amin, J.K. Ladha
Nutrient Management Experiments - Ludhiana, India - Tarahara, Nepal - Dinajpur, Bangladesh	 June '02- May '06 June '02- May '06 June '02- May '06	 R. Gupta, J.K.Ladha P. Kataki, C. Adhikari C. Meisner, R. Amin, J.K. Ladha
Annual review workshop	Feb '03- Feb '06	J. Duxbury, J. Lauren, collaborators
Modify CENTURY model to reflect residue C dynamics and critical variables obtained from process experiments	June '04- Jun '05 plus ?	J. Lauren, S. DeGloria, J. Duxbury
Validate modified CENTURY model with data tillage experiments and from long term soil fertility experiments	Feb '05- Feb '06 plus ?	J. Lauren, J. Duxbury, R. Gupta, J.K. Ladha

Objective 2.
Apply the methods to assess the potential for carbon sequestration for selected sites in South Asia

Output 1. Demonstrated capacity of reduced tillage management practices for sequestering carbon in soils of South Asia as a function of soil texture and mineralogy

Activity	When (Begin and End)	Responsible Investigator(s) (first person is lead investigator)
Development of texture/mineralogy-SOC algorithms using literature and experimental measurements	Feb '02 - Feb '03	J. Lauren
Determination of role of texture/mineralogy on C gains under different reduced tillage practices	June '02 - May '06	From Obj.1, output 2
Modification and validation of CENTURY model	June '04 - Feb '06	From Obj.1, output 2
Quantitative assessment of C sequestration by different reduced tillage practices using CENTURY	Feb '06 - Feb '07	J. Duxbury and collaborators

Output 3. An assessment of the potential for soil C sequestration in the IGP of in South Asia at scales necessary for carbon trading and agricultural policy development

Activity	When (Begin and End)	Responsible Investigator(s) (first person is lead investigator)
Country level using texture/mineralogy-SOC algorithms to determine maximum sequestration potential: - assemble current soil C data at 1:50,000 scale - compile GIS texture/mineralogy databases at 1:50,000 scale - use GIS framework and algorithms to calculate maximum SOC level and subtract current C levels to determine maximum C sequestration potential	Feb '03- Feb '04 Feb' 02- Feb '03 May '04- Oct. '04	J. Lauren S. DeGloria, GIS post doc S. DeGloria, GIS post doc, J.Duxbury,
Country level using protocol from Obj.1, output 1: - replace algorithms with CENTURY model then follow same process for maximum seq. potential - assess outcome for different sequestration practices - survey farmers for likely adoption of alternative sequestration practices - estimate achievable C sequestration levels	June '05- Sep. '05 Sep '05- June '06 other program June '06- Feb '07	S. DeGloria, J. Lauren, GIS post doc GIS post doc, J. Lauren D. Lee (from Cornell technol. Adoption program) J. Duxbury, GIS post doc

Schedule of Milestones, Completion Times – South Asia

Objective -Output	Milestone	Date to Achieve
1-1	Soil carbon status data bases for IGP are assembled	Feb ‘03
	Iterations of modified CENTURY C model available - initial version - final version	Feb ‘04 Dec ‘05
	Data bases on soil texture and mineralogy assembled for IGP	Feb ‘03
	Functional interface between GIS and CENTURY model	Mar ‘05
	Errors in scaling from field upwards are evaluated	Mar ‘06
	Protocol for assessing C sequestration at different scales is published	July ‘06
1-2	Site locations and process level study plans are finalized	Apr ‘02
	SOC relationships to texture and mineralogy established	Feb ‘03
	Process studies completed and final results incorporated into CENTURY model - residue quality - residue placement - root versus shoot contributions - nutrient management effects	Aug ‘04 Aug ‘05 Aug ‘05 May ‘05
	Modifications of CENTURY model completed	Dec ‘05
2-2	Algorithms to describe maximum and minimum SOC contents of IGP soils based on soil texture and mineralogy are established and generalizability of approach is broadly defined	Feb ‘03
	Effects of various reduced tillage practices on SOC sequestration predicted at field scale for selected IGP sites as a function of soil texture/mineralogy	Dec ‘05

2-3	Use of algorithms and GIS framework to evaluate C sequestration potential and dynamics at country scale is demonstrated	Oct '04
	Farmer acceptance of alternative tillage practices and constraints to adoption evaluated	Oct '05
	Country level estimates of maximum C sequestration potential and dynamics for best alternative tillage practices with current farmer resources	Oct '06
	Country level estimates of achievable sequestration potential considering farmer acceptance and socio-economic data (1-1)	Dec '06

Annex: Impact Assessment/Verifiable Indicators of Success

LOGICAL FRAMEWORK FOR IMPACT ASSESSMENT/ VERIFIABLE INDICATORS OF SUCCESS			
Description	**Objectively verifiable Indicators**	**Means of verification**	**Assumptions**
Constraint: "Lack of a standard procedures to measure gains and losses of C sequestered as soil organic matter."			
Objective 1: Develop practical methods to measure gains and losses of soil organic C over time in spatially variable soils.			
Output 1: Integrated protocol for measuring the gains and losses of soil C under agricultural systems incorporating sampling, prediction and remote sensing technologies	Existence of a C-measuring protocol developed by the project that considers sampling, prediction, and remote-sensing	Examination of documentation of such a protocol	- Such a protocol is possible to develop - C stored in soils can be sampled and predicted and - Remote-sensed technologies are available that can be used to detect C sequestration and management systems
Output 2: Predictive tools for evaluating options for soil C sequestration at both farm and cropping systems scales, including the role of livestock on C and nutrient balances	Existence of tools that permit evaluating options for soil C sequestration at both farm and cropping systems scales, including livestock	Examination of the use of example uses of such tools	-Tools can be developed to evaluate C sequestration - Examples of C sequestration are available and experiments can be conducted on such systems - Livestock systems are available and their role in nutrient balance can be experimentally determined
Objective 2: Apply the methods to assess the potential for soil C sequestration for selected sites in West Africa and Southern Asia			
Output 1. Land use-cropping systems with demonstrated capacity for sequestering C in soils in West Africa and South Asia under different rainfall regimes	Assessments of soil C sequestration in West Africa and Southern Asian sites in demonstrated landuse/cropping systems under different rainfall regimes	Examination of the assessments of soil C sequestration	- Collaborators can assist in carrying out of assessments - Assessment can be carried out because landuse/cropping systems are available to be assessed - Equipment and personnel areavailable to carry out such assessments

Output 2. Demonstrated capacity of reduced tillage management practices for sequestering carbon in soils of South Asia over soil texture gradients.	Assessments of soil C sequestration for the selected sites	Examination of the assessments and comparison with international requirements for C trading	- Collaborators can assist in carrying out assessments at such large regions - Components of the protocol are feasible carrying out the large scale assessment
Output 3. An assessment of the potential for soil Csequestration for the selected sites in West Africa and South Asia at large spatial scales necessary for C trading	Assessments of soil C sequestration for the selected sites	Examination of the assessments and comparison with international requirements for C trading	- Collaborators can assist in carrying out assessments at such large regions - Components of the protocol are feasible carrying out the large scale assessment

Annex: Cornell University Budget

Cornell University Carbon Sequestration - Year 1 Budget			
Personnel	**FTE**	**On Campus**	**Off Campus**
Research Associate	0.8	37,360	---
Extension Associate	0.5	---	16,950
Graduate students	1	17,900	---
Fringe benefits @32.91%, ex. grad. stud.		12,295	5,578
	Total	**67,555**	**22,528**
Sub-Contracts			
CIMMYT (RW Consort.)			32,300
Supplies		11,000	1,000
Travel			
Domestic			3,000
International			17,000
Other Direct Costs		29,055	27,500
Total Direct Costs		107,610	103,328
Indirect Costs (59% on-campus, 26% off-campus, less exclusions)		57,262	17,167
Total direct + indirect costs		164,872	120,495
	GRAND TOTAL	285,367	

Five Year Total Budget

Cornell University Carbon Sequestration Budget Summary ($)						
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total**
1. Salary and Wages	72,210	75,500	79,000	82,500	86,000	395,210
2. Fringe benefits (@32.91%)	17,873	18,759	19,746	20,733	21,721	98,832
3. Other Direct Costs:						
a. Subcontracts	32,300	21,000	21,000	21,000	21,000	116,300
b. Consultants	---	---	---	---	---	---
c. Equipment	---	---	---	---	---	---
d. Supplies	12,000	25,000	25,000	20,000	15,000	97,000
e. Travel						
Domestic	3,000	3,000	3,000	3,000	3,000	15,000
International	17,000	20,000	20,000	20,000	20,000	97,000
f. Other	56,555	40,000	35,000	35,000	30,000	196,555
4. INDIRECT COSTS						
On Campus @ 59%	57,262	43,710	44,691	46,552	45,908	238,123
Off Campus @ 26%	17,167	24,225	24,051	23,226	22,077	110,746
5. Sub-Total	285,367	271,194	271,488	272,011	264,705	1,364,765
6. Cost-sharing @25%	71,342	67,798	67,872	68,003	66,176	341,191
7. Total Estimated Costs	356,709	338,992	339,360	340,014	330,882	1,705,957

Cost sharing calculation (annual)

0.35 FTE Cornell faculty at average salary of $ 92,403	32,341
Fringe benefits @32.91%	10,643
Sub-total	42,984
Indirect costs @ 59%	25,361
Annual Total	68,345
5 year Total	341,725

Annex: University of Florida Budget

The Florida budget is first summarized by year and category below. A second set of budgets provide yearly budgets using the format specified in the instructions for the SM CRSP Request for Proposals 2002-2007. Finally, detailed budgets are provided for each output and year. In all cases, the budget is broken down into itemized categories for the UF portion of the budget, but only totals are given for the budgets to be allocated as subcontracts to collaborators at the University of Ghana, The Savana Agricultural Research Insititue (SARI) in Ghana, and the International Livestock Research Institute (ILRI) in Kenya. Overhead for the subcontracts was computed as 0.445 of the first $25,000 to each institute, according to university policy. A Budget Discussion follows the detailed budget information.

A. Florida Budget Summary, across all objectives and outputs

OBJECT	'02 PY1	'03 PY2	'04 PY3	'05 PY4	'06 PY5	Total
Post doc/scientist	45,000	46,350	47,741	49,173	50,648	238,912
Research Associate	25,000	25,750	26,523	27,319	28,139	132,731
Fringe benefits (8.3%)	5,810	5,984	6,164	6,349	6,539	30,846
Grad Students	30,000	30,000	30,000	30,000	30,000	150,000
Travel						
International	16,000	8,000	10,000	8,000	10,000	52,000
US	4,000	4,000	4,000	4,000	4,000	20,000
Supplies	10,500	4,300	10,500	4,300	10,500	40,100
UF Basis for Overhead	136,310	124,384	134,928	129,141	139,826	664,589
Overhead (44.5%)	60,658	55,351	60,043	57,468	62,223	295,743
Equipment	7,500	2,500	2,500	0	0	12,500
Tuition Waivers (2)	6,136	6,760	7,436	8,180	8,998	37,510
Collaborators						
SARI (Naab)	20,000	20,000	22,000	18,000	18,000	98,000
Overhead (1st 25000)	8,900	2,225	0	0	0	11,125
U. Ghana (Adiku)	20,000	20,000	22,000	18,000	18,000	98,000
Overhead (1st 25000)	8,900	2,225	0	0	0	11,125
ILRI (Thornton)	15,000	30,000	30,000	30,000	30,000	135,000
Overhead (1st 25000)	6,675	4,450	0	0	0	11,125
Total Collaborators	**79,475**	**78,900**	**74,000**	**66,000**	**66,000**	**364,375**
Sum of Overhead to UF	***85,133***	***64,251***	***60,043***	***57,468***	***62,223***	***329,118***
Total Budget	**290,079**	**267,895**	**278,907**	**260,789**	**277,047**	**1,374,717**

B. Line Item Budget for Each Year Using Specified Format

i) For Period from January 2002 to December 2002 (Project year 1)

Line Item	A	B (AID USE ONLY)	C
1. Salaries and wages			
Post Doc and Res. Assoc.	70,000		
Graduate Students	30,000		
2. Fringe benefits (rate: 0.083 for all but graduate students)	5,810		
3. Other direct costs			
a. Subcontracts	55,000		
b. Consultants	0		
c. Equipment	7,500		
d. Travel (domestic U.S.)	4,000		
Travel (international)	16,000		
f. Other			
Supplies, Other Expenses	10,500		
Graduate Tuition Waiver	6,136		
4. Indirect Costs (rates: 0.445 of funds spent at UF, excluding equipment and tuition waivers. For each Subcontract - 0.445 of first $25,000)	85,133		
5. Subtotal	290,079		
6. Cost Sharing (minimum 25% of Sub-total minus host country subcontracts)	58,770		
7. Total Estimate Costs (Year 1)	348,849		

ii) For Period from January 2003 to December 2003 (Project year 2)

Line Item	A	B (AID USE ONLY)	C
1. Salaries and wages			
Post Doc and Res. Assoc.	72,100		
Graduate Students	30,000		
2. Fringe benefits (rate: 0.083 for all but graduate students)	5,984		
3. Other direct costs			
a. Subcontracts	70,000		
b. Consultants	0		
c. Equipment	2,500		
d. Travel (domestic U.S.)	4,000		
Travel (international)	8,000		
f. Other			
Supplies, Other Expenses	4,300		
Graduate Tuition Waiver	6,760		
4. Indirect Costs (rates: 0.445 of funds spent at UF, excluding equipment and tuition waivers. For each Subcontract - 0.445 of first $25,000)	64,251		
5. Subtotal	267,895		
6. Cost Sharing (minimum 25% of Sub-total minus host country subcontracts)	49,474		
7. Total Estimate Costs (Year 2)	317,369		

iii) For Period from January 2004 to December 2004 (Project year 3)

Line Item	A	B (AID USE ONLY)	C
1. Salaries and wages:			
Post Doc and Res. Assoc.	74,264		
Graduate Students	30,000		
2. Fringe benefits (rate: 0.083 for all but graduate students)	6,164		
3. Other direct costs			
a. Subcontracts	74,000		
b. Consultants	0		
c. Equipment	2,500		
d. Travel (domestic U.S.)	4,000		
Travel (international)	10,000		
f. Other			
Supplies, Other Expenses	10,500		
Graduate Tuition Waiver	7,436		
4. Indirect Costs (rates: 0.445 of funds spent at UF, excluding equipment and tuition waivers. For each Subcontract - 0.445 of first $25,000)	60,043		
5. Subtotal	278,907		
6. Cost Sharing (minimum 25% of Sub-total minus host country subcontracts)	51,227		
7. Total Estimate Costs (Year 3)	330,134		

iv) For Period from January 2005 to December 2005 (Project year 4)

Line Item	A	B (AID USE ONLY)	C
1. Salaries and wages:			
Post Doc and Res. Assoc.	76,492		
Graduate Students	30,000		
2. Fringe benefits (rate: 0.083 for all but graduate students)	6,349		
3. Other direct costs	66,000		
a. Subcontracts	0		
b. Consultants	0		
c. Equipment	0		
d. Travel (domestic U.S.)	4,000		
Travel (international)	8,000		
f. Other			
Supplies, Other Expenses	4,300		
Graduate Tuition Waiver	8,180		
4. Indirect Costs (rates: 0.445 of funds spent at UF, excluding equipment and tuition waivers. For each Subcontract - 0.445 of first $25,000)	57,468		
5. Subtotal	260,789		
6. Cost Sharing (minimum 25% of Sub-total minus host country subcontracts)	48,697		
7. Total Estimate Costs (Year 4)	309,486		

v) For Period from January 2006 to December 2006 (Project year 5)

Line Item	A	B (AID USE ONLY)	C
1. Salaries and wages:			
Post Doc and Res. Assoc.	78,787		
Graduate Students	30,000		
2. Fringe benefits (rate: 0.083 for all but graduate students)	6,539		
3. Other direct costs			
a. Subcontracts	66,000		
b. Consultants	0		
c. Equipment	0		
d. Travel (domestic U.S.)	4,000		
Travel (international)	10,000		
f. Other			
Supplies, Other Expenses	10,500		
Graduate Tuition Waiver	8,998		
4. Indirect Costs (rates: 0.445 of funds spent at UF, excluding equipment and tuition waivers. For each Subcontract - 0.445 of first $25,000)	62,223		
5. Subtotal	277,047		
6. Cost Sharing (minimum 25% of Sub-total minus host country subcontracts)	52,762		
7. Total Estimate Costs (Year 4)	329,809		

C. Budget by Output: Yearly Values Plus Total

	Objective 1 - Output 1					
OBJECT	**'02 PY1**	**'03 PY2**	**'04 PY3**	**'05 PY4**	**'06 PY5**	**Total**
Post doc/scientist (0.20)	9,000	9,270	9,548	9,835	10,130	47,783
Research Associate (0.3)	7,500	7,725	7,957	8,196	8,442	39,820
Fringe Benefits (8.3%)	1,370	1,411	1,453	1,497	1,541	7,272
Grad Students (0.25)	7,500	7,500	7,500	7,500	7,500	37,500
Travel						
International	16,000	0	10,000	0	10,000	36,000
US	1,000	1,000	1,000	1,000	1,000	5,000
Supplies	7,000	800	7,000	800	7,000	22,600
UF Basis for Overhead	49,370	27,706	44,458	28,828	45,613	195,975
Overhead (44.5%)	21,970	12,329	19,784	12,828	20,298	87,209
Equipment	2,500	0	2,500	0	0	5,000
Tuition Waiver (0.5)	1,534	1,690	1,859	2,045	2,250	9,378
Collaborators						
SARI (Naab)	5,000				0	5,000
Overhead (1st 25000)	2,225					2,225
U. Ghana (Adiku)	5,000				0	5,000
Overhead (1st 25000)	2,225					2,225
ILRI (Thornton)	0					0
Overhead (1st 25000)	0	0	0	0	0	0
Total Collaborators	14,450	0	0	0	0	14,450
Totals	**89,824**	**41,725**	**68,601**	**43,701**	**68,161**	**312,012**

	Objective 1 - Output 2					
OBJECT	**'02 PY1**	**'03 PY2**	**'04 PY3**	**'05 PY4**	**'06 PY5**	**Total**
Post doc/scientist (0.60)	27,000	27,810	28,645	29,504	30,388	143,347
Research Associate (0.4)	10,000	10,300	10,609	10,927	11,255	53,091
Fringe Benefits (8.3%)	3,070	3,163	3,258	3,355	3,456	16,302
Grad Students (0.50)	15,000	15,000	15,000	15,000	15,000	75,000
Travel						
International	0	4,000	0	4,000	0	8,000
US	2,000	2,000	2,000	2,000	2,000	10,000
Supplies	2,500	2,500	2,500	2,500	2,500	12,500
UF Basis for Overhead	59,570	64,773	62,012	67,286	64,599	318,240
Overhead (.445)	26,508	28,824	27,595	29,943	28,746	141,616
Equipment	2,500	2,500	0	0	0	5,000
Tuition Waiver (1)	3,068	3,380	3,718	4,090	4,498	18,754
Collaborators						
SARI (Naab)	5,000	10,000	10,000		0	25,000
Overhead (1st 25000)	2,225	2,225	0	0	0	4,450
U. Ghana (Adiku)	5,000	10,000	10,000		0	25,000
Overhead (1st 25000)	2,225	2,225	0	0	0	4,450
ILRI (Thornton)	0					0
Overhead (1st 25000)	0	0	0	0	0	0
Total Collaborators	14,450	24,450	20,000	0	0	58,900
Totals	**106,096**	**123,927**	**113,325**	**101,319**	**97,843**	**542,510**

	Objective 2 - Output 1					
OBJECT	**'02 PY1**	**'03 PY2**	**'04 PY3**	**'05 PY4**	**'06 PY5**	**Total**
Post doc/scientist (0.1)	4,500	4,635	4,774	4,917	5,065	23,891
Research Associate (0.2)	5,000	5,150	5,305	5,464	5,628	26,547
Fringe Benefits (8.3%)	789	812	837	862	888	4,188
Grad Students (none)						0
Travel						
International						0
US						0
Supplies	0	0	0	0	0	0
UF Basis for Overhead	10,289	10,597	10,916	11,243	11,581	54,626
Overhead (.445)	4,579	4,716	4,858	5,003	5,154	24,310
Equipment						0
Tuition Waiver (0)						0
Collaborators						
SARI (Naab)	10,000	10,000	12,000	18,000	18,000	68,000
Overhead (1st 25000)	4,450					4,450
U. Ghana (Adiku)	10,000	10,000	12,000	18,000	18,000	68,000
Overhead (1st 25000)	4,450					4,450
ILRI (Thornton)	15,000	30,000	30,000	30,000	30,000	135,000
Overhead (1st 25000)	6,675	4,450				11,125
Total Collaborators	50,575	54,450	54,000	66,000	66,000	291,025
Totals	**65,443**	**69,763**	**69,774**	**82,246**	**82,735**	**369,961**

	Objective 2 - Output 2					
OBJECT	**'02 PY1**	**'03 PY2**	**'04 PY3**	**'05 PY4**	**'06 PY5**	**Total**
Post doc/scientist (0.1)	4,500	4,635	4,774	4,917	5,065	23,891
Research Associate (0.1)	2,500	2,575	2,652	2,732	2,814	13,273
Fringe Benefits (8.3%)	581	598	616	635	654	3,084
Grad Students (.25)	7,500	7,500	7,500	7,500	7,500	37,500
Travel						
International		4,000		4,000		8,000
US	1,000	1,000	1,000	1,000	1,000	5,000
Supplies	1,000	1,000	1,000	1,000	1,000	5,000
UF Basis for Overhead	17,081	21,308	17,542	21,784	18,033	95,748
Overhead (.445)	7,601	9,482	7,806	9,694	8,025	42,608
Equipment	2,500					2,500
Tuition Waiver (.5)	1,534	1,690	1,859	2,045	2,250	9,378
Collaborators						
SARI (Naab)						0
Overhead (1st 25000)						0
U. Ghana (Adiku)						0
Overhead (1st 25000)						0
ILRI (Thornton)						0
Overhead (1st 25000)						0
Total Collaborators	0	0	0	0	0	0
Totals	**28,716**	**32,480**	**27,207**	**33,523**	**28,308**	**150,234**

Annex: University of Florida Budget Discussion:

1. **Salaries and Wages:**

   List of personnel on UF team paid by project funds:
   - Scientist or Post Doc - 1.0 FTE. Dr. Arjan Gijsman will fill this position.
   - Research Associate - 1.0 FTE.
   - Graduate Students - 2 Students at ½ time each, or 1.0 FTE
   - Additional personnel will be hired by subcontractors, such as ½ time post doc at ILRI. Details on subcontracts are not provided here.

   List of UF faculty on the project team (paid by UF):
   - Dr. James W. Jones - 0.20 FTE.
   - Dr. Clifton K. Hiebsch - 0.10 FTE.
   - Dr. Kenneth J. Boote - 0.10 FTE.
   - Dr. Samira Daroub - 0.05 FTE.
   - Dr. Johannes Scholberg - 0.10 FTE.

2. **Fringe benefits:**

   - Regular employees of UF - 18.83% of salary + $4699.20/year for family health insurance.
   - Post Docs, Research Associates - 8.3 % of salary for social security, unemployment, and workman's compensation
   - Graduate students - None, but tuition waiver is required. Tuition waiver increases at 10% per year, starting at $3,068 in 2002 for a ½-time graduate student.

Cost Sharing

Cost sharing requirement is 0.25 of funds spent at UF, excluding host country subcontracts. The UF budget excluding host county contracts is $1,043,717. The minimum cost share requirement is twenty five percent of this budget: $260,929, or $52,186 per year.

Estimated based on senior faculty time, including fringe benefits, medical insurance and overhead at 44.5%. Total senior faculty time = 0.55 FTE (J. W. Jones (20%), C. K. Hiebsch (10%), K. J. Boote (10%), S. Daroub (5%), J. Scholberg (10%)).

Computed for each person by:
{FTE * (Estimated Salary (1+0.1883) + $4,699.20} {1.0 + 0.445}

Annual Cost Sharing Estimate: $74,653

5-Year Cost Sharing Total: $373,263

The estimated annual cost sharing is in excess of the minimum required for this contract by approximately 43%.

Indirect Costs (University of Florida)

EFFECTIVE PERIOD	RATE*	LOCATIONS	APPLICABLE TO
7/1/98 - 6/30/00	44.5%	On-Campus	Research
7/1/98 - 6/30/00	24.0%	Off-Campus	Research
7/1/98 - 6/30/00	46.0%	On-Campus	Instruction
7/1/98 - 6/30/00	31.0%	Off -Campus	Instruction
7/1/98 - 6/30/00	42.0%	On-Campus	AREC (A)
7/1/98 - 6/30/00	26.0%	Off -Campus	AREC (A)
7/1/98 - 6/30/00	19.4%	On-Campus	Other Sponsored Activity
7/1/98 - 6/30/00	16.9%	Off -Campus	Other Sponsored Activity
7/1/98 - 6/30/00	27.9%	All	Restricted Instr. (B)

* Apply the rate on the modified total direct costs (MTDC), which includes salaries & wages, fringe benefits, materials and supplies, services, travel, subcontracts & subgrants up to $25,000 each; excludes any equipment over $500, capital expenditures, charges for patient care, tuition, rental costs of off-site facilities, scholarships, fellowships, and the portion of subcontracts & subgrants in excess of $25,000

3. **Travel Expenses.**

<u>Domestic</u>. Travel funds are requested to allow one UF faculty member to make one trip per year to work with Russ Yost of Hawaii on activities that are shared among these two locations. Cost of the airline ticket from Gainesville to Honolulu is about $1,000 roundtrip, tourist class, lowest rate. Assuming the person stays 5 days and perdiem is about $120 per day, this results in an annual cost of $1,600. Requests are made for a second trip, once per year, to Washington, D.C. to work with Dr. Paul Doraiswamy on remote sensing-model linkage activities. Airline ticket cost from Gainesville is about $400 (lowest fare from Gainesville), and assuming that the person works there for five days at $120 per day for perdiem, this results in a cost of $1,000 annually. Additionally, we plan to support two of UF faculty trips per year to travel to symposia related to soil C sequestration or annual meetings of professional societies for presenting our findings and interacting with others doing similar work. For these two trips, we are requesting $700 per trip, times two trips per year, resulting in $1,400 for this travel. Total domestic travel request is thus $4,000 per year.

<u>International</u>. According to Travelocity, the cheapest US carrier airfare from Gainesville to Bamako, Mali and return is about $2,900. This is the fare assumed for all travel to and from West Africa. We also assume that the daily perdiem will be $100, regardless of location in West Africa visited.

During the first year, we plan to travel to Mali, Ghana, and Senegal to hold a workshop and select sites for the research. This is a critical trip, for we will present and discuss all aspects of the protocol for the research as discussed in Project Strategy and Approach. Three people will travel from UF to participate in these workshops, site visits, and planning sessions. In addition to J. Jones, A. Gijsman and either C. Hiebsch or J. Scholberg will go to cover the different facets of the protocol that UF is responsible for. The duration of the mission during this first year will be 14 days, and there will be travel among locations in Mali, Ghana, and Senegal. Estimated cost for each person for this mission will be $2,900 (airfare) plus $1,400 (perdiem) plus $1,033 (travel among locations). Multiplying this by 3 people results in a cost of $16,000 for first year international travel.

Our strategy is to have principal collaborators from Ghana (the sites UF is responsible for) make two trips to UF during the five year project. This travel will allow UF and Ghana researchers to work closely on various aspects of the data analysis and simulation activities and help ensure close coordination so that the comparative analysis can be done across locations. During the second and fourth years, Dr. Adiku and Dr. Naab will travel to UF and work for about 10 days. Thus, international travel in the amount of $8,000 is requested in each of the second and fourth years ($2,900 airfare, $1,100 perdiem and miscellaneous costs) for each person.

During the third and final years, two people from UF will travel to Ghana, Mali, and/or Senegal to work with collaborators. These trips are expected to last about 15 days each and thus cost $2,900 (airfare), $1,500 (perdiem), and $600 (travel within the region). This totals $5,000 per person per trip, and thus $10,000 is requested for international travel during the third and fifth years.

4. Equipment:

- Year 1. Three computer systems (at $2,500 each) will be purchased for use by the scientist position, the research associate, and one graduate student. These systems will include operating software, printer, and internet connection so that project personnel can perform their tasks and communicate with other personnel via the Internet.

- Year 2. A computer system ($2,500) will be purchased for use by the PI of the project. Other UF faculty investigators have computers and the project funds will not be needed to purchase computer systems for them.

- Year 3. A computer system will be purchased ($2,500) for the second graduate student. See above.

5. Other Expenses.

A total of $40,100 is requested for materials and supplies over the 5-year project. This request is based on the following estimates of expenses:

- Remote sensing images for the two Ghana sites ($24,800 total, including 6 high resolution IKONOS images at about $3,600 each and 8 LANDSAT images at about $400 each)

- Scientific programming software, necessary for the special aspects of this project, including software for geostatistics ($800), for programming tools for Internet sharing of data and models, such as Java and UML tools ($3,200)

- Laboratory supplies and equipment repair/maintenance (pressure plate apparatus) for conducting the experiments on soil organic matter decomposition - $4,000

- Costs for publications (scientific and lay) and photocopying - $4,300

- Long distance communications (telephone and fax costs) - $3,000

Annex: University of Hawaii Budget

SMCRSP Phase 2 proposal on carbon sequestration						
Personnel	**YR 1**	**YR 2**	**YR 3**	**YR 4**	**YR 5**	**Total**
Res. Assoc.	32,000	32,960	33,949	34,967	36,016	169,892
Grad. Asst.	19,000	38,000	38,000	38,000	38,000	171,000
Student	6,000	5,000	0	5,000	0	16,000
Fiscal Specialist	10,000	10,000	10,000	10,000	10,000	50,000
Fringe*	14,904	18,575	18,794	19,121	19,356	90,751
Subcontracts@						
Mali	25,000	25,000	25,000	25,000	25,000	125,000
Senegal	25,000	25,000	25,000	25,000	25,000	125,000
Gambia	10,000	10,000	20,000	20,000	20,000	80,000
Cabo Verde	10,000	10,000	20,000	20,000	20,000	80,000
Supplies	29,857	20,542	7,324	8,642	7,358	73,722
Equipment	0	0	0	0	0	0
Travel	20,000	20,000	25,000	20,000	25,000	110,000
Indirect Costs@	73,239	59,923	51,933	49,270	49,270	283,635
Total	**275,000**	**275,000**	**275,000**	**275,000**	**275,000**	**1,375,000**

* -- Fringe Rates RA=27.2%, GA=18%, Student=1%, Fiscal=27.20%
@ -- Indirect cost based on 36.30% of MTDC (Modified Total Direct Cost)

Modified Total Direct Cost = Total Direct Cost less the initial $25,000 of each Subcontract

Cost Sharing: Required amount = 25% of Total Costs less Subcontracts to Host-countries and less Training of Participants (Grad Assistants). YR1 = Yost @ .25FTE, Uehara @ .15FTE, Fringe @ 27.17%. YR2-5 = Yost @ .20FTE, Uehara @ .20FTE, Fringe @ 27.17%.

Travel events:

Year 1: RAssoc, Yost - Mali, Senegal, The Gambia, Cabo Verde, Ghana: $10,000, GAsst: to Univ. Hawaii $5000, Collaborators Mali, Senegal, The Gambia, Cabo Verde to workshop$5000.

Year 2: RA Mali, Senegal, The Gambia, Cabo Verde, Ghana: $10,000; Yost Mali, Senegal; $6000, GA: To Mali, Senegal $4000.

Year 3: RA/Yost: Mali, Senegal The Gambia, Cabo Verde, Ghana: $12,000, GA to Mali/Senegal $5000, Collaborators travel to local workshop $8000,

Year 4: RA: Mali, Senegal The Gambia, Cabo Verde, Ghana: $10,000; Collaborators to US $5000, GA: Mali/Senegal $5000.

Year 5: RA, Yost: Mali, Senegal The Gambia, Cabo Verde, Ghana: $12,000; GA to Mali, $5000. Collaborators to workshop $8000.

Budget +150%						
Personnel	**YR 1**	**YR 2**	**YR 3**	**YR 4**	**YR 5**	**Total**
Res. Assoc.	32,000	32,960	33,949	34,967	36,016	169,892
Grad. Asst.	38,000	38,000	38,000	38,000	38,000	190,000
Student	6,000	5,000	0	5,000	5,000	21,000
Fiscal Specialist	10,000	10,000	10,000	10,000	10,000	50,000
Fringe*	18,324	18,575	18,794	19,121	19,406	94,221
Subcontracts@						
Mali	50,000	50,000	50,000	50,000	50,000	250,000
Senegal	50,000	50,000	50,000	50,000	50,000	250,000
Gambia	25,000	50,000	50,000	50,000	50,000	225,000
Cabo Verde	25,000	50,000	50,000	50,000	50,000	225,000
Supplies	36,634	31,371	27,500	28,818	22,484	146,806
Equipment	0	0	0	0	0	0
Travel	25,000	20,000	25,000	20,000	25,000	115,000
Indirect Costs@	96,543	56,594	59,257	56,594	56,594	325,581
Total	**412,500**	**412,500**	**412,500**	**412,500**	**412,500**	**2,062,500**
Total - Indirect	**315,958**	**355,906**	**353,243**	**355,906**	**355,906**	**1,736,919**

* -- Fringe Rates RA=27.2%, GA=18%, Student=1%, Fiscal=27.20%
@ -- Indirect cost based on 36.30% of MTDC (Modified Total Direct Cost)

Modified Total Direct Cost = Total Direct Cost less the initial $25,000 of each Subcontract

Supplies for year 1 include $20,000 for imagery, $3000 for each country for DGPS units, three technologies will be explored in each country with additional funds

Travel events:

Year 1: RAssoc, Yost - Mali, Senegal, The Gambia, Cabo Verde, Ghana: $10,000, GAsst: to Univ. Hawaii $5000, Collaborators Mali, Senegal, The Gambia, Cabo Verde to workshop$5000.

Year 2: RA Mali, Senegal, The Gambia, Cabo Verde, Ghana: $10,000; Yost Mali, Senegal; $6000, GA: To Mali, Senegal $4000.

Year 3: RA/Yost: Mali, Senegal The Gambia, Cabo Verde, Ghana: $12,000, GA to Mali/Senegal $5000, Collaborators travel to local workshop $8000,

Year 4: RA: Mali, Senegal The Gambia, Cabo Verde, Ghana: $10,000; Collaborators to US $5000, GA: Mali/Senegal $5000.

Year 5: RA, Yost: Mali, Senegal The Gambia, Cabo Verde, Ghana: $12,000; GA to Mali, $5000. Collaborators to workshop $8000.

University of Hawaii Budget Discussion:

Principal activities will be to develop and test a "General Protocol" of measuring soil organic C at the field level and scaling up such measured values to regional estimates for use in C accretion and possible C trading activities. In addition, activities will be selected to emphasize and encourage and build on previous and currently promising landuse/cropping systems for food production that improve the natural resource base and provide income. We will work through National Agricultural Research Organizations, seeking to identify the expertise and resource strengths of each scientist that can contribute to the project and the long term capacity-building goals. Examples of increased capacity may be increased skill and ability in the use of remote-sensing imagery, improved analytical skill, especially with respect to soil carbon and soil organic matter, improved skill and versatility in the use of simulation models, and in the ability to work at several scales as illustrated by the scaling up of field measurements to regional estimates.

Assistance and expertise in remote-sensing will be provided by Dr. Sibiry Traore, ICRISAT/Bamako, Mali. Mr. Traore has managed and maintained the GIS and GPS systems from their first introduction at IER/Mali. Mr. Traore is improving the capability of ICRISAT and IER in the use of information science tools. Mr. Antonio Querido, INIDA/Cabo Verde will also participate in the remote-sensing team for the project based on his experience while studying at Wageningen University, The Netherlands. In addition, at least one graduate student will work with remote sensing technology both in identifying landuse/cropping systems, and in the scaling up techniques. Dr. Russ Yost and Jim Jones will coordinate the initial remote-sensing, sampling, and C measurements.

Dr. M. Doumbia, IER/Mali, with his training in soil chemistry at Texas A&M University, and more than 15 years experience in research in the Sahel and Dr. Aminata Badiane, ISRA/Senegal, with her work on soil organic matter beginning with her thesis work, will provide the core of the expertise in soil organic carbon measurement, interpretation, and assessment of methodology. One graduate student from IER/Mali will concentrate on improving the measurement technology, with the assistance of Dr. Greg McCarty, ARS/USDA. Dr. Modou Sene, ISRA/Senegal, soil physicist / water relations, will provide his expertise together with short term assistance of Dr. Kevin Brannan in the use of KINEROS in water and soil conservation modeling. Mr. Antonio Querido, INIDA/Cabo Verde, will also collaborate with these studies as an extension of his MS thesis work from Wageningen University, The Netherlands.

Studies quantifying the C accretion aspects of alternative systems will be undertaken in a less intensive mode in The Gambia and Cabo Verde. In The Gambia, with its unusually high animal population, will collaborate with the whole farm modeling effort coordiated by Dr. Phil Thornton. Mr. Alieu Bittaye, NARI/The Gambia, an economic modeler with recent short term training at Purdue University with Dr. John Sanders, will likely be the primary collaborator for this cooperative effort. Studies on the interaction between manure and inorganic fertilizer, i.e. the 'manure extender' will be undertaken by Babou Jobe, NARI/The Gambia and Isaurinda Baptista, INIDA/Cabo Verde. Both of the later scientists will also evaluate water and soil conservation technologies in their respective countries.

Dr. Jim Jones will coordinate the work with simulation modeling of C status in soils using the data generated at all sites and for the candidate landuse/cropping systems in identifying the steady state C levels and predicting accretion levels. Drs. Jones and Yost will work together in upscaling estimates of C accretion such that estimates of uncertainty based on input data and the upscaling technique are included. A graduate student will be assigned to this challenging topic and jointly advised by the investigators.

Activities with a budget increase of 150%:

We propose to expand the scope of the project, should a 150% budget increase be granted, to use the "General Protocol" for regional estimates of C sequestration with known estimation uncertainty to address the larger, ever-pervasive issue of rapid climate change that plagues the Sahel. We will examine the rate of re-vegetation and soil properties and status on this change through cooperative studies with climate change modelers. To carry out this task we again need the ability to scale up field estimates of C accretion to a large region in order to match the unit cells that are used as input in regional climate models. In addition, one of our sites has undergone a large scale adoption of improved water conservation technology (Konobougou, Mali), which may have resulted in a measureable effect on climate of the region – a working hypothesis.

Annex: Institutional Arrangements – West Africa

The University of Florida team will work closely with the University of Hawaii investigators on activities focused on West Africa. The UF team will be responsible for coordinating and overseeing the work by collaborators in Ghana, for refining and evaluating the DSSAT-CENTURY models for predicting soil C changes, and it will share responsibilities for the scaling up of C sequestration across all sites in Africa with the UH team, which is led by Dr. Russell S. Yost. Dr. James W. Jones will be responsible for the overall University of Florida activities and products. The UF team will also cooperate with Dr. John Duxbury of Cornell University, who is responsible for the activities in Asia. This cooperation will involve sharing of the models used in predicting soil C sequestration, data from West Africa, and all procedures and results obtained from Africa. In addition, the comparative study to be performed by UF during the last two years of the project will include lessons learned from Asia relative to extending the protocol that we are developing and testing as part of the project in Africa. Details are provided below for the responsibilities of each investigator from the University of Florida along with the responsibilities of collaborators in Ghana and ILRI. Activities to be carried out by collaborators in Mali, Senegal, and Cabo Verde will be described in the University of Hawaii component of this proposal, and also supported by their budget.

We anticipate direct funding from the SM CRSP Management Entity to support activities in which the UF investigators and collaborators from Ghana and ILRI are engaged. Subcontracts will be written to support the activities of collaborators from Ghana (to the Savanna Agricultural Research Institute and the University of Ghana) and the collaborator fromILRI, the CGIAR centerin Nairobi, Kenya.

Summary of Responsibilities of UF Team Members

A team at UF will work with Dr. Jones on the refinement and evaluation of the predictive model. This team will consist of Dr. Clifton Hiebsch and Dr. Kenneth J. Boote, who will be responsible for overall adoption of the crop models for simulating cropping systems in west Africa and for evaluating the uncertainties in the model predictions; Dr. Arjan Gijsman (paid by project funds in the post doc/scientist position), who will be responsible for the soil organic matter component of the models and integrating the soil phosphorus component into the DSSAT-CENTURY version to handle organic P; Dr. Samira Daroub who will be responsible for the soil P model content and its evaluation, working with Dr. Jesse Naab in Ghana and other team members at UF; Dr. Johannes Scholberg who will be responsible for developing the relationship between soil water potential and soil organic matter decomposition, working with Dr. Samuel Adiku and Dr. Jesse Naab of Ghana, and for overseeing these experiments on soils of West Africa. We will also work closely with Dr. Russ Yost of UH on these activities because of his extensive experience on soil P and expert systems for soil fertility management. All of the UF personnel are paid by UF except for Dr. Gijsman, who will be paid by project funds (post doc/scientist position).

The post doc/scientist position (Dr. A. J. Gijsman) will provide major scientific input to the project across all outputs, but he will focus on Objective 1 Output 2. His work on the other outputs will mainly be to provide advice to collaborators and to help in the formulation of the integrated protocol for measuring gains and losses of soil C.

One graduate student will work first on incorporating the soil P module into the DSSAT crop models, and then on experiments to quantify the effects of soil water potential on decomposition rates of organic matter. The second graduate student will work on scaling up predictions to large areas, emphasizing the linkage of remote sensing inputs in the models, and on uncertainty analysis of model predictions at all scales. He or she will also work closely with the UH team, where focus will be on the use of remote sensing and geostatistics for developing spatial inputs for the models.

The research associate will be responsible for assembling data from the different parts of the research, integrating the different model components for evaluation, assisting with the uncertainty analysis, and creating tools to facilitate sharing of data and quality control of model versions with new components. He or she will also be responsible for assisting Dr. J. W. Jones maintain active communications and information exchange among all who are contributing to the project.

Dr. Jesse Naab of SARI in Ghana will be responsible for the field studies in Wa, in northern Ghana. In addition, he will be responsible for assembling data from the region to evaluate the DSSAT- CENTURY model for soils low in P and using experimental data where P was applied. Dr. Samuel Adiku of the University of Ghana in Accra will be responsible for the field studies in Kpeve in southeastern Ghana. In addition, Dr. Adiku will conduct the experiments to quantify the effects of soil water potential on soil organic matter decay rates for the sandy soils in their region. Dr. Philip Thornton of ILRI will be responsible for the studies to understand how livestock management influences soil C sequestration and on methodology for assessing these effects under varying soil, climate, and management systems, working closely with Dr. Gijsman and Dr. Hiebsch of UF. Funds from the project will be provided to Dr. Thornton for personnel (½ time post doc) to do this work under his supervision.

Subcontracts for Collaborators:

a. Savanna Agricultural Research Institute. Total Cost - $98,000 (plus $11,225 taken out by UF for Overhead on the first $25,000). Dr. Jesse Naab of SARI in Ghana will be responsible for the case studies in Wa, in northern Ghana to evaluate agricultural management systems with potential for sequestering carbon. The candidate systems involve the use of leguminous cover crops and the use of supplemental fertilizer on maize. He will cooperate with project team members from the U.S. as well as other countries in West Africa in carrying out the activities identified in the plan of work for each case study. In addition, Dr. Naab will be responsible for assembling data from the region to evaluate the DSSAT-Century model for soils low in P and using experimental data where P was applied. He has been conducting research on phosphorus responses of crops in this region. Dr. Naab has extensive experience in station and on-farm research in this region, and has cooperated with UF on the Peanut CRSP project. He is a soil physicist and has strong experience in the use of the DSSAT models as well. See his CV for additional information. The funds will be used to pay for technicians and field workers, travel, and operating expenses for the experiments. In addition, Dr. Naab will need to purchase a Campbell Scientific weather station (about $3,000), a notebook computer (about $2,000). Based on past experience, these purchases are best made in the US and then thip equipment to Ghana. Budget figures include costs for this equipment. Details of the budget will be worked out when the subcontract is set up.

b. University of Ghana. Total Cost - $98,000 (plus $11,225 for Overhead taken out by UF on the first $25,000). Dr. Samuel Adiku of the University of Ghana in Accra will be responsible for the case studies in Kpeve in southeastern Ghana to evaluate agricultural management systems with potential for sequestering carbon. He will evaluate fallow management using native leguminous shrub or elephant grass in a maize cropping system. In addition, Dr. Adiku will conduct the experiments to quantify the effects of soil water potential on soil organic matter decay rates for the sandy soils in their region.He will cooperate with Dr. J. Scholberg, Dr. C. Hiebsch and Dr. J. Jones who will conduct parallel studies in Florida to cover a wide range of soil textures. The budget will mostly be used to hire students and technicians to carry out the research, travel to Kpeve, and operating expenses for the case studies. He will need to purchase a Campbell Scientific weather station for the Kpeve location (about $3,000), and a notebook computer (about $2,000) for data collection and processing. In addition, Dr. Adiku will need equipment to carry out the experiment on soil organic matter decay. He will need a sandtable system for establishing high water potential conditions for the soils in the experiment, and funds to repair or replace the pressure plate apparatus for these experiments. Budget figures include these costs for equipment and repairs. Details of the budget will be worked out when the subcontract is set up.

c. International Livestock Research Institute. Total Costs - $144,000 (plus $11,225 in Overhead to be taken out by UF on the first $25,000). Dr. Philip Thornton of ILRI will be responsible for the studies to analyze how livestock management influences soil C sequestration and on methodology for assessing these effects under varying soil, climate, and management systems. Funds from the project will be provided to Dr. Thornton for personnel (½ time post doc) to do this work under his supervision.

d. Other Collaborators. Activities of collaborators in Mali, Senegal, and Cabo Verde will be described and supported through the University of Hawaii component of this proposal.

Annex: Bio-data - West Africa
University of Florida & Collaborators:

James W. Jones
Biographical Sketch
Time Commitment on Project – 20%

Professional Preparation:
- B.S., Agricultural Engineering, Texas Tech. Univ., 1967
- M.S., Agricultural Engineering, Mississippi State Univ., 1970
- Ph.D., Agricultural Engineering, North Carolina State Univ., 1975

Appointments:
- 1998-Present: Distinguished Professor, Agric. & Biol. Engr. Dept., University of Florida
- 1983-1998: Professor, Agric. & Biol. Engr. Dept., University of Florida
- 1978-1983: Associate Professor, Agric. & Biol. Engr. Dept., University of Florida
- 1967-1977: USDA/ARS and Asst. Prof., Agric. & Biol. Engr. Dept., Miss. State Univ.

Research Interests:
Agricultural systems analysis. Computer simulation of crop growth and development, and soil-plant-water processes, including models for soybean production systems and other grain legumes. Development of Decision Support System for impact and risk assessments. Managing crops in spatially variable soils; precision agriculture. Linkage of crop and soil models with Geographic Information Systems. Climate prediction applications in and potential impacts of climate change on agriculture. Industry applications of decision support tools.

Professional Societies and Offices Held:
Fellow member of American Society of Agricultural Engineers (1977-Present; Assoc. Editor, 1984- 89; Co-Chair & Chair of IET Division, 1988-1992; Board of Directors, 1989-1992); Fellow member of American Society of Agronomy (1981-Present); Crop Science Society of America, 1981-Present).

Synergistic International Activities:
- 1998-2003: CIAT Board of Trustees
- 1996-2001: International Advisory Board to the C. T. de Wit Graduate School of Production Ecology, Wageningen Agricultural University.
- International Consortium for Agricultural Systems Applications (ICASA). Co-Chair of Board of Directors since 1997;
- 1995-2000: International Training Programs on Crop Simulation.
- 1990-2000: Task Leader for Crop Modeling, International Geosphere-Biosphere Program (IGBP), Global Change & Terrestrial Ecosystems (GCTE).

Recent Publications Closely Related to the Proposed Project:

Boote, K. J., J. W. Jones, and N. B. Pickering. 1996. Potential uses and limitations of crop models. Agron. J. 88(5):704-716.

Bowen, W. T., and J. W. Jones. 1993. Evaluating soil nitrogen models under green manure practices. Agron. J. 85(1):153-9.

Hansen, J. W., and J. W. Jones. 1996. A systems framework for characterizing farm sustainability. Agr. Systems 51(2):185-201.

Fraisse, C. W., K. L. Campbell, J. W. Jones, W. G. Boggess, and B. Negahban. 1995. Integration of GIS and hydrologic models for nutrient management planning. US-EPA Seminar Publication No. EPA/625/R-95/004. Office of Research and Development, EPA, Washington, D.C. pp 283-291

Batchelor, W. D., J. W. Jones, and K. J. Boote. 1993. Extending the Use of Crop Models to Study Pest Damage. Trans. ASAE 36(2):551-558.

Jones, J. W., and J. C. Luyten. 1998. Simulation of biological processes. In: Peart, R. M., R. B. Curry (eds.), Agricultural Systems Modeling and Simulation. Marcel Dekker, Inc. pp. 19-62.

Hansen, J. W., and J. W. Jones. 2000. Scaling up crop models for climate variability applications. Agr. Systems 65:43-72.

Jones, J.W., Hansen, J.W., Royce, F.S., and Messina, C.D. 2000. Potential benefits of climate forecasting to agriculture. Agriculture, Ecosystems and Environment 82:169-184.

Clifton K. Hiebsch
Biographical Sketch
FTE on Project - 10%

Professional Preparation:

- B.A., Sociology, Southwestern College, 1969
- M.S., Agronomy, Kansas State University, 1975
- Ph.D., Soil Science, North Carolina State University, 1980

Appointments:

- 1986-present: Associate Professor, Agronomy Dept., Univ. of Florida
- 1980-1986: Assistant Professor, Agronomy Dept., Univ. of Florida
- 1975-1980: Research Assistant, Soil Science Dept., N. Carolina State Univ.

Research Interests:
Conduct studies on crop ecology with emphasis on crop/crop, crop/environment, and crop/resource-input interactions on the productivity, human carrying capacity, stability, and sustainability of cropping systems. Primary focus is subsistence, low-input and indigenous tropical cropping systems and the land and resources required to adequately feed humans. Multi-disciplinary research on enset-based systems in Ethiopia and other farming systems in African have been the main target systems.

Professional Societies and Offices Held:
American Society of Agronomy, Crop Science Society of America, Soil and Crop Science Society of Florida, and Soil Science Society of America.

Synergistic International Activities:
Participate in multi-disciplinary research 1) on gender-and-soil-fertility related constraints to food production in East African with the Soil Management CRSP, and 2) on productivity and resilience of enset-based systems in the highlands of Ethiopia. Develop an algorithm and software for balancing human diets and for comparing the ability of cropping systems to meet human nutritional requirements.

Recent Publications Closely Related to the Proposed Project:

Gladwin, C.H., K.L. Buhr, A. Goldman, C. Hiebsch, P.E. Hildebrand, G. Kidder, M. Langham, D. Lee, P. Nkedi-Kizza, and D. Williams. 1997. Gender and soil fertility in Africa. p. 219-236. In R.J. Buresh, P.A. Sanchez, and F. Calhoun (ed.) Replenishing Soil Fertility in Africa. SSSA Special Publication Number 51, SSSA, Madison.

Hiebsch, C.K. 1996. Yield of Ensete ventricosum–a concept. p 15-35. In Tsedeke Abate, C. Hiebsch, S.A. Brandt, and S. Gebremariam (ed.) Enset-Based Sustainable Agriculture in Ethiopia. Institute of Agricultural Research, Addis Abeba, Ethiopia.

Hiebsch, C., Endale T., Gizachew W.M., M. Dougherty, Mulugeta D., and Shiferaw T. 1997. Difficulties in measuring enset yield and human carrying capacity in indigenous systems. p. 804-812. In K. Fukui, E. Kurimoto, and M. Shigeta (ed.) Ethiopia in Broader Perspective. Vol. 3. Papers of the 13th International Conference of Ethiopian Studies, 12-17 Dec. 1997, Kyoto, Japan.

Hiebsch, C.K. and M.P. Dougherty. (in review). Supplying energy, protein, and amino acid requirements for humans I. nutrient density. J. of Nutrition.

Hiebsch, C.K. and M.P. Dougherty. (in review). Supplying energy, protein, and amino acid requirements for humans II. diet formulation. J. of Nutrition.

Hiebsch, C.K. (in review). Nutrient density vs protein quality for evaluating and balancing human diets for energy, protein, and amino acids. J. of Nutrition.

Kenneth J. Boote
Professor of Agronomy, Agronomy Department
University of Florida, Gainesville, FL 32611-0500

Professional Preparation:
- B.S., Agronomy, Iowa State University, 1967
- M.S., Crop Physiology, Purdue University, 1969
- Ph.D., Crop Physiology, Purdue University, 1974

Appointments and Current Affiliation (70% research/30% teaching):
- 1985-present: Professor, Agronomy Dept., Univ. of Florida
- 1979-1985: Associate Professor, Agronomy Dept., Univ. of Florida
- 1974-1979: Assistant Professor, Agronomy Dept., Univ. of Florida

Time Commitment to Project: 10% FTE

Relevant Training and Experience:
Research on measuring photosynthesis, respiration, whole-plant growth, C and N metabolism of grain legumes and forages in response to drought, CO_2-enrichment, temperature, and genotypic attributes, studied in controlled-environment chambers, field, and temperature-gradient greenhouses. Developed and tested crop growth models for purposes of enhancing physiological understanding, improving crop management strategies, and evaluating physiological traits for genetic improvement. Currently adapting CROPGRO model for forage crops.

International Activities:
Conduct crop growth modeling training courses, collaborate with scientists on grain legume responses to climate change factors, and present invited papers, in the Netherlands, Niger, Ivory Coast, Taiwan, India, United Kingdom, Republic of South Africa, Belgium, Argentina, Japan, The Philippines, Australia, Austria, Ghana, Benin, Togo, Egypt, Germany, and Spain. Have current USAID-sponsored peanut CRSP project in Ghana and Benin, and scientific exchange in Spain.

Five Relevant Publications:
Fritschi, F. B., K. J. Boote, L. E. Sollenberger, L. H. Allen, Jr., and T. R. Sinclair. 1999. Carbon dioxide and temperature effects on forage establishment: I. Photosynthesis and biomass production. Global Change Biology 5:441-453.

Sau, F., K. J. Boote, and B. Ruiz-Nogueira. 1999. Evaluation and improvement of CROPGRO - soybean model for a cool environment in Galicia, northwest Spain. Field Crops Res. 61:273-291.

Boote, K. J., J. W. Jones, and G. Hoogenboom. 1998. Simulation of crop growth: CROPGRO Model. Chapter 18. pp. 651-692. IN: R. M. Peart and R. B. Curry (eds.). Agricultural Systems Modeling and Simulation. Marcel Dekker, Inc, New York.

Piper, E. L., K. J. Boote, and J. W. Jones. 1998. Evaluation and improvement of crop models using regional cultivar trial data. Applied Engineering in Agriculture 14:435-446.

Boote, K. J., J. W. Jones, and N. B. Pickering. 1996. Potential uses and limitations of crop models. Agron. J. 88:704-716.

Samira Daroub
Assistant Professor
University of Florida

Professional Preparation:

- B.S., Agriculture, The American University of Beirut, 1983
- Diploma Agricultural Engineering, The American University of, 1983
- M.S., Soil Science, The American University of Beirut, 1986
- Ph.D., Soil Chemistry, Michigan State University, 1994

Appointments:

- May 2000- Present: Assistant Professor, Soil & Water Science Dept. and the Everglades Research and Education Center, University of Florida.
- 1995- 2000: Research Associate, Crop & Soil Science Dept., Michigan State University.
- 1986-1989: Research Assistant, Soil, Irrigation & Mechanization Dept., American University of Beirut

Time commitment to Project : 5% FTE

Research Interests:
Computer simulation of crop growth and development. Phosphorus nutrition of crops, chemistry in the soil and movement in the soil-water system. Use of simulation models to predict phosphorus availability to plants, chemistry and loss of P in the soil-water system for agricultural and environmental applications.

Professional Societies:
The Alpha Alpha chapter of Phi Beta Delta, an Honor Society for International Scholars (1990), The American Society of Agronomy (1991-Present), The Soil Science Society of America (1991- Present), The International Soil Science Society (1995-Present).

International Activities:
Visiting scientist at International Center for Tropical Agriculture (CIAT) in Colombia, South America, October-December, 1997, visiting scientist at International Center for Agricultural Research in the Dry Areas (ICARDA) in Syria, January-March, 1998.

Recent Publications Closely Related to the Proposed Project:

Daroub, S.H., F.J. Pierce, and B.G. Ellis. 2000. Phosphorus fractions and fate of phosphorus-33 in soils under plowing and no-tillage. The Soil Science Society of America journal. 69:170-176.

Daroub, S.H., B.G. Ellis and G.P. Robertson.2001. Effect of cropping and low-chemical input systems on soil phosphorus fractions. Soil Science. Accepted.

Daroub, S.H., Gerakis, A., Ritchie, J.T., Friesen, D., Ryan. J. Development and testing of a soil-plant phosphorus simulation model (In preparation).

Daroub, S. H., A. Gerakis, J.T. Ritchie, and D.K. Friesen. 2000. Performance of a newly developed simulation model under semi-arid and tropical conditions. The annual meetings ASA, CSSA, ASSA. November 5-9, 2000. Minneapolis, Minnesota. Agronomy Abstracts. P. 17.

Wilkens, P., S. Wood, M. Rivera and S.H. Daroub. 2000. Linking biophysical and economic models to evaluate the impact of agricultural research. The annual meetings ASA, CSSA, ASSA. November 5-9, 2000. Minneapolis, Minnesota. Agronomy Abstracts. P. 71.

Arjan J. Gijsman
Biographical Sketch

Appointments:

- 2000-Present: Visiting Scientist, Agric. & Biol. Eng. Dept., University of Florida
- 1999: Consultant, Agron. Dept. / Agric. & Biol. Eng. Dept., University of Florida
- 1992-1999: Senior Research Fellow and earlier Postdoc, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia
- 1992: Research Scientist, Wageningen Agricultural University, The Netherlands
- 1991: International Centre for development-oriented Research in Agriculture (ICRA), Wageningen, The Netherlands, Soil fertility specialist in a consultancy team in Tanzania.
- 1986-1990: Institute for Soil Fertility Research (IB; presently AB-DLO), Haren, The Netherlands, Research Scientist

Degrees:

- PhD., Soil Fertility, Plant-Soil Interaction, Simulation Modeling, State Univ.Groningen, The Netherlands, 1990
- MSc., Soil Fertility, Plant Nutrition, State Univ.Utrecht, The Netherlands, 1986

Professional Societies:
Dutch Soil Science Society, International Soil Science Society

Recent Publications Closely Related to Project:

Gijsman A.J., Hoogenboom G., Parton W.J. and Kerridge P.C. submitted. Modifying DSSAT for low-input agricultural systems, using a SOM/residue module from CENTURY. submitted.

Gijsman A.J. 2000. Linking DSSAT with the soil-organic-matter/residue module of the CENTURY model: A detailed report. Consultancy report for the Univ. Florida, Agronomy Dept / Dept. of Biol. & Agric. Engineering, Gainesville, FL.

Gijsman A.J. and Bowen W.T. 1999. Simulating crop production in low-input agricultural systems with DSSAT linked to the CENTURY soil-organic-matter module. Third International Symposium on Systems Approaches for Agricultural Development (SAAD-III), November 8-10, 1999.

Gijsman A.J. and Sanz J.I. 1998. Soil Organic Matter Protection in a Volcanic-Ash Soil under Fallowing or Cultivation with Applied Chicken Manure. European Journal of Soil Science 49: 427-436.

Giraldo L.M., Lizcano L.J., Gijsman A.J., Rivera B., Franco L.H. 1998. Adaptación del modelo DSSAT para simular la producción del Brachiaria decumbens. (Adapting the DSSAT model for simulating the production of Brachiaria decumbens). Pasturas Tropicales 20:2-12.

Gijsman A.J., Oberson A., Tiessen H. and Friesen D.K. 1996. Limited applicability of the CENTURY model to highly weathered tropical soils. Agronomy Journal 88: 894-903.

Gijsman A.J. 1996. Soil aggregate stability and soil organic matter fractions under agropastoral systems established in native savannas. Australian Journal of Soil Research 34: 891-907.

Jesse Bonaventure NAAB
Curriculum Vitae
Time Commitment to Project - 0.15 FTE

Academic qualifications:

- University of Ghana, Legon, 1982-1986, B.Sc. Agriculture (Soil Science), Second Class Upper Division, (Awarded October 1986)
- University of Reading, England, 1990-1994; Ph.D, Research, Soil Science (Awarded July 1995).

Positions held:

- Research Assistant, Savanna Agricultural Research Institute, Tamale, Ghana, Sept. 1986 - April 1995 (including study leave from Sept. 1990- April 1995).
- Research Officer, Savanna Agricultural Research Institute, Tamale, Ghana, April 1995 - to date
- Part time lecturer in Soil Physics, University for Development Studies, Tamale, Ghana, June - October 1997.
- Demonstrator, Dept. of Soil Science, University of Reading, UK, Oct. 1992- Aug 1993

Current Position and Responsibilities:
Soil Scientist and Team Leader, Upper West Farming Systems Research Team, Wa, Ghana. As soil scientist in the group, I am responsible for independent research in the fields of soil fertility and soil-plant-water relation relevant to the Upper West Region of Ghana. As Team

Leader of the Upper West Region Farming systems research team, I am responsible for:

- the co-ordination of the work of the scientists in the group,
- ensuring that reports of the group are written and presented to management,
- the vehicles and equipments of the group and
- preparing travel itineraries of the group

Current Research Activities

- Effects of crop rotation, manure and fertilizer on soil properties and maize yield
- Leguminous cover crops as nitrogen source to maize
- Effects of phosphorous fertilizer on growth and yield of groundnuts
- Evaluation of a peanut crop growth model in the interior savanna zone of Ghana.

Workshops/Training Programs and Scientific Visits:

- International Course on 'Sustainable Agriculture and On-farm Experimentation', University of Los Banos, Philippines, 7th Nov.- 2nd Dec. 1988.
- International Course on 'Alley Farming for Tropical Africa', IITA, Ibadan, Nigeria, 10th-25th August 1989.
- International Course on 'Advanced Statistical Computing Using GENSTAT 5.0' IITA, Ibadan, Nigeria.
- International Course on 'Computer Simulation of Crop Growth and Management Responses', IFDC, Lome, Togo, 9 - 14th February 1998.

Scholarships/Awards

- German Agency for Technical Co-operation (GTZ) scholarship for Doctoral studies, University of Reading, England (1990 - 1994)
- German Foundation for International Development (DSE) scholarship for training in "Sustainable Agriculture and On-farm Experimentation", 7th Nov. - 2nd Dec. 1988.
- Ghana Government Award for undergraduate studies, University of Ghana, Legon, 1982 - 1986

Publications

(Naab, J.B. , and Simmonds, L.P. (1996). The influence of root:shoot partitioning on water use and water use efficiency of potato crops. (Submitted to: Potato Research)

Naab, J.B., Gaze, S.R. and Simmonds, L.P. (1996). A rapid technique for estimating root length density of crops. (Experimental Agriculture)

Naab, J.B., Afuakwa, J.J., Agyare, W., and Kombiok, J.M. (1998). Effect of different tillage methods on root growth and soil properties (Ghana Journal of Agriculture)

Alhassan, A.Y., Abatania, L., Naab, J.B. and Bolaji, M.H.A. (1998). A practical assessment of wealth ranking as a tool for deciding recommendation domains. Ghana Journal of Agricultural Science (In press).

Naab, J.B. and Nyamekye, A.L. (1989). Evaluation of Gliricidium sepium germplasm: adaptation to the semi-arid zone of Ghana. Proceedings, Workshop on "Improving Farming Systems in the Savanna Zone of Northern Ghana"

Naab, J.B. (1986). Comparison of lime and gypsum as amendments for acid soil infertility. B.Sc. Dissertation, Department of Soil Science, University of Ghana, Legon .

Naab, J.B. (1994). Interaction of Canopy and Root system on water use of potato. Ph.D. Thesis, Department of Soil Science, University of Reading, England.

ABRIDGED CURRICULUM VITAE

Samuel Godfried Kwasi ADIKU

Higher Education

Degrees and dates of Award

- 1979-1982; University of Ghana, Legon, Accra, Ghana B.Sc. Agriculture (1982)
- 1985-989; Technische Universitaet Berlin, Germany M. Sc. Agriculture (1989)
- 1992-1995; Griffith University, Brisbane, Australia Ph.D. Env. Science (1996)

Post-doctoral Qualification

- 1997- 1998 Institute fuer Oekologie, TU Berlin, Germany Modelling salinity/plant growth
- 1999 Jan -May Institute National de la Recherche Agronomic Modelling root architecture and INRA, Guadeloupe, France water competition in intercrops.

Title: Senior Lecturer in Soil Science

Institutional Affiliation:

Department of Soil Science, Faculty of Agriculture, P.O. Box 245,
University of Ghana, Legon, Accra, Ghana.Tel/Fax: ++233 21 500 467
Email: s_adiku@hotmail.com

Time commitment to Project: 25 % of normal load (About 10 hours a week)

Relevant Training and experience to the proposal:

- Computer skills: Programming Languages: (FORTRAN 77, BASIC, PASCAL); Word Processing (WP5.1, MS WORD) and Statistical & Data Processing Software (MINITAB, EXCEL)
- Workshop: Use of Decision Support Systems for Crop Modelling: Mauritius, 1990

Relevant Publications:

Adiku, S.G.K. (1995). A field investigation and modelling the effect of soil, climate and management factors on the growth of a maize-cowpea intercrop. Ph.D. Thesis, Griffith University, Australia, 458 pp.

Adiku, S.K., P.S. Carberry, C.W. Rose, R.L. McCown and R. Braddock (1995). A maize/cowpea intercrop model. In: H. Sinoquet and P. Cruz (eds). Ecophysiology of Tropical Intercropping Pub. INRA Editions, Versailles, France. pp 395-406, ISBN 2-7380-0603-5.

Carberry, P.S., S.G.K. Adiku, R.L. McCown and B.A. Keating (1996). Application of APSIM cropping systems model to intercropping systems In: O. Ito, C. Johansen, J.J. Adu-Gyamfi, K. Katayama, J.V.D.K. Kumar Rao and T.J. Rego (Eds.), Dynamics of roots and nitrogen in cropping systems of the Semi-Arid Tropics. Pub. Japan Centre for Agricultural Sciences. pp. 637-648, ISBN 4-906635-01-6.

Dowuona, G.N., A.K. Mermut, S.G.K. Adiku and E. Nartey (1998). Improvements in the quality of soils under agroforestry practise in Ghana. Proc. Regional Workshop on Soil Fertility Management in West Africa. Pub.: Margraf Verlag, Wekersheim, Germany, :251-258.

Adiku, S.G.K., Rose, C.W., Braddock, R.D. and H. Ozier-Lafontaine (2000). On the simulation of root water extraction: Examination of the minimum energy hypothesis.Soil Science 165:226-236.

Letters of support:

Prof. J.W. Jones
Department of Agricultural and Biological Engineering
University of Florida
Gainsville, FL 32611
USA

January 3, 2001

Dear Sir,

Re: LETTER OF COMMITMENT TO PARTICIPATE IN "THE CARBON SEQUESTRATION RESEASRCH; PROPOSED BY DRS. J.W. JONES AND R. YOST AS A SOIL CRSP PROPOSAL SUBMITTED TO USAID FOR FUNDING

Following correspondence between the Department of Agricultural and Biological Engineering of the University of Florida and the Department of Soil Science, University of Ghana, I write to indicate that the Department of Soil Science hereby expresses its willingness to participate in the above-mentioned project. At this time, we present our commitments briefly as follows:

1. Appoint a team of researchers from Soil Science Department to participate in the joint project under the leadership of Dr. S.G.K. Adiku as coordinator of the project,
2. Members of research team will make available 15 % of their research time toward the project while the coordinator will commit 25% of his time to the project,
3. Allow other staff members of the Faculty of Agriculture and the Ministry of Agriculture Experimental Station at Kpeve to participate in the project when necessary, and
4. To make available laboratory space, technical and equipment support to the project.

While expressing our willingness, the Department of Soil Science requests CRSP to provide the following:

1. The project will provide computing facilities to support both data analysis and modeling
2. The project will provide the running costs for soil sampling and analysis, chemical costs, transportation costs and some minimum equipment support where necessary
3. The project will provide some essential field equipment such as a weather station
4. The project shall support project implementation in terms of providing funds for system evaluation, hiring of farmers and other field workers, and
5. The project may promote staff development and student training in the Department of Soil Science.
6. Although a detailed budget statement is yet to be drawn, the project shall provide about 10 to 15,000 US$ per year for 5 years.

We anticipate your decision on this issue in the course of the year. Once the sponsoring body (USAID) officially approves the project, a formal agreement, which would specify further detailed commitments from our side and a budget statement, will be provided.
We look forward to working with you in this very important and relevant research project.

Yours sincerely,

Dr. S.G.K. Adiku
(Head, Department of Soil Science).

University of Hawaii & Collaborators:

Curriculum Vitae

Russell Yost

Address:
Department of Tropical Plant and Soil Sciences
University of Hawaii
3190 East West Road
Honolulu, HI, 96822
Phone: (808)-956-7066
FAX (808)-956-3894
Internet: rsyost@hawaii.edu

Degrees:

- Ph.D. Soils with minors in Plant Physiology and Statistics; North Carolina State University
- M.S. Soil Science, University of Nebraska at Lincoln

Current Position: Researcher, Professor of Soil Science

Professional Interests:

- Soils: Tropical soils, soil phosphorus, soil acidity, statistics, geostatistics.
- Crops: Plant nutrition, legumes, trees, green manures, VA mycorrhizae. .
- Computer technology: Artificial intelligence, computer languages to capture and transfer expertise, geostatistics. Participatory Development

Selected Publications:

Wang, X., R.S. Yost, and B. A. Linquist. 2001. Soil aggregate size affects phosphorus desorption from highly weathered soils and plant growth. Soil Sci. Soc. Am. J. 65:000-000.

Li, Mengbo and R.S. Yost. 1999. Management-Oriented Model Guided Within-season Nitrogen Management, In P. Robert (ed.), Proceedings Fourth International Symposium on Precision-Agriculture, St. Paul, Minnesota.

Li, Z.C., R.S. Yost, and R.E.Green. 1998. Incorporating uncertainty in a chemical leaching assessment. J. of Contaminant Hydrology 29(4):285-299.

Software:

Ogoshi, R. and R. Yost. 2001. Implementing the AFR (Revised Attenuation Factor) in a GIS framework for pesticide leaching assessments in Hawaii (Pesticide Branch, Dep. of Agriculture).

Yost, R.S., R. Kablan, M. Doumbia, A. Berthe, A. Badiane, B. Jobe, and I. Baptista. 2000. BILAN2: Nutrient balance estimation (en francais). InterCRSP/West Project, Honolulu, Hawaii.

Li, MengBo, R.S. Yost, J. Silva, N.V. Hue, and R. Uchida. 1998. FACS2 (Fertility and Advice Consulting System, Internet version). Unpublished manuscript, 1998.

Approximately 150 peer-reviewed papers in national and international journals.

Collaborators on projects, books, articles, reports, or papers during the last 48 months:
Linquist, Bruce - Lao-IRRI, Laos
Ikawa, Haryoshi - University of Hawaii
Hue, Nguyen - University of Hawaii
Smith, Chris - NRCS, Honolulu, HI

Mamadou Doumbia - IER/Mali

Name and title:
Mamadou D. Doumbia, PhD
Soil Chemist, Senior Research Scientist, and Head of Laboratory

Institutional affiliation
‘Laboratoire Sol – Eau – Plante'
‘Institut d'Economie Rurale'
B.P. 262
Tel: +223 24 61 66
Fax: +223 22 37 75
E-mail: madu.Doumbia@ier.ml

Time commitment to the project: 20% of time committed to this research

Relevant training/experience

- Trained as soil chemist (PhD) with special reference to soil organic matter, P, and soil acidity issues
- Restoring and maintaining soil fertility through soil organic matter and P management are key research objectives
- Key, relevant research activities include: (i) composting phosphate rock, (ii) reduced soil tillage, (iii) cover crops, (iv) crop residue management, (v) cattle corralling, and (vi) live fencing.

Titles of 5 relevant publications or other documents:
Student thesis:

(i) Etude de dissolutiuon des phosphates naturels de Tilemsi en association avec de la matière organique. Aliou Badara Kouyate. Université du Mali. Décembre 2000.
(ii) Etudes de fertilisation organique à base du fumier Sabunyuma. Mamadou Baba Diarra. Université du Mali. Décembre 2000.
(iii) Combinaison et placement de la fumure organique et de la fumure minérale. Moussa Siaka Diarra. Université du Mali. Décembre 2000.

Doumbia, M.D., L.R. Hossner, and A. B. Onken. 1998. Sorghum growth in acid soils of West Africa: variations in soil chemical properties. Arid Soil Research and Rehabilitation. 12:179-190.

Doumbia, M.D., L.R. Hossner, and A. B. Onken. 1993. Variable sorghum growth in acid soils of subhumid West Africa. Arid Soil Research and Rehabilitation. 7:335-346.

Takow, J.A., M.D. Doumbia, and L.R. Hossner. 1991. Acid soil profiles of the semiaridand subhumid tropics in Central and West Africa. In R.J. Wright et al. (Eds.) Plant-soil interactions at low pH. p. 313-320. Kluwer Academic Publishers. The Netherlands

Abou Berthe - IER/Mali

Name and title:
Berthe Abou, Farming Systems Research and Natural Resources Management (FSR&NRM) Program Officer, IER/Mali

Institutional affiliation: Institut d'Économie Rurale, Ministry of Rural Development/ Mali

Estimated time commitment to the project: 25%

Relevant training and experiences:

Academic training:

- 1991, Ph.D Animal Science, University of Florida (Gainesville/USA)
- 1984, Diploma of Advanced Studies in Range Management and Animal Nutrition, National Polytechnical Institute/ENSA (Toulouse/France)
- 1976, Diploma of Engineering in Animal production, National Polytechnical Rural Institute (Katibougou/Mali).

Training courses/seminars:

- April 1999, Short course in GIS on fishery monitoring in the Inlet Delta of Niger IRD-Bamako
- August 1994, Internal training course on "Environmentally Sound ResourcesPlanning in Intensive Agriculture: Concepts and Tools for Sustainable Agricultural Development". DSE-Food and Agriculture Centre - Feldafing andSchortau - German Foundation for International Development.
- 1991 - 1993, diverse training on Participatory approaches in agricultural (PRA, RRA, Gender) and farming systems research and extension, etc..

Experiences:

- Has worked as Animal scientist, project officer, Team officer and Program officer since 1979 on interdisciplinary research on farming system and natural resource management and development.
- From 1996 à 1999: 55 consulting reports on community natural resource development and planning, community natural resource management planning for different projects, NGO's.

Titles of relevant publications:

A. Berthé, M.A. Diallo, N. Koné, S. Mahotière et Y. Cissé, 1992 :Eléments de reconnaissance générale dans les zones du Delta et du Seno en 5ème région, Rapport de recherche, 162 p. ; CRRA de Mopti, Avril 1992.

H. Doucouré and A.Berthé, 1997: Etudes des pratiques d'utilisation des ressources auto générées dans les exploitations agricoles en zone soudano-sahélienne : Cas des résidus de récolte et de la fumure organique ; Rapport de recherche, 39 pages. CRRA de Sotuba, Août 1997.

H. Doucouré and A. Berthé, 1997: Etude des pratiques d'utilisation des ressources pastorales dans les terroirs en zone zone soudano-sahélienne. Rapport de recherche, 39 pages. CRRA de Sotuba, Août 1997.

O. Doumbia, M.Djitteye, L. Diarra and A. Berthé, 1999: Approche méthodologique pour un suivi environnemental dans la zone d'intervention du Projet de Gestion des Ressources Naturelles (PGRN). Série note méthodologique, Volet B du PGRN. Octobre 1999.

O. Doumbia, M.Djitteye, L. Diarra and A. Berthé, 2000: Caractérisation et choix des terroirs villageois pour le suivi environnemental en zone PGRN dans la région de Koulikoro. Série note méthodologique, Volet B du PGRN. Août 2000.

Aminata Badiane - ISRA/ Senegal

Name and title:
Aminata Niane Badiane, soil scientist, Institut Senegalais de Recherches Agricoles (ISRA), under the Ministry of Agricuture and Animal Husbandry.

Training:

- 1979 Graduate as Agronomy engineer from INA of Algiers (major soil chemistry);
- 1983 MS in Soil Science at NCSU at Raleigh, North Carolina, USA,
- 1993; PhD in Agronomic Sciences at INPL, Nancy, FRANCE.

Experience:
Worked over 20 years at ISRA in Soil Science related in soil Organic Matter, Natural resources management

Time commitment: 20%

Publications:

Badiane, A.N., 1993. Le statut organique d'un sol sableux de la zone Centre-Nord du Senegal. Docteur de L'INPL-Institut National Polytechnique de Lorraine, Lorraine, France.

Diack, M., M.Sene., and A.N. Badiane, 2000 Piliostigma reticulatum used for soil organic matter build up: Effects on soil quality and crop yield in the peanut basin of Senegal Improving and Sustaining Food and Raw Material Production in West Africa. Institut Senegalais de Recherche de Agricole, Kaolack, Senegal.

Diack, M., M. Sene, A.N. Badiane, and M. Diatta, 2000. Decompostion of a native shrub, Piliostigma reticulatum, litter in soils of semiarid Senegal. Arid Soil Research and Rehabilitation 14: 205-218.

Badiane (ed.) Improving and Sustaining Food and Raw Material Production in West Africa, vol. 1. ISRA, Senegal, Kaolack, Senegal,Proceedings of a Workshop held in Kaolack, Senegal, Jan. 1999. InterCRSP/West Project.

Modou Sene – ISRA/Senegal

Name and title:
Modou Sene, Soil and Water conservationist, Institut Senegalais de Recherches Agricoles (ISRA) Bambey Station, Senegal

Training:

- 1985 MS in Soil Science, North Carolina State University
- 1990 Doctorate in Soil Management, Nice, France

Time commitment: 25%

Publications:

Diack, M., M.Sene., and A.N. Badiane, 2000 Piliostigma reticulatum used for soil organic matter build up: Effects on soil quality and crop yield in the peanut basin of Senegal Improving and Sustaining Food and Raw Material Production in West Africa. Institut Senegalais de Recherche de Agricole, Kaolack, Senegal.

Diack, M., M. Sene, A.N. Badiane, and M. Diatta, 2000. Decompostion of a native shrub, Piliostigma reticulatum, litter in soils of semiarid Senegal. Arid Soil Research and Rehabilitation 14: 205-218.

Babou Jobe – The Gambia
National Agricultural Research Institute, Brikama, The Gambia
M.S. Soil Science, University of Wisconsin
Coordinator, InterCRSP/West Project
Time commitment - 20%

Alieu Bittaye – The Gambia
National Agricultural Research Institute, Brikama, The Gambia
M.S. Agricultural Economics, Wye College
Short-term training, Farm-level economics modeling, Purdue University, 2001
Coordinator, InterCRSP/West Project
Time Commitment - 10%

Isaurinda Baptista – Cabo Verde
Insituto Nacional de Desenvolimento de Agricultura (INIDA)
Head of Agriculture and Livestock Department
Time commitment to project: 30%
Relevant / training / experience:
MS in Agronomy (Soil Fertility) by the University of Georgia, Athens (1996);
BS in Agronomy (Soil Science) by Colorado State University, Fort Collins (1988).
Researcher currently working with crop production, variety testing (vegetables, strawberry, peanut). From 1989 to 1994 worked with soil fertility and crop nutrition.
Relevant publications:
Use of Animal manure to supply N to crops in Cape Verde. MS thesis Vulnerability and adaptation of agriculture and impacts of climate change.
Mitigation of Greenhouse Gases in the agriculture and livestock sector.
National Communication for Climate Change.
Strategy and Action Plan for Climate Change

Antonio Querido – Cabo Verde

Caixa Postal # 84 - INIDA
Praia - Cabo Verde
Work:(238) 71 11 47
Fax: (238) 71 11 33
E-mail: Tony_Querido@hotmail.com

Experience:

- March 93- Present: National Research Institute for Agrarian Development (INIDA)
  São Jorge, Cape Verde
  Plant Science/Agronomist/Environmentalist - Research group Coordinator
  Head of the Environmental Science Department

  · Environmental System Analysis and Monitoring, using Remote Sensing and GIS for data integration, management and Analysis
  · Study of the impact of watershed management techniques on erosion, run-off, production and soil fertility. To generate hazard maps.
  · GIS integration of several layers of information (slope, land use, land suitability, road, streams, wells, conservation structures, social economic infrastructures et..) for several watershed of Santiago Island.
  · Erosion modeling (Kineros & AGNPS) at plot and watershed level
  · Monitoring the seawater intrusion at lower Ribeira Seca.

- June 1991-1992 : Hunt-Wesson, Sacramento, California
  CO-Packer Field Supervisor
  Responsible for Hunt-Wesson production lines at Sierra Quality Canners. Quality and production control of canned peaches.

- June 1992-1993: Campbell Soup Company, Sacramento, California
  Laboratory Personnel
  Conducting series of analysis, such as Solid Contents, Sugar, Acid, Bostwick, Triple X, Color, Mold Counting, Brix, etc...
  These tests were performed to control production quality of different products manufactured by Campbell's Sacramento Plant

- March-June 91: University of California - Davis, Davis, California
  Statistical and Mathematical Analysis Internship
  Conducting statistical analysis and computer simulation of the incidence patterns of melon viruses in San Joaquim, Stanislaus and Mercedes areas with the objective of determining the location of the over wintering host of the virus complex.

- 1983-1987: INIA- Agronomy Department, Cape Verde
  Laboratory analyst/Field Assistant/Extension

Education:

- International Institute for aerospace Survey and Earth Science,
  The Enschede, Netherlands
  Master of Science, 1997-1999
  Environmental Systems Analysis and Monitoring
  Watershed System Analysis for Evaluating the Efficiency of Soil and Water Conservation works: A Case Study in Ribeira Seca, Santiago Island, Cape Verde.

- University of California-Davis, California, United States of America.
  Bachelor of Science, 1988 to 1992
  Major: Plant-Science-Agronomy

Other Training:

- Geographical Information System
  Familiarization with the differences and capabilities of Unix vs P.C. Arc-Info, Remote Sensing, and introduction to GRID in Arc-Info.
  University of Georgia - Griffin Experimental Station
  Georgia-USA, April-May 1996

- ZOOP - Logical Framework to project Monitoring and Evaluation
  The logical framework approach on how to plan, monitor and evaluate projects. Jan 30-Fev 7, 1995 São Jorge Cape Verde.

- Strategic Planing and Management of Public Organization
  Organized by ACDI-WARD Project, 16-19 Jan. 95 Praia

- Proposal Development and Marketing
  The guidelines for developing and writing wining grant proposals.
  University of Georgia/SANREM-CRSP/INIDA, Mar 95,São Jorge

- System d'Information geographique et Utilization des Techniques de Modelization Agrometeoroligique
  Agro-meteorological modeling techniques and GIS (introduction to Arc-Info)
  Centre de Cooperation International en Recherché Agronomique pourr Developpement (CIRAD), Montpellier, France 1995

- Management and Communication Training,
  Short course on communication and management skills
  Management Training and development Institute-Washington DC, Orlando, Florida December 1989

Consultancy:

- 1997 - PROMEX - AITS (Automated Investment Tracking System) Dbase application build in FoxPro, capable of tracking potential investors interested in Cape Verde. The main task was to make AITS user friendly in Windows environment.

- 1999 - UNICEF – SIG implementation plan for Santiago island. A comprehensive frame framework for an ideal implementation of SIG at all sectors in Santiago

- 2000 - UNICEF – SIG Geocoding of all UNICEF interventions in Santiago. Using GPS, the geographic coordinates of all UNICEF interventions in Santiago were taken allowing the mapping of the interventions according to the year, type, place, population covered, cost etc…

- 2000 –Environmental Impact Assessment of Touristy complex in Boavista. EuroTuristica.

- 2000 – INGRH/UNICEF/INIDA – Lectures on the Basics of Arcview GIS.

- 2000 – Inventory of projects and activities related desertification and drought mitigation

- 2000 – Desertification Information System

Significant Publications:

Flood management in Cape Verde: The case study of Praia, UrbanWater 1 (1999) 161-166. 2000 Elsevier Science Ltd.

Impact of seawater intrusion on water quality, InterCrsp workshop 31 Jan-5 Fev. 2000. Mali

SIG, uma ferramenta útil na caracterização dos recursos naturais, 1999 Boletim-INIDA. Watershed System Analysis for Evaluating the Efficiency of Soil and Water Conservation works: A Case Study in Ribeira Seca, Santiago Island, Cape Verde. 1999. ITC, Enschede, The Netherlands.

Watershed Management and Conservation- Teba Catchment, Spain. 1998. ITC, Enschede, The Netherlands.

Pratiques d'utilisation de Ressources Renouvelables au Cap-Vert, Fev. 96

Relatório da Campanha pluvial Jan 96 - Draft

Etude de l'impact de techniques agronomiques et d'amenagement sur le ruissellment et l'erosion dans une zone semi-arid de Santiago, Novembre. 95

Gestão Territorial (Cabo Verde), April 94

Rapport de la Campanhe Agricole, 1993

International Meeting Participation:

- Leadership, Agriculture and Economic Development. ATLAS conference. April 24-28 2000, Windhoek, Namibia.

- Regional Atelier on Ressource Management and technology transfer in Sahel Inter-CRSP annual meeting. 1-6 February. 2000 - Bamako, Mali.

- Proposal Development on Regional Priority Area of Soil and Water Conservationand Management. INTER-CRSP, 5-6 February 1997 - Georgia, USA.

- Regional Atelier d'Harmonization des Outils Methologique de Collecte et Suivi des Donnes Agro-Socioeconomique en Gestion des Ressources Naturelles au Sahe. 17-18-19 February 1997 - Dakar, Senegal

- Regional Atelier on Natural Resource Management in Sahel INSAH - CILLS. 1-6 April 96 - Bamako, Mali.

- Regional Research Activities Planing and Technology Transfer INSAH - USAID, 16-17 September 1996 - Dakar Senegal.

- Atelier Regional sur L'harmonisation et Operationalisation du Concept de Gestion de Terroirs dans une Perspective de Developpment Durable. UNSO (United Nation Sudano-Sahelian Office) 11-15 April 94 Niamey, Niger.

- Sustainable Land Management in African Semi-arid and Sub Humid Zones. SCOPE international Workshop (Scientific Committee on Problems of Environment). 15-19 Nov. 1993 - Dakar Senegal.

Computer Experience:

- Machines: IBM and IBM type machines, MacIntosh
- Languages: Basic, QuickBasic, Visual Basic, Dbase programming, Rbase and Pascal.
- Programs: Excel, Word, Write,WordPerfect, MS-Publisher, Page Maker, Power Point, Q-Pro, Dbase, FoxPro, Acess, SAS, SPSS, Estatística, Statview, Statgraph, Norton utilities, anti-virus, Canvas.
- Operating: Windows 95, MS-DOS, OS/2, UNIX, Macintosh System.
- G.I.S.: ARC-INFO (Arc, Aredit, Arcplot, GRID), ILWIS, Arcedit, Rootspro, Map Info, ACE, Arcview.
- Network: Novel Netware 4.01, Design/setup network, server and station configuration, Network administration, Ms-E-mail server

Languages:

- Portuguese - excellent Criolo - (Mother tongue)
- English - excellent Spanish - (working knowledge)
- French - good

Reference:

Insituto Nacional de Desenvolvimento de Agricultura
M.S. Soil Science, Wageningen University, The Netherlands

Time Commitment: 25%

DR. S. D. DeGLORIA
234 Emerson Hall, Dept. Crop and Soil Sciences
Cornell University -- Ithaca, NY 14853
(607) 255-5459
sdd4@cornell.edu

Title and Professional Affiliation:
Associate Professor & Chair Dept. Crop and Soil Sciences, Cornell University
Director Cornell Institute for Resource Information Systems

Time Commitment: 5% FTE

Area of Expertise:
Advancing development and use of spatial data for environmental information needs domestically and internationally; focusing on aerospace imagery, spatial models coupling multi-spectral and multi-temporal data from satellites with edaphic variables, and integrating resource inventory data in spatially-explicit simulation models of nutrient and pesticide transport

Relevant Publications:

Mikhailova, E.A., R.B. Bryant, S.D. DeGloria, C.J. Post, and I.I. Vassenev. 2000. Modeling soil organic matter dynamics after conversion of native grassland to long-termcontinuous fallow using the CENTURY model. Ecological Modeling 132: 247-257.

DeGloria, S.D., M. Laba, S.K. Gregory, J. Braden, D. Ogurcak, E. Hill, E. Fegraus, J. Fiore, A. Stalter, J. Beecher, R. Elliot, and J. Weber. 2000. Conventional and fuzzy accuracy assessment of land cover maps at regional scale. p. 153-160. In G.B.M. Heuvelink and M.J.P.M. Lemmens (ed.) Proc. 4th Int. Symp. Spatial Accuracy Assessment in Natural Resources and Environmental Sciences. Delft University Press, Delft, The Netherlands.

Kuo, W-L., T. S. Steenhuis, C.E. McCulloch, C.L. Mohler, D. Weinstein, S. DeGloria, and D. Swaney. 1999. Effect of grid size on runoff and soil moisture using a variable-source-area hydrology model and geographic information system. Water Resources Research 35(11): 3419-3428.

Laba, M., S.D.Smith, S.D. DeGloria. 1997. Landsat-based land cover mapping in the Lower Yuna River watershed in the Dominican Republic. Int. J. Remote Sensing 18: 3011-3025.

Lynn, H., C. Mohler, S.D. DeGloria, and C.E. McCulloch. 1995. Error assessment in decision-tree models applied to vegetation mapping. Landscape Ecology 10(6): 323-335.

DR. J.M. DUXBURY
917 Bradfield Hall, Dept of Crop and Soil Sciences
Cornell University -- Ithaca, NY 14853
(607) 255-1732
jmd17@cornell.edu

Title and Professional Affiliation:

- Professor Dept. Crop and Soil Sciences, Cornell University 1970 to present
- Member Rice-Wheat Consortium 1994 to present

Time Commitment: 10% FTE

Area of Expertise:
Functions and dynamics of soil organic matter; nitrogen and phosphorus cycle processes in upland and flooded soils; greenhouse gas fluxes and feedbacks in agricultural ecosystems; sustainability of rice-wheat cropping systems

Relevant Publications:

Hobbs, P.R., Y. Singh, G.S. Giri, J. Lauren and J. Duxbury, 2000. Direct seeding and reduced tillage options in the rice-wheat systems of the Indo-Gangetic plains of S. Asia. Paper presented at IRRI workshop "Direct seeding in Asian rice systems", Bangkok, Thailand, Jan 25-28.

Cerri, C., J. Dumanski, J.M. Duxbury, J. Freney, R. Gupta, O. Heinemeyer,T. Kolchuginga, J. Lee, K. Minami, A. Mosier, K. Paustian, D. Powlson, N. Rosenberg, N. Sampson, D. Sauerbeck, H. Tiessen, M. van Noordwijk, and Q. Zhao. 1996. Agricultural options for mitigation of greenhouse gas emissions. In Watson, R.T. et al. (eds.) Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change. Camb. Univ. Press.

Mosier, A.R., J.M. Duxbury, J.R. Freney, O. Heinemeyer, and K. Minami. 1996. Nitrous oxide emissions from agricultural fields: Assessment, measurement and mitigation. Plant and Soil 181:95-108.

Duxbury J.M., L.A. Harper, and A.R. Mosier. 1993. Contributions of agroecosystems to global climate change. pp.1-18. In L.A. Harper, A.R. Mosier, J.M. Duxbury, and D.E. Rolston (eds.) Agroecosystem Effects on Radiatively Important Trace Gases and Global Climate Change, Amer. Soc. Agron. Special Publication no. 55, Amer. Soc. Agron., Madison, WI.

Duxbury, J.M., M.S. Smith, and J.W. Doran. 1989. Soil Organic Matter as a source and a sink of plant nutrients. In D. Coleman, M. Oades, and G. Uehara (eds.). Tropical Soil Organic Matter. U. Hawaii Press, Honolulu. pp 33-67.

DR. RAJ. K. GUPTA
CIMMYT-India
Old NBPGR Building
Indian Agricultural Research Institute
New Delhi 110012 India
(011) 5822940
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Title and Professional Affiliation:
Facilatator & CIMMYT Liason Officer Rice-Wheat Consortium for the Indo- Gangetic Plain
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Soil fertility, saline-sodic soils, irrigation water quality, simulation modeling, rice- wheat cropping systems

Relevant Publications:

Gupta R.K., and I.P. Abrol. 2000. Salinity build-up and changes in the rice-wheat system of the Indo-Gangetic plains. Exp. Agric. 36(2): 273-284.

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Rice-wheat agronomy; modified tillage systems; GIS

Relevant Publications:

Hobbs, P.R., Y. Singh, G.S. Giri, J. Lauren and J. Duxbury, 2000. Direct seeding and reduced tillage options in the rice-wheat systems of the Indo-Gangetic plains of S. Asia. Paper presented at IRRI workshop on Direct seeding in Asian rice systems, 25-28 January 2000. Bangkok, Thailand.

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Soil fertility, plant nutrition, biological N_2 fixation, rice-wheat cropping systems

Relevant Publications:

Gami, S.K., J.K.Ladha, H. Pathak, E. Pasuquin and D. Joshy. 2001. Long-term changes in yield and soil fertility in a 20 year rice-wheat experiment. Biol. Fert. Soils. In press.

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Residue and green manure nutrient benefits, integration of grain and green manure legumes into cropping systems; fertilizer N dynamics and utilization; interpretation and proper utilization of 15N isotopes; aggregate stability as measures of soil quality; rice-wheat cropping systems

Relevant Publications:

Lauren, J.G., J.M. Duxbury, V. Beri, M.A. Razzaque II, M.A. Sattar, S.P. Pandey, S. Bhattarai, R.A. Mann, and J.K. Ladha. 1999. Direct and Residual Effects from Forage and Green Manure Legumes in Rice-Based Cropping Systems. Proceedings of Workshop on Residual Effects of Legumes in Rice and Wheat Cropping Systems of the Indo-Gangetic Plain. ICRISAT Asia Center. Pantancheru, Andhra Pradesh, India

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Relevant Publications:

Lee, D.R. and C.B. Barrett (eds.). 2001. Tradeoffs or Synergies? Agricultural Intensification, Economic Development and the Environment. Wallingford, U.K.: CABI Publishing. 2001.

Neill, S.P., and D.R. Lee. 2001. Explaining the adoption and disadoption of sustainable agriculture: the case of cover crops in northern Honduras. Economic Development and Cultural Change, Vol. 49 In press

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Relevant Publications:

Fischer, P.R., A. Rahman, J.P. Cimma, T.O. Kyaw-Myint,- A.R.M..L. Kabir, K. Talukder, N. Hassan, B.J. Manaster, D.B. Staab, J.M. Duxbury, R.M. Welch, C.A. Meisner, S. Haque, and G.F. Combs Jr. 1999. Nutritional rickets without vitamin D deficiency in Bangladesh. J. Trop. Pedia. 45(5): 291-293.

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Annex: Initial Draft of Procedures for Protocol – West Africa

1. **Selecting Control fields**

Estimating change in C status in both biomass and soils should be estimated for individual fields because results from small plots may be different from those measured at the field level (Gigou et al., 1999). Comparing landuse and cropping systems at the field level is, however, complicated by spatial variability in soil, topography, management and other factors which may over-shadow or mask differences caused by landuse and cropping system. Consequently, we recommend a careful search for "Control fields", probably adjacent to the test fields, that are similar in soil, crop, topography, and management (other than the specific technology) to those on which the technology is being tested.

2. **Sampling Soils for Measuring C**

The phase 1 sampling is designed to obtain a rapid, inexpensive assessment of C status, variability, and soil nutrient status. Sample locations may be configured in a star pattern and include from 40 to 80 samples per star in order to obtain a range of distances between samples and in order to both characterize the statistical distribution (mean or median and variance depending on the distribution) of the sample values as well as the spatial dependence of sample values. Soils should be sampled from 0 - 20 cm and from 20 - 40 cm increments in order to estimate changes in C in the tillage layer and in the subsoil beneath the plow layer. From this set of samples, the landuse / cropping system can be assessed as sufficiently uniform for useful estimates of C accretion or too variable, whereupon the landuse / cropping system will not be further considered and evaluated. In addition, geostatistical analysis will be performed – semi-variograms in particular – will be estimated from these data in order to develop the phase 2 sampling spacing and number of samples. As an initial estimate we suggest taking the range of the semi-variogram assuming that spatial dependence occurs. If there is no spatial dependence then no economy of precise spacing and location of phase 2 samples is possible and a sampling plan developed for a random process will be adequate – in such case more samples will be needed and sample numbers can be estimated using conventional variance / no. of sample relationships for landuse / cropping systems that differ in variance.

3. **Suggested Procedure for Laboratory Analysis of Soil C**

Current methods of measuring soil organic carbon include the Walkley-Black, Addison, combustion, and mid-infrared methods. A comparison of methods will be compared among collaborators and with the assistance of Dr. G. McCarty, USDA-ARS, who has been adapting a mid-infrared method that shows considerable promise over the other methods. The ranking and comparison of procedures will be the subject of a proposed graduate thesis to be developed by a Malian student based in the IER/LaboSEP laboratory at Bamako, Mali, and who will be working at the University of Hawaii and with the USDA-ARS scientists.

4. **Suggested Procedure for Experiments to Measure Soil Organic Matter Decomposition**

Soil organic matter (SOM) decomposition is to be measured be measuring the CO2 produced by soil microbes during the SOM decomposition. This can be done by capturing the CO2 in NaOH, where it forms HCO3- after which the decline in OH- can be measured by titration. For both of these, a soil sample is generally put into a small container (not much bigger than the soil sample) and is incubated for a certain time at specific soil water and temperature conditions. In the studies in this project, soil samples should be taken from a plot that has been bare for a while and does not have fresh-root pieces. The samples are taken in bulk-density rings (e.g. 5-cm diameter and 5-cm height) and not sieved or otherwise disturbed. To obtain a certain water condition for the soil, the ring with the soil sample is put on a pressure plate to obtain desired soil water potential values. Treatments should include soil water potential values from near saturation to wilting point, using the pressure plate, as well as soil collected at its air dry value. Once the desired water potential value has been reached the ring with the soil is put in an airtight container, which also holds a small vial with NaOH. Care should be taken not to breath into the container. The container can be made airtight by wrapping a piece of rubber around its lid (parafin may also be used, but it is not re-usable). The vial with NaOH is removed every few days and put into a refrigerator. A new vial of NaOH is added to the container. The container should be closed as soon as possible to prevent atmospheric CO2 from entering, and care should be made not to breath into the container. During this switching of the vials, the container will be open only briefly, so that the soil sample will not dry out. For measuring the background level of CO2 absorption by the NaOH, the whole procedure is done also for a container without a soil sample. Four replicates for each soil and water potential combination should be used. This procedure can be done in an identical way at the same time for different water potential values, so that one obtains the relationship of a soil's water condition with the SOM decomposition rate. Since this is likely to be different for different soil types, it should be repeated for a range of soils. Ideally all of this should be done at the same time in order to get the same conditions for the incubation.

The amount of CO2 absorbed by the NaOH can be measured by direct titration of the carbonic acid after neutralizing the left-over NaOH. Details of this "two endpoint" titration are described by Jenkinson, D. S. and D. S. Paulson, 1976, Soil Biol. Biochem. 8, 208-209, and by Zibilske, L. M., 1994, SSSA Book Series No. 5, pp. 835-863, Soil Sci. Soc. Am, Madison, WI (USA).

5. Measurements in Agricultural Production Systems

Measurements are needed for specific fields where detailed studies will be undertaken, and variations of these data over space are needed for predicting C sequestration and productivity of optional agricultural systems over the sites being studied. The International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) has developed a minimum dataset needed for making predictions with the crop simulation models (Jones, 1984; Hunt and Boote, 1998).

Weather data.

Daily weather data needed are: daily maximum and minimum temperature, precipitation and global solar radiation. At each field measurement location, daily precipitation should be recorded each day during the year. Temperature and solar radiation can be interpolated from nearby measurement sites (e.g., within 100-200 km). In addition, daily weather data from the last ten to twenty years should be obtained for each study site. If historical daily data are not available, monthly averages of these variables should be provided as well as the number of days with rainfall during each month.

Soil characteristics.

Soil data will be collected from the selected fields where detailed measurements are to be made. Profile characteristics needed by soil layer are texture, water holding characteristics (lower limit, field capacity, saturation), SOM content, P and K concentrations, bulk density and pH. This requires that soil samples be taken at 10 cm increments to the maximum rooting depth, followed by physicochemical analysis of the soil samples. At minimum, soil texture information is needed for each site so that the required soil properties can be estimated using pedotransfer functions (e.g., Saxton et al., 1986; Rawls et al., 1982). However, these estimates will introduce uncertainty in the simulations (Gijsman et al., in preparation) and will only be used when field samples cannot be taken.

For scaling up from the selected fields where detailed measurements are made, soil maps at the highest resolution available are needed. The pedotransfer functions and relationships from the detailed measurement sites will be used to estimate soil properties for each spatial unit in the area for scaling up the predictions of production and soil C sequestration.

Land Management specifications.

Descriptions of the farming systems in use in the region as well as optional systems aimed at maintaining productivity while increasing soil C sequestration are needed. Crop management, such as cultivars, planting window, planting method (broadcast / in rows / ridge planting), and planting density are all needed. Also, residue management must be defined for each system. Crop or crop-fallow rotations, and the role of livestock in the system should be described. If fertilizers are applied, their application dates, application method (broadcast / banded, application depth), types and amounts need to be known. For organic residues (crop residues, manure) a similar set of characteristics is needed, supplemented by the lignin, N and P concentration of the residues.

Crop productivity

Measurements of crop growth, yield, and crop growth duration are needed to calibrate and test the crop-soil models for local conditions. Data from previous experiments in the region (on station and/or on farm) should be assembled for this purpose. In addition, measurements will be made at each detailed measurement field for traditional (control) systems as well as those being studied for increasing soil C. For fields being monitored for calibrating or testing the crop-soil models, the following data will be collected: management practices (including dates of operations such as planting), plant population, leaf area index and above-ground biomass about 40 days after planting (near anthesis date), final grain yield and above ground residue. Plant samples taken about the time of anthesis are needed to evaluate the ability of remote sensing to correctly estimate leaf area index and crop biomass to determine uncertainties of extending point samples to larger areas using satellite imagery. More detailed protocols for in-field sampling are provided in the DSSAT documentation (Tsuji et al., 1994).

Residue

Measurements of residue left in the field should be made in April to provide information on the amount of biomass and C that will be added to the soil cattle have grazed the land and humans have removed all that they intend to take. Coinciding with this measurement date, a satellite image should be obtained for developing relationships to estimate annual additions of residue for the different cropping systems for scaling up from point measurements to area-wide predictions of C sequestration.

Pests and diseases.

If a crop is hit by a pest or disease, and, consequently, does not produce as well as it could have done, this will not only affect the harvestable product, but also the amount of residues returned to the soil. The disease pattern should be registered and the losses estimated.

6. Prediction of C sequestration and productivity

The crop models in the Decision Support System for Agrotechnology Transfer (DSSAT; Tsuji et al., 1994) will be used to predict C sequestration and productivity of different cropping systems in this project. DSSAT is widely used in both developed and developing countries (Algozin et al., 1988; Bowen and Wilkins, 1998; Jagtap et al., 1993; Lal et al., 1993; Singh et al. 1993; Thornton and Wilkins, 1998). The soil organic matter component of crop models plays a crucial role in predicting crop productivity as well as changes in soil carbon over time in low input systems. For this reason, a widely used and tested soil-organic-matter (SOM) model (from CENTURY; Parton et al., 1988, 1994; Smith et al., 1997) has been incorporated into the crop models in DSSAT (Gijsman et al., submitted) to more realistically simulate SOM levels and greenhouse gas production of different cropping systems.

The models will be used to simulate crop productivity and changes in soil C at each field for traditional cropping systems as well as those being evaluated for increasing soil C. This will be done in two steps. First, the models will be used to simulate the exact situations in the selected field sites for calibrating the model to local climate, soil, and management conditions. This step will provide comparisons between observed and simulated experiments, but only for relatively short time period of about five years. Secondly, the models will then be used to project potential C sequestration and changes in crop productivity over a 40-year time period. For step 1, inputs will be measured (see above) to simulate the conditions that are observed in the field. Comparisons between simulated and observed productivity and soil C will provide the information needed to adjust crop and soil parameters so that the models accurately simulate the systems for the specific conditions under which they have been measured. Then, 100 years of weather data will be generated using the DSSAT weather generator to simulate the long term potential for soil C increases. Results from these simulations for each intensively measured field will provide projections of C sequestration potential over the next 5, 10, 20 or more years. In addition, steady state soil C for these fields and management systems will be estimated by determining the asymptotic levels of C after 100 or more years of simulations. The maximum soil C sequestration potential for the soil, climate, and management system will be estimated by subtracting initial values of soil C from the soil C values after any specified length of time or from the steady state soil C amount.

7. Remote Sensing for Verifying Cropping Systems and Management Practices

Soil carbon accretion and improved agricultural productivity is dependent upon the adoption of improved land management. Remote sensing data will be used for characterizing land use and management practices. It will be used to establish fields for intensive monitoring and study, and for identifying larger areas for input into the DSSAT-CENTURY model for scaling up predictions of soil C accretion potential. Landsat imagery (15 and 30m resolution) will be the primary source of data for land use classification. IKONOS imagery (1m pan and 4 m multi-spectral) will be used to complement Landsat data and in-situ measurements, specifically to detect ridge-tillage practice at mid-season and surface residue at the end of the dry season. IKONOS data will be particularly useful for identifying and monitoring tillage systems and residue management where field size is only a few hectares. The proposed time for the acquisition of IKONOS data would be during the peak vegetative period because this would provide the maximum discrimination between the ridge-tillage and other management practices followed by farmers. Another critical time would be the end of the dry period to account for crop residue remaining on the soil after grazing. Monitoring of tillage practices and crop residue at the beginning of the next cropping period is needed to account for carbon sequestration in the soil. The supervised classification techniques developed Cook et al. (1996)

will be adapted to identify the crop and management practices using the Landsat and IKONOS data. Ground truth data will be acquired in a systematic sampling scheme that will cover all study sites.

8. Analysis of Livestock Management Role in Soil C Sequestration

Household Characterization. Household characterization studies will be undertaken in three of the project sites having the widest diversity of rainfall amounts and mixed farming systems. Data will be collected at each site on the biophysical variables that describe the farming system, household objectives and decision making processes that may influence livestock and cropping system management, management intensity, reflecting the managerial capacity of the farm household and the level and frequency of management interventions within each of the system's components, and the intensity of interactions between the livestock, crop production, and other system components. Data protocols for smallholder farming systems being developed through other activities will be used (Hansen et al., 1997; Herrero et al., 2000). It is anticipated that through the partner organizations, much of the baseline characterization data already exists in survey and GIS databases. This activity will involve primarily re-analysis of existing data sets, through clustering or application of household prototyping techniques. The resultant characterization will then be validated and ground-truthed through rapid participatory assessments to ensure its appropriateness.

Adapt household crop-livestock models. The systems characterization work will identify a set of household types across a gradient of the selected project sites. For each type, a small number of household models will be set up (the number depending on the variability within each cluster) to represent their respective groups. These household models will be based on existing, separate crop and livestock models that have been widely applied and tested in diverse tropical environments. The integrating framework for linked crop-livestock models that incorporate the major crop-livestock interactions has already been developed (Thorne, 1998; Thornton et al., 2000) within the context of the ICASA toolbox initiative (http://www.icasanet.org). Some work towards linked crop and livestock models, within a multiple-objective mathematical programming framework, has been done already (Herrero et al., 1999; Castelán-Ortega, 1999), and the work here will build on these earlier approaches to minimize repetition. The household model will deal with the flow of carbon and other biophysical materials, cash flow, and resource constraints. In addition, if households have communal resources, then some modifications will be made to the household models to account for decisions made concerning resource use at a community level. The household models will be calibrated and validated using existing data sets so far as possible.

Analysis of Target C Sequestration Options Including Scenarios for Livestock Management. Analyses of the target management systems will be made, taking into account livestock management as well as household needs and constraints at each of the sites where a farm modelwas developed. This analysis will characterize the extent that existing livestock managementsystems affect the potential for soil C sequestration, and whether optional livestock management would both meet household needs and increase the potential for soil C sequestration. Finally, a comparative study will be made across sites to identify factors that determine how much livestock management will influence the expected outcome of soil C sequestration initiatives. This information will be used to assess the potential influence in other regions when the protocol is extended to those areas.

9. Scaling up Predictions of Soil C sequestration

A combined remote sensing and modeling approach will allow the assessment of regional carbon sequestration. Remote sensing can characterize land use over areas of about 10,000 ha at each site. This information will be used to estimate the areas that potentially could adopt management systems for sequestering C in soils. Climate data at the grid level is generated by interpolation between climate stations in the study region. Similarly, soil maps of the sites will be used to provide soil inputs at a grid level. The climate, soil, and management inputs for each grid will be developed in a Geographical Information Systems (GIS) database. The DSSAT-CENTURY models are run for each grid, first using existing management systems on the land targeted for use in soil C sequestration. Then, different levels of adoption of practices will be assumed to run the models and predict the levels of soil C accretion for different times in the future (e.g., 1, 5, 10, 20, 100 years). Sensitivity analyses will be performed to characterize the levels of uncertainty in soil C accretion levels. Maps of carbon potential, crop yield, and biomass will be produced for areas at each site to inform potential users of the levels of adoption of specific systems needed in order to sequester target levels of soil C, and the uncertainty associated with each map.

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Request for Proposal

Biotechnology
and the Rhizosphere

REQUEST FOR PROPOSAL

Topic: Biotechnology and the Rhizosphere

Biotechnology has great potential for increasing agricultural productivity in developing countries where insects and diseases take a heavy toll on crop yields before and after harvest. Much of the attention, however, is focused on the above-ground portion of plants, but gene manipulation may also impact positively or negatively on the microorganisms and other animals that inhabit the soil. Genetically engineered plants designed to protect the above-ground plant parts can defend roots against nematodes and pathogens, but can also prevent mycorrhizae and nitrogen fixing organisms from establishing symbiotic relationships with their host plants.

The positive or negative impact of biotechnology on rhizosphere ecology is especially important in low-input farming where crop production is virtually impossible without mycorrhizal enhancement of nutrient uptake. Biological nitrogen fixation can also be affected by gene manipulation to fend off bacteria that infect leaves, stems, and fruits.

The impact of biotechnology on rhizosphere function will constitute a highly focused effort of the CRSP. To initiate the effort, the CRSP will issue a request for proposals and give priority to those that emphasize the impact of genetic engineering on nutrient uptake and water use efficiency by plants, biological nitrogen fixation and carbon sequestration.

Budget:
A 12-month plan of work and budget will be requested for an award amount not to exceed $200,000.