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The Soil Management CRSP Proposal for Extension 1994–1999

A Refocussed Program to Serve Global Land-Management Needs

Submitted by

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Executive Summary

Founded in 1981 under Title XII of the United States Foreign Assistance Act, the Soil Management CRSP (referred to as *TropSoils* until 1992) initially consisted of four institutions: Cornell University, North Carolina State University, Texas A&M University, and the University of Hawaii. In 1992, the CRSP was expanded to include four additional organizations: the Nitrogen Fixation by Tropical Agricultural Legumes Center (NifTAL), the USDA/Soil Conservation Service's Soil Management Support Services (SMSS), and the USDA/Technology for Soil Moisture Management Program (TSMM) with components from both the Agricultural Research Service (ARS) and the Economic Research Service (ERS).

During 13 years of collaboration with NARCs, IARCs, and USAID missions, the CRSP has increased the land-management knowledge base and developed a broad range of human resources. These efforts have reshaped our understanding of soils and created a global network of soil-management expertise. They also provide the foundation for an aggressive new program to develop and promote problem-solving tools.

Foundation is the appropriate metaphor. Since its inception, the CRSP has helped lay the groundwork upon which sustainable development depends. We have learned how to manage the soil nutrients so that continuous cropping can replace slash-and-burn systems, thus reducing the need to clear more and more land. We have shown that biological nitrogen inputs can increase food production and reduce the need for expensive nitrogen fertilizers. We have developed on-farm strategies for increasing production on small intensively farmed areas so that larger areas can be allowed to regenerate. We have helped more than 55 countries improve their soil inventories, monitor resource degradation and rejuvenation, and apply consistent soil-taxonomy data. We have trained thousands of developing-country citizens at national and regional workshops. We have provided on-site instructional programs and a variety of training publications. And we have helped more than 125 students earn advanced degrees, preparing them for positions of authority in their home countries. (A more detailed list of accomplishments is given in Appendix III).

At research sites representative of broad agroecological zones, we have shown that tropical soils respond to directed management, and we have helped

clarify the management practices best suited to particular sites. Equally important, we have learned that soil science principles applicable to temperate sites also apply in the tropics. Thus a wealth of information has become available to improve and conserve land productivity.

The significance of these efforts is readily apparent. It means that what we learn in one part of the world can be modified and adapted to other regions. It means that the dramatic increases in soil science understanding to which the CRSP has contributed can have a world-wide impact. Having determined better ways to manage the world's soils, we can now work to see that those soils are in fact *being* better managed.

To achieve this objective, the CRSP has been reorganized and its programs refocussed. The eight institutions participating in the Soil Management CRSP have historically functioned as independent entities, each with a designated budget and a self-defined program. Although each program has achieved soil-management goals supportive of USAID's objectives, interaction among institutions has been limited. Funding for the current programs terminates in September 1994.

USAID has informed the Management Entity that the proposal for extending the CRSP must present a unified program which addresses the immediate needs of field missions. Because funds will be limited, a tightly focussed program must be developed and executed by multi-institutional teams. USAID's directives make clear that institutional entitlements will be eliminated and that no current program will be automatically continued.

This proposal addresses USAID's prerequisites and presents a restructured and refocussed CRSP. It also introduces a major shift in program emphasis and implementation. Rather than working as individual institutions to expand the knowledge base, the CRSP will now establish multi-institutional teams of scientists to develop problem-solving tools. This change reflects a widely recognized reality: our understanding of soil and water systems has improved dramatically over the last 15 years, and as a result, our principal challenge has become using what we know to solve basic soil-management problems.

The restructured CRSP will employ a conceptual framework consisting of targets, problems, and tasks. *Targets* are problem areas with a high potential for being solved by CRSP programs and for producing significant beneficial impacts on soil-management practices. *Products* are knowledge-based problem-solving tools; their attributes will depend on the nature of the problem. *Tasks* are activities leading to the development of a product; they will vary depending on the characteristics of the product and its state of development.

Targets were selected from information gathered at the CRSP's Global Planning Workshop, which was attended by representatives from 13 developing countries, USAID, IARCs, U.S. universities, and U.S. federal agencies. Target

selections also reflect the CRSP's interactions with NARCs and USAID field personnel, along with experiences gained during a 20-year partnership with USAID. Products and tasks were determined at five workshops involving participants from all eight CRSP institutions.

All problem-solving tools share this feature: they must serve the practical needs of USAID field missions and their collaborators in a readily usable manner. They must also focus on three essentials of sustainable development: conservation and environmental protection, land resource quality, and soil productivity and economic growth. All products will be capable of diagnosing a problem and prescribing a remedy. They will have a global dimension and thus will be applicable wherever the targeted problem occurs. In addition, products will be capable of facing two ways at once: down at field-level problems and up at policy-level problems.

Typical products to be developed over the five-year extension include the following: policy-making guidelines on the inputs needed to develop sustainable land-use practices, procedures to rejuvenate degraded lands, practices to reduce wind and water erosion, mechanisms to assess land-resource quality, guidelines for selecting alternative land-use practices, and decision aids for managing soil acidity and providing essential plant nutrients.

Developing problem-solving tools will not in itself solve land-management problems. The tools must be explained and promoted—particularly as they relate to national land-use policies and site-specific contexts. Thus, the refocussed CRSP will implement an aggressive Outreach Program. Working with USAID field missions, LDC collaborators, and the public sector, this high-priority activity will help diagnose land-management problems, explain and demonstrate how CRSP products can solve these problems, and evaluate the results of product use. Feedback from these experiences to the product-development teams will insure that the programs remain responsive to user needs. Each work plan will contain criteria for assessing progress in product development, adoption, and impact.

The proposed program reflects the assessments and recommendations of the External Evaluation Panel. The program will be increasingly aware of USAID's broad societal goals and increasingly responsive to mission requests for assistance. In addition, institutional strengths will be integrated, and individual tasks will focus on the CRSP's clearly defined mission. An assertive Outreach Program will assure the effective application of CRSP outputs and the relevance of funded activities to USAID's goals.

During the first year, the refocussed CRSP will (1) refine, test, and promote prototype products; (2) evaluate potential products for their applicability to targeted problems; (3) conceptualize, formulate, and evaluate new products

based on user needs; (4) intensify outreach efforts for those problem-solving tools which are already available; and (5) identify personnel and establish the organizational structures to provide a ready response to requests from USAID field missions.

The Soil Management CRSP is well positioned to carry out this far-reaching and issue-oriented program. It has the technical expertise to assess land-resource characteristics, to diagnose land-use problems, and to prescribe sound land-management practices. It has a foundation of experience built on more than 20 years of work with USAID officials and LDC administrators and scientists. It can draw on a world-wide network of collaborators to implement decisive actions that can solve on-the-ground problems. And it is committed to enacting a knowledge-based program that places professional integrity at the service of LDC needs.

Over the next five years, we expect the Soil Management CRSP to help many developing-countries establish policies that encourage and support improved land uses. We also expect the CRSP to provide leadership in developing soil-management practices that will increase food and fiber production while reducing land degradation. And we anticipate that the result of such improvements will be a greater awareness of the relationship between economic development and the land. Together, these changes will reflect an increased international commitment to preserving and enhancing global soil and water resources.

Foreword

As background for developing this proposal, we have studied the changes in mission and structure being considered by USAID and the actions taken to implement these changes. As a long-time partner, we have also reexamined our own experiences and assets to see how they relate to USAID's emerging objectives.

Any successful effort to improve the lot of humanity must sooner or later reckon with the source of its sustenance—the land. Early management actions can enhance productivity and prevent degradation. Later actions require more costly remedial measures. Indeed, recent studies have shown that mismanagement has so damaged 17% of the earth's vegetative surface that restoration has become both difficult and expensive.

For more than four decades, the constituent institutions of the Soil Management CRSP have been engaged in collaborative programs with USAID and developing countries to better understand and better manage the diverse lands of the developing world. The experiences and achievements that have emerged from this relationship can support USAID's new goals for economic growth and environmental protection.

This proposal details the nature of that support in five parts: a Global Plan, a Basic Work Plan, a Prioritized Work Plan, a Scope of Work, and Appendices.

- The *Global Plan* sets forth the land-management issues pertinent to the new USAID agenda, outlines a hierarchy of program objectives, describes the conceptual framework for the refocussed CRSP, and clarifies how that framework will guide the achievement of program objectives.
- The *Basic Work Plan* was developed on the assumption that the program would be funded at the current level. It identifies target problems, specifies the products necessary to solve those problems, and outlines the tasks necessary to generate products.
- The *Prioritized Work Plan* was developed from the *Basic Work Plan*. It identifies target problems and products, and it presents detailed budgets for each of three funding levels: 80%, 70%, and 60% of current funding.
- The *Scope of Work* is a self-standing program summary based on the prioritized work plan.

- The *Appendices* describe the collaborative process by which this document was prepared, and they list the CRSP members involved in the preparation. They also list the CRSP's collaborators, outline representative accomplishments, highlight our interCRSP activities, provide a brief program history, and document the procedures for estimating collaborator budgets.

Together, these elements demonstrate that matching our capabilities to USAID's needs can contribute significantly to sustainable development on a global scale.

1.
Global Plan

A Refocussed Soil Management CRSP

Global Needs

To the ancients, earth was elemental, the very stuff of life. A source of food, fuel, and fiber, it was also described—from Africa to Asia to the Americas—as the raw material from which mankind was created. In the Mideast, this bond was embedded in the language: *adam* (both "Adam" and "humanity") derives from *adama* ("cultivated earth").

A profound insight unites these details. At its core is an enduring truth, a recognition that transcends dogma. We are linked to the land, our ancestors perceived. We depend on it for survival. We cannot degrade it without in some sense degrading ourselves.

History suggests that civilizations disregard this insight at their peril. It demonstrates that soils are, quite literally, *fundamental*: they are the fundament, the essence, the crux. Whether the topic is crops or livestock, family nutrition or economic vigor, genetic diversity or global warming, the underlying issue is the same: How are we using the land?

Sustainable development cannot be achieved unless we answer that question wisely. Economic growth, agricultural productivity, and environmental security all depend on the responsible use of our finite soil and water resources. Degrade those resources, and the results are all too predictable—crops fail, economies founder, malnutrition increases, and the quality of life declines.

The challenge ahead is starkly framed: at current production levels, about 0.5 hectares of arable land are required to meet each person's basic needs. Only 0.28 hectares are available. Even if the remaining reserves of arable land are cultivated, the World Resources Institute estimates that only 0.15 hectares will be available by the year 2050. Intensified agriculture—i.e., that which generates higher productivity per hectare—is the only way to meet the rising demand for food, fuel, fiber, and construction materials.

Intensification of this sort will place profound stress on soil and water resources, particularly in developing countries, where the need to increase productivity is greatest. Indeed, by 2025 developing countries are expected to account for 84% of the world's population. And the majority of those people will derive their income from land that already exhibits one or more severe constraints to sustained production.

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These changes threaten to exacerbate some grim economic and environmental realities. At present, for example, developing countries account for 77% of the world's population, but earn only 15% of its income. And even at current production levels, 17% of the earth's vegetated surface has been severely degraded. Water and wind erosion from inappropriate land-clearing and cropping practices have caused the bulk of this degradation, with the result that soil productivity has declined and lakes and waterways have been damaged by siltation.

To avoid serious economic and environmental problems, developing countries must adopt policies that promote responsible land use and encourage land-management practices that increase productivity without compromising the stability and resiliency of the agroecosystem. Efforts to promote these goals will be most effective if they provide knowledge-based tools that serve both policy- and field-level decision-makers.

Natural-Resource Productivity and the Environment

Although historically the CRSP's mission has been to increase food production, global needs now dictate that we devote equal attention to environmental and natural-resource problems.

This change reflects the growing realization that responsible soil and water management are inextricably linked to a wide range of developmental issues. Genetic diversity, global warming, deforestation, family nutrition, sustainable resource management—all these contain a fundamental soil component. In response to world-wide concern over the way resource degradation affects such issues, the restructured CRSP will now address the interrelated problems of agricultural production, environmental protection, and natural-resource management.

The CRSP recognizes that environmental-protection programs will fail if they do not also meet the immediate needs of the world's poor and hungry. Our experience suggests, however, that environmentally sound development does not have to be less productive than the resource-depleting strategies currently employed across large parts of the world. When soil and water resources are managed efficiently, productivity and sustainability will not be antagonists.

Mission Statement

Based on the comparative advantage conferred by our personnel, the Soil Management CRSP's mission in confronting the global challenge is as follows:

> *To help growing populations manage the land in a way that meets their needs and aspirations while also enhancing the soil and water resources upon which future generations will depend.*

Program Objectives

To fulfill our mission, the CRSP has identified the following core problem and hierarchy of program objectives:

Core Problem:	Population increases and societal needs are placing demands on finite land resources; those demands cannot be met with presently applied policies and technologies.
Core Objective:	To achieve sustainable increases in soil and water resource productivity so that developing countries can meet their basic needs while enhancing the natural-resource base and environmental quality.
Goal:	Land users employ soil- and water-management products that improve food security and enhance economic well-being.
Purpose:	National policy research and advisory systems, along with other user groups, employ globally applicable soil- and water-management products developed by the CRSP.
Outputs:	Products for diagnosing and solving specific problems in ways that increase soil and water resource productivity, improve economic growth, and enhance environmental quality.

Program Strategy

Rather than working as individual institutions to expand the knowledge base, the restructured CRSP will establish multi-institutional teams of scientists to develop and promote tools that can both diagnose problems and prescribe solutions. Research will be conducted as necessary to fill critical gaps in the knowledge base. Key elements in the operational strategy are as follows:

- Providing the tools necessary to solve problems important to missions (i.e., employing tools that are already available and developing additional tools as necessary).
- Evaluating clientele requests and user responses to guide program adjustments and priorities.
- Promoting product use with an aggressive outreach program.
- Maintaining the personnel and technical capability to support USAID missions on land-management issues related to sustainable development and environmental quality.

Problem-solving tools will be developed through a concept involving targets, products, and tasks.

Targets are problem areas with a high potential for being solved by CRSP programs and for producing significant beneficial impacts on soil-management practices once they are reduced. Each target will have a technical, a socioeconomic, and an outreach component.

Products are knowledge-based tools that enable users to diagnose and solve problems, as well as to monitor change. Product attributes will vary depending on the nature of the problem, the magnitude of the information gaps, and the targeted users. All products will have a global dimension and thus be applicable wherever the targeted problem occurs. Moreover, each product will provide guidance for use at a location-specific level. Products will be developed by multi-institutional teams.

Tasks are activities leading to the development of a product. They may range from summarizing and interpreting unpublished literature, to conducting applied field experiments, to undertaking basic research. The specifics will depend on what actions must yet be taken to produce a reliable product.

Targeted Users of CRSP Products

The products developed by the CRSP will invoke the Janus principle. Like the Roman god, they will be capable of facing two ways at once: *down* at field-level problems and *up* at policy-level problems. This dual capability will help link practice and policy. CRSP products will be designed to serve the following support groups and, through them, enhance USAID's ability to achieve its goals:

- *Policy-makers,* for evaluating long-term economic and environmental outcomes of alternative land-use policies.
- *Research scientists,* for identifying knowledge gaps and enhancing their efficiency in ways that help solve high-priority problems.
- *NGOs, PVOs, extension agents, and teachers,* for training, diagnosing, and prescribing ways to deal with site-specific soil-management issues concerning agronomy, natural resources, and the environment.
- *LDC famers and land users,* for enhancing productivity and preserving environmental quality.
- *Agribusiness,* for estimating agronomic value and the environmental side-effects of agricultural inputs on a site-specific basis.
- *Regulatory agencies,* for assessing the risk and consequences of enforcing government regulations.
- *Banks and lending agencies,* for assessing the credit risk of agricultural loans.
- *Private consultants,* for expanding the range and quality of service to clients.

Program Structure

To achieve its goals and objectives, the Soil Management CRSP has restructured its program and refocussed its energies. These changes were made in consultation with USAID officials, host-country collaborators, and the Board of Directors.

The first element in the new structure encompasses program-wide activities that focus on providing direct assistance to USAID missions and on employing an aggressive outreach effort to explain and promote the CRSP's products. The second element in the new structure will focus on developing products (i.e., tools) to solve targeted problems. The overall structure is depicted in the diagram below.

The Soil Management CRSP Program Structure

Product Research and Development Focus

1. *Conservation and Environmental Protection*
   - Water and wind erosion control
   - Rejuvenation of degraded lands
   - Water resource use and protection
2. *Land Resource Quality*
   - Quality and degradation indicators
   - Productivity and use options
   - Soils and environmental data bases
3. *Productivity and Economic Growth*
   - Amelioration of acid soils
   - Integrated nutrient and water management
     - Phosphorus management
     - Nitrogen management
     - Water harvesting and use

Program-Wide Focus

1. *Outreach*
2. *Field Support to USAID Missions*

Product Research and Development Focus

The CRSP will develop problem-solving tools capable of having a measurable impact on USAID's new sustainable-development initiative. This change from the CRSP's previous approach reflects a widely recognized reality: our understanding of soil and water systems has improved dramatically over the past 15 years, and as a result, the principal challenge has now become applying what we know to basic management problems.

To this end, the new program will analyze existing information and use this information to develop evaluative and prescriptive products. These globally applicable tools can be adapted to diagnose and solve location-specific problems. Under the new framework, component research will be conducted as necessary to close knowledge gaps that inhibit the development of specific problem-solving tools.

To determine the most important land-management obstacles to sustainable development, the CRSP used the following resources:

- Results from the CRSP's Global Planning Workshop, which included participants from 13 developing countries, USAID, International Agricultural Research Centers, U.S. universities, and U.S. federal agencies.
- Interaction with USAID bureau and mission personnel in Honduras, Mali, Niger, Bolivia, the Philippines, Burkina Faso, Indonesia, and Jamaica.
- Interactions with personnel from National Agricultural Research Centers in developing countries where the CRSP has collaborated.
- Assessments of probable needs under USAID's reorganized structure, focus, and priorities.
- Experiences gained from 20 years of partnership with USAID.

Target 1. Conservation and Environmental Protection

Over the last 45 years, more than a billion hectares of land have been degraded—an area roughly equal to India and China combined. All told, 17% of the earth's vegetative surface is now so seriously degraded that restoration has become costly or—in some cases—impossible. Agricultural activities have accounted for much of this degradation. As population increases, the pressure to meet human needs by intensifying production on marginal lands threatens to exacerbate such problems. Indeed, evidence suggests that another billion hectares could be degraded by 2025 unless improved land-management policies and practices are integrated and implemented.

The Soil Management CRSP has identified three problem areas crucial to conservation and environmental protection, all of which can be reduced by the development and application of problem-solving tools.

Water and Wind Erosion Control

Water erosion accounts for more than half of all human-induced land degradation; wind erosion accounts for another quarter. In Africa, the two cause nearly equal amounts of damage. In Latin America and Asia, water erosion is the more pernicious, destroying both cropland and waterways. Intensified steepland agriculture in the Philippines, for example, has rendered all but lifeless 84 of the nation's 300 rivers; in addition, the fish farming industry has been crippled, health problems have increased, and flash floods have intensified.

Although in the past a lack of appropriate technologies has prevented farmers from avoiding erosion problems, the current need is to modify existing technologies so that they fit site-specific physical, economic, and policy contexts. Such integration is essential if producers are to adopt the improved methods. Long-term solutions will also require the integration of agricultural and environmental concerns: environmental policies must be considered for their effect on farm income; policies to maintain farm income must be considered for their long-term impact on the environment.

Rejuvenation of Degraded Lands

According to the World Resources Institute (WRI), the productive potential of more than one billion hectares has been severely reduced since the end of World War II. The primary causes of this degradation have been agricultural activities, overgrazing, fuelwood and timber exploitation, and deforestation.

Land degradation imposes harsh human, economic, and environmental costs. M. S. Swaminathan points out, for example, that current trends provide "an early warning that we are losing potential agricultural productivity that may be critical in providing food and [meeting] other essential needs of a burgeoning population." Land degradation also threatens biodiversity and alters ecological cycles that maintain water quality, air quality, and soil fertility.

There are four principal causes of soil degradation: water erosion, wind erosion, fertility depletion, and physical deterioration (e.g., compaction by machinery). This CRSP's primary focus will be on degradation caused by agriculturally related erosion and land-use practices. CRSP products will accommodate typical and diverse climatic and soil conditions; they will also target lands in which degradation, regardless of severity, is potentially and economically reversible. The products will serve two distinct purposes—either singly or together: (a) restoring soil productivity for agricultural use and (b) stabilizing the total landscape to avoid further degradation.

Water Resource Use and Protection

The quality and quantity of surface water and groundwater are intricately related to land-use practices. Runoff may transport contaminants such as sediment, agricultural chemicals, manures, and wastes to streams, lakes, reservoirs, and estuaries. Chemical leaching may contaminate groundwater,

making it unsuitable for consumption. Soil erosion may affect stream flow, especially in steepland watersheds. Loss of soil buffering capacity causes high peak flows (including floods) during wet periods and both low stream flow and spring dry-up during dry periods. Irrigated agriculture may become unsustainable if groundwater resources are not replenished.

Management of land and water is most effective when conducted at the watershed level. Within watersheds, land use and water needs may conflict. In a coastal watershed in southern Honduras, for example, slash-and-burn hillside farming causes stream-flow extremes, extends drought periods, and decreases water availability for irrigating the downstream coastal plain. By altering water salinity fluctuations and increasing water sediment and chemical levels, agricultural practices have adversely affected commercial shrimp production and the ecology of mangrove forests.

Effective watershed management assesses the sources of water degradation and evaluates land-management alternatives based on physical, social, cultural, and economic factors. Planners and policy-makers need system-wide information on how various land-use practices affect water quality and quantity. They also need a framework for integrating land-use activities at the watershed scale.

Target 2. Land Resource Quality

Land resource quality is directly linked to quality of life, and, specifically, to social and economic equity; it is thus part of the socioeconomic context for sustainability. In the past, the CRSP's focus has been on rehabilitating degraded lands; the refocussed CRSP will supplement these efforts by assessing the potential for land degradation, the resilience characteristics of land systems, and the technological options best suited to specific resilience properties. Developing *early-warning indicators* and *land-resilience criteria* will thus be crucial to the program. Since both are to some extent site-specific, the task of developing generally useful tools must be undertaken by an international network of collaborators.

Quality and Degradation Indicators

Soil-survey information continues to be a high-priority need, particularly as it is used for computer technologies, for decisions concerning the management of degraded lands, and for establishing early-warning indicators of degradation. Soil taxonomy has important applications to this endeavor. Soil-survey interpretations are currently made manually and thus are unable to capitalize on the wide range of expertise available around the world, particularly that which exists on expert systems and related computer technologies. Placing a soil data base on a geographic information system (GIS) and coupling it to an expert system is a powerful tool for predicting and analyzing resource behavior.

CRSP products will consist of manuals, guidelines, training packages, extension documentation, computer models, and data-base management

systems. The CRSP will also develop monitoring systems to evaluate specific properties that enhance or degrade soil health or that have an impact on soil performance.

Productivity and Use Options

Sustainable land management (SLM) is the key to harmonizing the environmental and ecological concerns of society with the economic realities of producing adequate food and fiber and ensuring a basic minimal quality of life. Although SLM focuses on maintaining the integrity of the biophysical land resource base, it also recognizes that sustainability cannot be achieved unless land users understand the impacts of land-management options so that they can optimize the socioeconomic and environmental benefits of their choices. Because insufficient attention has been given to this aspect of SLM, this CRSP will make a concentrated effort to link SLM to on-farm socioeconomic realities. The CRSP will also work to develop the concepts, frameworks, and mechanisms of SLM.

The thrust of this activity will be to generate, mobilize, integrate, and process land and environmental data for scientific land-use planning. Team members will take advantage of both indigenous knowledge and the latest advances in information science and digital information technology.

A framework for SLM will have wide application in agricultural research and development, as well as in environmental assessment. It will provide the scientific basis for evaluating the environmental impact of proposed land-use changes. It has the potential to evaluate the consequences of projected changes in global climate. And when coupled with computer technologies such as simulation modelling, GIS, and expert systems, it has the potential to emerge as one of the most powerful tools for SLM.

Soil and Environmental Data Bases

Technology transfer demands changes not only in the management of people and materials, but also in the management of information. To make technical decisions that are ecologically, economically, and socially responsible, decision-makers in environmentally endangered countries need information sources that are easily available, well-organized, and accurate. The CRSP's Biophysical Resource Appraisal Support System (BRASS) provides a means of structuring and evaluating the information used by decision-makers. BRASS integrates modern sources of information so that users can make strategic decisions with confidence. BRASS is the product of an expanding computer industry which increasingly offers the decision-maker electronic sources of information.

The CRSP's plan is to develop a scale-sensitive information system that links BRASS to a family of computerized decision support systems. Such a system will serve the network of decision-makers involved in the use and distribution of resources. BRASS developers recognize that decision-makers at all levels of

society must participate in the design and implementation of any tool that affects their social, economic, and ecological well-being.

Target 3: Productivity and Economic Growth

In developing countries, 60 to 90% of the population works in agriculture. Economic growth and agricultural productivity are thus inextricably related. At present, both are constrained by the inefficient use of soil nutrients and water. Any proposal that seeks to sustain development in these countries must include a provision to increase the long-term productive capacity of their soil and water resources.

To generate such increases, the CRSP has identified two problem areas where its personnel and experience enable it to develop technologies and decision aids that address current and anticipated problems.

Amelioration of Acid Soils

Crop yields in acid soils are frequently reduced to 50% of optimum levels. Among soil chemical problems, acidity and phosphorus deficiency are the only constraints that can reduce yields to zero. Soil acidity destabilizes production by limiting root growth. It also limits the roots' ability to absorb essential nutrients and exacerbates the effects of stresses such as drought. In their attempts to minimize risks of crop failure, subsistence-level farmers in LDCs are unable to capitalize on high-yielding varieties, which are often more vulnerable to such stresses.

Worldwide, 32% of all arable soils are acid, and that figure climbs to 50% in the tropics. Acidity problems are especially prevalent in areas where rainfall exceeds evaporation. Soluble nutrients such as calcium, magnesium, and potassium are leached as water moves down through soils. These nutrients are replaced by aluminum, hydrogen, and manganese—the elements most commonly associated with soil acidity.

Many soils become acidic as human activity is intensified. Cultivated crops take up large quantities of calcium, magnesium, and potassium—which are exported from the land in harvested products. Unless these nutrients are replenished, the soil becomes progressively more acid with succeeding crops. Because legumes are particularly sensitive to soil acidity, producers can eventually lose the economic benefits of a low-cost supply of N from biological fixation.

The Soil Management CRSP has had long and extensive experience working with LDC collaborators to diagnose acidity problems and to prescribe remedial treatments. This experience will help the CRSP develop the following problem-solving tools:

- A computerized knowledge-based decision aid able to (1) diagnose prevailing acidity problems worldwide; (2) recommend a range of practical management alternatives with considerations for differences in crop tolerance to acidity and resources locally available to ameliorate the problem; and (3) provide reliable estimates of the economic consequences for the proposed remedial practices.

- Regionally relevant and practical information guides so that improvements in the knowledge base have an impact on managing acid soils.
- Improved techniques for selecting cultivars tolerant to major soil acidity factors and improved methods for characterizing the genetics of such tolerance.

Integrated Nutrient and Water Management

Productivity on more than half of the world's arable land is limited by soil acidity, phosphorous and nitrogen deficiencies, water deficits, or a combination of these problems. Efforts to increase productivity invariably address several of these constraints. For example, overcoming soil acidity improves root growth and plant access to available soil water and nutrients, but favorable crop yields will not be achieved unless phosphorus and nitrogen are in adequate supply. Similarly, biological nitrogen fixation is a low-cost alternative to inorganic nitrogen fertilizers, but legume sensitivity to soil acidity may restrict farmers' ability to capitalize on this management practice.

Harvested crops remove large quantities of nutrients from the land, making soils progressively more acid and nutrient-poor unless remedial measures are implemented. This problem is often compounded by province- and nation-wide fertilization policies which fail to recognize that individual nutrients must each be applied at specific times, frequencies, and amounts. Centralized policies insensitive to these variables have helped to create, on the one hand, soils with continuing nutrient deficits and low productivity and, on the other hand, soils where excesses of phosphorus and nitrogen threaten to contaminate surface- and groundwater.

As population increases, and pressure mounts on cultivated lands, many farmers are forced onto marginal lands with acid, infertile soils. Their nutrient problems must be corrected before crop production can be optimized. Enhanced productivity through improved nutrient and water management will also help reduce land abandonment and deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands.

To achieve such improvements, the CRSP will work to integrate Product Research and Development efforts in three areas: Phosphorus Management, Nitrogen Management, and Water Harvesting and Use.

PHOSPHORUS MANAGEMENT

The world's food supply depends on about 1.5 billion hectares of land. Phosphorus, an essential plant nutrient, limits crop yields on most of these soils. Of 500 soils sampled in a recent survey, 92% required phosphorus fertilization to increase or maintain food production. This high proportion occurs because both acid and calcareous soils are plagued by phosphorus deficiency, although by very different mechanisms.

A further concern is that increasing population places additional pressure on the existing lands, often forcing farmers onto marginal, already deficient,

erosion-prone lands. Ever larger quantities of such lands are needed to produce the same amount of food. These lands need fundamental correction of their nutrient-poor condition before certain crops can produce at their potential.

While P-deficiency poses the main problem, some soils have received excessive phosphate fertilization due to centrally planned fertilization policies wherein nitrogen and phosphorus fertilizers are applied at the same time and frequency. These policies erroneously assume that application patterns should be the same for both nutrients. Such province- or country-wide fertilization policies have resulted in soil P excesses in some areas and continuing deficiencies in others. Recognizing that nutrient-management decisions are best made at the local level, the management strategies suggested by the CRSP will emphasize the need for site-specific recommendations. The CRSP's products will combine local knowledge with the best scientific knowledge to make the most appropriate management suggestions for specific fields and cropping systems.

The CRSP's problem-solving tools will include the following:

- A knowledge-based computerized decision aid for providing (1) site-specific diagnoses of P deficiencies and excesses and (2) recommendations of remedial management practices, including fertilizer quantities and materials based on the type of crop, economic conditions, and management goals.
- Step-by-step procedural guides that enable in-country transfer agents to both diagnose existing situations and predict future problems for situations where computer software is not appropriate.
- Cost-effective techniques for evaluating, selecting, and transferring P-efficient germplasm between regions with similar P-management constraints.
- Phosphorus budget spreadsheets that facilitate the planning of nutrient inputs and outputs at a variety of project scales; this tool will serve planning efforts by policy-makers, NGOs, and other users.

Nitrogen Management

Rice, wheat, maize, sorghum, and millet production are most frequently limited by nitrogen availability. Indeed, N limits production on more than 50% of all cultivated soils. Not only do plants need more N than any other nutrient, but it is also the most expensive input. Since most LDCs cannot afford or do not have access to the natural gas required to make chemical N fertilizers, efficient use of limited imports is essential to increasing productivity. Where chemical fertilizers are neither available nor affordable, biological N fixation (BNF) from legumes can play an important role in supplying N needs of cropping systems.

Inappropriate use of N from animal or human waste, legumes, or chemical-based fertilizers can have a significant adverse effect on surface water and groundwater. Unless management practices and crop use efficiencies are improved, increased production demands will require larger and larger

amounts of N, a progression that can exacerbate environmental problems. The capture of N through BNF is an economically efficient means of reducing these risks. In addition to increasing plant yields, N-fixing legumes can also serve as an important source of protein for human consumption.

To meet the need for increased N in an environmentally benign manner, the CRSP will develop and promote the following problem-solving tools:

- A computerized knowledge-based aid to improve N management decisions; diagnosis of soil N deficiencies or excesses will take into account crop requirements, soil types, organic and inorganic N sources; prescriptions will include when and how fertilizer N should be applied and estimates of the economic consequences of proposed remedial practices.
- BNF technologies that (1) increase farmer access to superior legume symbionts and other beneficial microbial inoculants, (2) improve the performance of both plant and microbes in less-than-optimal environments, and (3) conserve N derived from biological sources.
- Legume-based soil management technologies that provide alternatives to chemical N inputs for resource-limited farmers.
- A nitrogen input/output balance model that enables LDC planners and policy-makers to estimate long-term N needs.
- Regionally relevant information guides so that improvements in the knowledge base produce corresponding improvements in N-management practices.

Water Harvesting and Use

Water deficiency constitutes one of the major constraints to plant growth and crop yields. The causes of deficiency range from low rainfall to high runoff, from restricted absorption to inefficient utilization. To combat this problem across agroclimatic zones, land users need a variety of tools.

In the last few decades, water use efficiency has been improved in a number of ways—generally by increasing rainwater retention on fields, improving irrigation, and selecting more efficient varieties in monoculture systems designed to maximize the yield of a given crop per unit of land area. Several new technologies have improved the use of soil and water resources in ways that allow crops to be produced under conditions where production had been impossible. Four such technologies have shown particular potential for expanded use in LDCs: agroforestry, raised beds, water harvesting, and improved genotypes.

Agroforestry systems are particularly relevant where farmers want specific tree products. From a systems perspective, agroforestry may also be of interest where a greater exploitation of vertical space (both above and below ground) is feasible and where the short- or long-term dynamics impart advantages for growing

crops and maintaining the resource base. In the past, many indigenous communities have practiced some form of *raised-bed agriculture*. Attempts to reintroduce such technologies are worth assessing, particularly in light of their potential to sustain crop production in difficult environments. *Water harvesting* exploits low rates of precipitation over large areas that normally could not support crop growth; it focuses limited water inputs on small areas, thus enabling crops to grow on at least part of the land. *Improved genotypes* will more effectively absorb soil water and more efficiently use that water to produce plant material.

Program-Wide Focus

USAID has asked that the refocussed CRSP give high priority to technical assistance for field-mission goals and programs. The CRSP is prepared to meet this need by responding directly to USAID mission requests and by developing an aggressive outreach effort.

1. Outreach

Unused tools have no impact. To achieve its goals and objectives, the CRSP must do more than develop problem-solving products: it must also demonstrate their relevance to site-specific problems.

This process will require an extensive Outreach Program with three broad objectives: promoting CRSP-developed products, assisting in their implementation, and adapting and revising them to fit local conditions. These efforts will be among the refocussed CRSP's primary program-wide activities.

The CRSP has both the expertise and the personal contacts to initiate an aggressive Outreach Program that can create a steadily increasing impact as product-development activities generate results:

- The Nitrogen Fixation by Tropical Agricultural Legumes Center (NifTAL) has a proven record of working with government agencies and the private sector, both to promote biological methods of providing plant-essential nitrogen and to produce and market organisms that enhance this process.
- Through workshops and private consultations, the Soil Management Support Services (SMSS), the Technology for Soil Moisture Management (TSMM), and the participating universities have explained, promoted, and enhanced the use of land-resource information in ways that guide policies and on-farm practices.
- All CRSP members have developed a network of personal and institutional contacts, both in government and in the private sector; these contacts will serve as the Outreach Program's front-line forces.

2. Field Support to USAID Missions

The refocussed CRSP's primary emphasis will be to develop and promote problem-solving tools. USAID missions will be an important partner in this process, the aim of which is to address host-country land-management problems. The CRSP will work in both a *reactive* and a *proactive* mode.

The *reactive component* will consist of timely responses to mission requests for assistance on issues ranging from project design to human resource development. The *proactive component* will consist of providing problem-solving tools to mission collaborators and other groups who support mission goals—both in the public and the private sector.

To prepare programs, missions frequently need baseline data on developmental problems. Too often, the initial assumption is that work must start from the beginning, as if no data had ever been collected. Better information on the current state of LDC land resources will enable missions to avoid costly redundant activities. It will allow them to avoid doing what has already been done and rediscovering what is already known.

The CRSP is well-positioned to make assessments on the full range of land-management issues—from the field level to the policy level. Working with reliable data, the CRSP can conduct workshops at which administrators and scientists can identify knowledge gaps, policy deficiencies, and operational weaknesses—crucial steps in developing mission programs that respond more effectively to LDC needs.

From policy-level data bases to farm-level technologies, the CRSP's problem-solving tools respond to the expressed and perceived needs of USAID missions and host-country collaborators. Specific CRSP services will include the following:

- Backstopping mission projects, which frequently require specialized soil-management expertise.
- Designing projects and evaluating ongoing projects, particularly those involving land-resource inventories, conservation, and land/crop management.
- Responding to requests of LDC institutions or other organizations in collaboration with missions and bureaus.
- Identifying core problems and recommending the remedial actions required to achieve sustainable-development and environmental goals.

Collaborative Relationships

Collaborative is the first word in our acronym and our most important program descriptor. By linking our relative strengths to the wide range of expertise housed in other organizations, the CRSP will insure that product-development efforts respond to real-world demands in a cost-effective fashion. Such efficiency is the key to maximizing product impact.

LDC collaborators will help the CRSP identify user needs and incorporate indigenous knowledge into product-development efforts. The CRSP's Outreach Program has been designed so that LDC collaborators will be involved in all phases of product development, testing, and promotion.

This CRSP will also cooperate with *other CRSPs* on projects where our respective specialties enable us to complement one another's efforts—either in a lead role or in a supporting role. By providing an effective vehicle for sharing technical insights, such collaborations enhance the overall effectiveness of the CRSPs.

We will also build on our long-standing collaborative relationships with the *International Agricultural Research Centers (IARCs)*. Not only will the IARCs serve as repositories of technical know-how for developing and validating our products, but their global networks can provide an effective means of expanding our product impact.

The expanded capabilities of the refocussed CRSP will enable us to increase our involvement with *PVOs and NGOs*, thus forging vital links for moving products from development to testing to application. The CRSP's familiarity with the needs of LDCs and the interests of *private-sector agribusinesses* will also allow it to serve as an important middleman in transactions that benefit both parties.

The first step in developing detailed Work Plans will be to conduct a series of workshops with collaborators from all of the above-mentioned groups. These workshops will provide the impetus for essential follow-up activities related to identifying problems and to developing, testing, and promoting products that respond to those problems. A detailed listing of specific tasks and collaborators is given in Appendix II.

Distinctive Qualifications

Through training and experience, the CRSP is made up of soil experts. That expertise enables us to assist non-soil scientists such as geographers and environmentalists, many of whom know the general rules of soil management, but are often unable to use the knowledge base in dealing with exceptions to these rules. This distinction is crucial, for the ability to resolve complex natural-resource and environmental problems will depend not simply on applying general land-management principles (which most farmers and many policy-makers already know), but on an ability to determine a course of action when general principles prove inadequate. Exceptions to the rules make sustainable development elusive and specialized expertise essential.

The CRSP has access to a world-wide network of professional soil scientists with whom we can interact to develop, evaluate, and update problem-solving tools. These scientists include colleagues and collaborators in NARCs, researchers at IARCs, and more than 115 alumni of our graduate research

programs. Many CRSP graduates now occupy positions of leadership and authority in national and international product-development programs.

Impact Assessment

The refocussed CRSP will produce tools to solve the real-world problems facing a range of users—from policy-makers to farmers to ranchers. The product-development scientists, outreach leaders, and administrative support teams all recognize that the success of their efforts will be measured in terms of the program's impact on the immediate and long-term needs of LDCs.

Because the CRSP's tools are designed to address site-specific problems, their impacts can be readily identified. Detailed operational plans for developing each product will describe the specific problems to which the tool can be applied, the means by which the tool can help solve those problems, and the criteria by which the tool can be evaluated.

Individual programs will be structured to provide affirmative answers to these kinds of questions:

- Will the product address the technical, social, and economic needs of local people as they define those needs?
- Has indigenous knowledge been used to specify and prioritize the kinds of problem-solving tools that are developed?
- Will adaptation of the products enable developing countries to build capacities for permanently improving their quality of life?
- Will the products serve USAID-supported expatriate and indigenous PVOs and NGOs?
- Will the products enable users to improve soil productivity, decrease soil erosion and degradation, rejuvenate degraded lands, and protect the environment?
- Will the products help formulate policies and support institutions that must implement natural-resource safeguards?

Benefits to the U.S.

Outputs of the refocussed CRSP will enhance the social, economic, and environmental stability of developing countries by helping to solve fundamental land-management problems. In turn, these benefits will serve our own long-term economic and environmental interests.

As USAID officials have emphasized, environmental degradation does not respect political or national boundaries, nor do oceans separate us from the effects of economic unrest. Failure to deal with these issues at the international level thus poses a strategic threat to our national security every bit as dangerous

as armed conflict. Implementing practices that reduce the potential for global warming will directly benefit the U.S. Likewise, U.S. financial interests will be well-served by erosion-control strategies that enhance the production of commercial products important to our trading partners.

A familiarity with the needs of developing countries and the interests of U.S. agribusiness will also enable the CRSP to serve as an important technical middleman in transactions that benefit both parties. Such activities are already under way in Latin America, where the CRSP has helped the U.S. fertilizer industry expand its markets as it provides developing-country farmers with a cost-effective means of increasing production. The CRSP is also attracting investments from U.S. companies with the resources to refine and market its problem-solving products.

U.S. land-management programs need science-based decision aids capable of solving location-specific problems. The refocussed CRSP's problem-solving tools will be capable of meeting this need because they will be based on universal soil-science principals. A number of CRSP products are already paying dividends in the U.S. Various decision support systems developed by the CRSP, for example, are being used by groups as diverse as extension agents, land planners, agribusiness representatives, and climate-change modelers. As the CRSP devotes more of its energies to developing these kinds of products, U.S. users will be able to adapt them to their own needs simply by supplying location-specific data.

2.
Basic Work Plan

Approach

The Basic Work Plan outlines a comprehensive program that will enable the CRSP to (1) generate products that solve targeted problems relevant to the missions' broader goals as identified in the Global Plan, (2) conduct an aggressive Outreach Program so that CRSP products are developed and applied in ways that meet LDC needs, and (3) provide field support for USAID missions. The Work Plan also describes the general tasks the CRSP will undertake and estimates the distribution of funds among various activities.

The refocussed CRSP will have two foci. The first is to conduct research and develop tools that solve problems in three target areas. The second is directed to program-wide issues, specifically, (1) outreach services to groups whose work directly supports USAID goals and (2) field support to USAID missions. These foci are shown in Table 1, along with target areas and specific target problems.

Table 1. The Soil Management CRSP Program Structure

Product Research and Development Focus

1. *Conservation and Environmental Protection*
   - Water and wind erosion control
   - Rejuvenation of degraded lands
   - Water resource use and protection
2. *Land Resource Quality*
   - Quality and degradation indicators
   - Productivity and use options
   - Soils and environmental data bases
3. *Productivity and Economic Growth*
   - Amelioration of acid soils
   - Integrated nutrient and water management
     - Phosphorus management
     - Nitrogen management
     - Water harvesting and use

Program-Wide Focus

1. *Outreach*
2. *Field Support to USAID Missions*

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The CRSP's primary focus is to develop tools capable of solving soil-management problems that impede economic growth and threaten environmental stability. The tools must be (1) globally relevant and thus applicable wherever the targeted problem occurs, (2) capable of diagnosing a problem and prescribing a remedy, and (3) capable of facing two ways at once: down at field-level problems and up at policy-level problems. Products will be developed by multi-institutional teams of scientists. An aggressive Outreach Program will promote these products and insure that they respond to users' needs.

Target problems were selected from the recommendations supplied at the CRSP's Global Planning Workshop, which was attended by representatives from 13 LDCs, as well as by collaborators from IARCs, USAID, U.S. Universities, and U.S. federal agencies. More than 40 scientists attended a subsequent series of workshops, each of which focussed on a specific problem area, specified research gaps and goals, detailed outreach issues, and developed the elements for the *Basic Work Plan*.

Workshop reports, along with a roster of participants, are presented under the following target headings:

- Water and Wind Erosion Control
- Rejuvenation of Degraded Lands
- Water Resource Use and Protection
- Quality and Degradation Indicators
- Productivity and Use Options
- Soils and Environmental Data Bases
- Amelioration of Acid Soils
- Integrated Nutrient and Water Management
  - Phosphorus and Nutrient Management
  - Integrated Nitrogen Management
  - Water Harvesting and Use

Each report identifies the products (tools) needed to help solve the target problem, outlines critical information gaps, lists the tasks necessary to develop a product, and sets forth a first-year plan of work. Each major heading (above), is afforded a separate chapter, as are the two program-wide topics discussed in detail at the workshops:

- Outreach
- Field Support to USAID Missions.

Water and Wind Erosion Control

Product Title

Decision Aids for Controlling Wind and Water Erosion and Minimizing Associated Environmental Impacts.

Relevance to Targeted Problem

Water and wind erosion caused by improper and intensive land-use practices account for about 75% of all human-induced land degradation. Erosion thus represents the major global impediment to sustainable agricultural development. Excessive erosion degrades land resources (on-site), and the resulting sedimentation and non-point source pollution destroy valuable downstream investments and resources (off-site).

To protect the environment and ensure that future generations receive enough food, fiber, fuel, and construction materials to meet their needs and aspirations, national governments worldwide need to give high priority to the responsible use and conservation of the natural resource base, particularly to soil, water, and air quality. Failure to recognize the impacts of excessive erosion is a major (and often disregarded) factor leading to the destruction of fragile soil resources. As degradation becomes severe, soil restoration often becomes unaffordable and, in some cases, impossible. Efforts to avoid these problems must be developed within a management framework sensitive to the social, cultural, economic, and policy constraints that block the implementation of corrective technologies. The framework must also be broad enough to encompass well-defined watersheds and farm systems. Products developed in this program will be relevant to the SANREM CRSP as well.

Description of Product Prototypes

The CRSP will develop decision aids that address the physical and biological components of soil erosion as they relate to an integrated land-management program. At present, a number of empirical and process-based models for predicting wind and water erosion are available or being developed. Nearly all of these models have originated in developed countries; some have been investigated by researchers in other countries. However, despite considerable problems in model validation, the models have received little or no formal and

coordinated validation in LDCs. Although CRSP scientists have cooperated with the USDA to test the Universal Soil Loss Equation (USLE) and the revised USLE in tropical settings, additional work will be required if models for predicting and controlling erosion are to be adapted for diverse agroclimatic conditions and so lend themselves to the successful development of decision support systems for conservation and planning purposes.

In addition to the USLE and the revised USLE, erosion prediction and control models that may be adaptable include the Modified Universal Soil Loss Equation (MUSLE), the Griffith University Estimator of Soil Erosion (GUESS), the Water Erosion Prediction Project (WEPP), the Wind Erosion Equation (WEQ), the Revised Wind Erosion Equation (RWEQ), and the Wind Erosion Prediction System (WEPS). Impact models include those that address erosion impacts on productivity (e.g., EPIC, the Erosion Productivity Impact Calculator; and the Productivity Index) as well as those that address environmental impacts (e.g., CREAMS, the Chemical Runoff Erosion in Agricultural Management Systems; GLEAMS, the Groundwater Loading and Erosion in Agricultural Management Systems; and AGNPS, Agricultural Non-point Source Pollution System).

The CRSP's product prototype will use (a) a combination of features as deemed appropriate from a review of the above-mentioned models; (b) field assessments and observations about the conservation effectiveness of typical land-use systems; (c) data bases on soils, climates, and landscape features at selected benchmark locations in the network of cooperating regions and countries; (d) expert systems, manuals, or other guides to develop an integrated watershed-based decision support system for sustainable land use. To mitigate erosion and sedimentation impacts, the CRSP will emphasize biological nonstructural measures that are compatible with indigenous knowledge and land-use preferences.

Critical Information Gaps

- Existing models to predict and control erosion have not been sufficiently validated for the range of soils, climates, topographies, and multiple land-use systems in USAID-targeted countries.
- Tools for evaluating the effects of soil erosion on agricultural and economic productivity and environmental quality have not been applied to diverse agroclimatic conditions.
- Acceptable baseline standards are not available for (a) assessing erosion impacts and (b) establishing scientifically based management targets that preserve soil productivity and environmental quality.
- Scientifically based decision aids are not available for determining when biological conservation systems alone are effective and when mechanical conservation measures or a combination of the two are necessary.
- LDC policy-makers, land-use planners, administrators and extension agents need educational materials and guidelines on wind and water erosion assessments, causes, impacts, and mitigation technologies.

Tasks for Product Development

- Inventory and evaluate alternative models for predicting and controlling *water* erosion based on wide applicability and potential utility; select, adapt, combine, and validate a model that can meet diverse conservation-planning needs on a national, regional, and global scale.
- Inventory and evaluate alternative models for predicting and controlling *wind* erosion based on wide applicability and potential utility; select, adapt, combine, and validate a model that can meet diverse conservation-planning needs on a national, regional, and global scale.
- Convene workshops of potential collaborators, SANREM CRSP researchers, network members, and active organizations to update state-of-the-art reviews for both of the above-mentioned tasks.
- Establish regional networks at benchmark locations for adapting, testing, and evaluating the applicability of developed products.
- Access and use available soil and environmental data bases for estimating erosion impacts on crop productivity and environmental quality at selected benchmark locations.
- Establish baseline erosion standards that, if met as management targets for conservation planning, would sustain the productivity and quality of soil and water resources.
- Establish scientifically sound prototype alternatives for combining biological- and mechanical-based soil and water conservation technologies.
- Develop educational materials and guidelines on wind and water erosion parameters for developing-country clientele, particularly policy-makers, land-use planners, administrators, and extension workers.
- Develop decision support systems capable of integrating erosion and sedimentation information into an overall strategy for sustainable land use at the watershed level.

Anticipated Products[1]

- A validated model for predicting and controlling *water* erosion; it will be applicable over a broad range of agroclimates and management systems (111).
- A validated model for predicting and controlling *wind* erosion; it will be applicable over a broad range of agroclimates and management systems (112).
- Standardized procedures for (a) measuring wind and water erosion in the field and (b) documenting and assessing the range of farming systems that lead to or exacerbate erosion problems (113).

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[1]The three-digit code refers to actions reported in Appendix I.

- A widely applicable system for estimating soil erosion's impact on crop productivity (114).
- A system for setting baseline erosion standards that have minimal adverse effects on soil resources and the environment (115).
- Alternative erosion-control practices that combine biological- and mechanical-based measures (116).
- Educational materials (e.g., handbooks, pamphlets, audiovisual aids) on erosion processes and impacts; the target audience will be policy-makers, land-use planners, administrators, and extension workers (117).
- An integrated watershed-based decision support system for designing conservation-effective sustainable land-use systems (118).

Plan of Work for Year 1

- Survey, identify, and formalize collaborative partnerships at International Centers, National Centers, NGOs, FAO, UNDP, UNEP, the World Bank, and other institutions; document the extent of their work on erosion, field-assessment methods, predictive and impact models, control systems, and technology-transfer activities.
- In cooperation with these partners, and following a literature review, evaluate and inventory field-assessment methodologies for testing wind and water erosion models.
- In collaboration with interested partners, select (a) appropriate models for erosion prediction and impact and (b) standard field-assessment methods to be adapted/adopted by network members.
- Develop site criteria for benchmark locations where adapted models and methods can be tested.
- Review educational materials from collaborators and (as necessary) begin developing materials for informing policy-makers, land-use planners, administrators, and extension workers about erosion problems and the potential for implementing effective control measures.
- Link activities with complementary projects within the CRSP, the long-term objective of which is to develop a framework for integrated watershed assessment and management.

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Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. Reduce water and wind erosion to insure sustainable use of the natural resource base, preserve land productivity and protect the environment.	1. Country adoption of the World Soil Charter or related global proclamation into national policies. 2. Land development projects incorporating effective counter-erosion strategies. 3. USAID mission and other donor-funded project-related activities.	1. Government, mission and project reports. 2. Questionnaires. 3. Network site collaborator input and site visits. 4. Presentation at meetings and society conferences.	(Goal to Supergoal) 1. Country and regional commitment to controlling degradation by erosion and sedimentation. 2. Country commitment to sustainable development.
Purpose: 1. Identify and quantify biophysical, socioeconomic policy parameters for implementing conservation effective land management systems.	1. Progress reports and databases with regionally relevant information on specified models and parameters. 2. Network collaborators actively engaged in developing and validating selected models and requisite inputs. 3. Extent of applicability of overall framework and quantitative decision support system.	1. Number of network collaborators and project participants. 2. Number of project reports and products requested and utilized.	(Purpose to Goal) 1. Substantial work on wind and water erosion already accomplished or ongoing at benchmark sites. 2. Data from benchmark sites are available and usable for models. 3. Policy makers place high priority on sustainable land use.
Outputs: 1. A system designed to optimally combine biological and mechanical conservation practices. 2. Integrated, watershed-based decision support system for designing conservation-effective land use. 3. Valid watershed-based framework for assessing erosion impacts. 4. Standardized field-based procedures for measuring erosion and assessing causative farm management systems. 5. A system for idenitfying acceptable soil losses with minimum adverse on- and off- site effects. 6. Educational aids targeted for diverse clientele.	1. Applicability of models for predicting water and wind erosion and control in benchmark locations. 2. Framework for predicting on- and off-site impacts at network benchmark watersheds. 3. Applicability of methodology for field erosion assessments. 4. Validity of suggested system for addressing diverse erosion impacts and fostering sustainability. 5. Use of educational materials at network and other locations. 6. Applicability of combined technology for diverse climates, soils, topography, and cropping situations.	1. Model testing and validation activity. 2. Additional sites involved in regional networks. 3. Number of requests for product adaptation or translation within and outside established networks. 4. Monitoring activities for degradation indicators and sustainability. 5. Number of development projects adopting project models and decision support systems for conservation planning. 6. Number of professional trainees and field advisors using decision support system.	(Output to Purpose) 1. Country and regional capacity for model and decision support system design and use are adequate or enhanceable. 2. Benchmark sites can be found to represent important climates, soils, topography, and land use systems. 3. Access to sources of indigenous knowledge and information.

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
7. Valid models for predicting and controlling water and wind erosion.		7. Correspondence, newspaper accounts, and similar documentation. 8. In-country, regional, and international visitors to benchmark sites. 9. Internal-external progress reviews.	
Activities: 1. Organize networks to design decision support system integrating erosion/sedimentation information into overall watershed-based sustainable land use strategies. 2. Integrate scientific technologies with indigenous knowledge into a balanced conservation and sustainable production system. 3. Establish acceptable erosion standards for sustaining resource productivity and environmental quality . 4. Use available data bases to estimate erosion impacts on crop productivity and environmental quality at benchmark locations. 5. Establish network(s) at benchmark locations to adapt, test and evaluate applicability of developed products. 6. Convene workshops of potential network collaborators and appropriate institutional representatives to facilitate above activities. 7. Inventory, evaluate, select and adapt water and wind erosion prediction and control models from among available, currently used alternatives. 8. Synthesize available knowledge on erosion causes, impacts, and control into educational materials for diverse clientele.	Inputs/Resources: 1. Project Budget $1.30 million 2. Participating university will match 25% under standard provision regulations and BIFADEC guidelines. 3. Developing countries are expected to provide equal $1.13 million 4. Human resources dedicated from CRSP institutions, NARS IARCs and other collaborators. 5. Benchmark site and network collaborators. 6. Inter- and intra- network travel. 7. International meetings or workshops to propagate validated models and decision support products.	1. Review of CRSP annual Work Plans & Budgets and Executive Summary report. 2. Number of and suitability of benchmark sites. 3. Number of trainees and "Model Projects" utilizing CRSP products. 4. Number of workshop proceedings and data bases containing network contributions. 5. Timeliness of decision support system availability. 6. Country and USAID Mission reports. 7. Periodic project and budget reviews. 8. Correspondence from users, policy makers and other clients.	(Activity to Output) 1. Funds for network participants available to allow effective contributions in project activities. 2. Scientists can participate effectively at their respective network locations. 3. Differences in terms and methods of erosion assessments can be reconciled. 4. Hardware and software requirements affordable.

Rejuvenation of Degraded Lands

Product Title
Technologies and Decision Aids for Rejuvenating Degraded Lands

Relevance to Targeted Problem
According to the World Resources Institute (WRI), the productive potential of more than one billion hectares—an area roughly equal to India and China combined—has been severely reduced over the last 45 years. As a result of agricultural activities, overgrazing, fuelwood and timber exploitation, and deforestation, more than 17% of the earth's vegetative surface is now seriously degraded.

Land degradation imposes harsh human, economic, and environmental costs. M. S. Swaminathan points out, for example, that current trends provide "an early warning that we are losing potential agricultural productivity that may be critical in providing food and [meeting] other essential needs of a burgeoning population." In addition, land degradation is a primary threat to biodiversity, and it is altering ecological cycles that maintain water quality, air quality, and soil fertility.

There are four principal causes of soil degradation: water erosion, wind erosion, fertility depletion, and physical deterioration (e.g., compaction by machinery). CRSP products will focus on erosion-induced degradation and on the physical, chemical, and biological deterioration in soil quality caused by human activity. According to WRI figures, these factors account for about 88% of all human-induced land degradation.

Description of Product Prototypes
Human activities often promote land degradation. Some lands are prone to severe degradation, in part because of variables such as climate and soil type. The potential for rejuvenation, along with assessment methods and economic considerations, will vary with location. CRSP products will accommodate typical and diverse climatic and soil conditions; they will also target lands in which degradation, regardless of severity, is potentially and economically reversible. The products will serve two distinct purposes—either singly or together: (a) restoring soil productivity for agricultural use and (b) stabilizing the total landscape to avoid further degradation.

Using preliminary data from land-rejuvenation activities in Niger and Honduras, the CRSP has developed a GIS-based methodology for integrating information on soil quality, topography, hydrologic conditions, vegetation, and indigenous land-use patterns. The methodology currently helps users identify distinct land-management units that form the basis for remedial measures. It will be further refined to (a) identify land-degradation according to severity level and type (i.e., it will clarify the interaction of physical, chemical, and biological components) and (b) assess land carrying capacity for watersheds in various ecological regions. The methodology will also allow users to monitor the impact of land-rejuvenation strategies.

The GIS-based methodology will serve as a component of a larger product to be developed with inputs from a number of groups within the Soil Management CRSP: a watershed-based land-rejuvenation decision aid for use at both the field and landscape level. This tool will be used to characterize landscapes and to enable policy-makers and planners to identify economically viable, environmentally sound, and socially acceptable management alternatives for different land units.

While mechanical and structural measures of land rejuvenation are sometimes necessary, these alone are often insufficient to reverse degradation. For rejuvenation strategies to be adaptable and sustainable, biological rejuvenation schemes based on land husbandry must be emphasized. Unfortunately, although considerable information is available on mechanical rejuvenation systems, biological rejuvenation systems and combinations of biological and mechanical systems have not been systematically developed. The CRSP will thus work to develop ecologically sound legume- and nonlegume-based technologies to rejuvenate degraded lands. These efforts will be closely linked to the CRSP's work on integrated N management (see Target 3).

Critical Information Gaps

- Quantitative criteria for diagnosing degradation types and quantitative indicators for evaluating degradation severity in relation to the land-management systems prevalent across various agroclimatic and soil conditions.
- Sensitivity and stability indicators of land degradation and rejuvenation.
- Criteria, quantitative indicators, and models for predicting the type, rate, and intensity of land degradation and for evaluating various rejuvenation options and their likely effectiveness, particularly in the context of whole-farm systems in watersheds.
- Indigenous knowledge on land degradation and rejuvenation.
- Systematic procedures for matching alternative rejuvenation technologies—particularly those that are biologically based—to the climatic and soil-based constraints of various degraded lands.
- Quantitative information on the chemical, biological, and physical processes (and their interactions) that occur during rejuvenation.

Tasks for Product Development

GIS-based Decision Aid

- Synthesize available information and develop a data base on the physical and socioeconomic attributes of degraded and comparatively nondegraded ecosystems at benchmark sites.
- Develop quantitative indicators of land degradation and rejuvenation.
- Delineate and characterize the extent and intensity of land degradation in problem regions.

Biologically Based Rejuvenation Technologies

- Identify and evaluate legume and nonlegume species capable of rejuvenating benchmark sites.
- Develop a data base of potential combinations of legume species and microsymbionts for soil rejuvenation.
- Screen legume species and microsymbionts for maximum N-accumulation as it relates to soil rejuvenation; identify establishment requirements; quantify the N status of soils and initiate microbial monitoring systems for predicting responses to microbial inputs.

Landscape-based Land-rejuvenation Decision Aid

- Identify and evaluate biological, physical, and chemical practices for use at both the field and the landscape levels.
- Design and evaluate land-rejuvenation systems that integrate biological, chemical, and mechanical technologies with social and economic variables at benchmark sites covering interdependent landscape segments.

Anticipated Products[1]

- A computerized GIS-based decision aid that (a) identifies and classifies degraded land and (b) monitors land-rejuvenation processes in a manner that identifies land-rejuvenation indicators and quantifies the physical, biological, and chemical components of rejuvenation processes (121).
- Biologically based technologies and decision aids for land rejuvenation (122).
- A landscape-based land-rejuvenation decision aid for use at both the field and landscape level. This tool will also assist in the subsequent use and conservation of rejuvenated lands. Special emphasis will be given to severely eroded and polluted lands (123).
- Extension and educational materials for enhancing the awareness and understanding of policy-makers, extension workers, and students on preventing land degradation and rejuvenating lands that have already been degraded (124).

[1]The three-digit code refers to actions reported in Appendix I.

Plan of Work for Year 1

GIS-based Decision Aid

- Continue the collection of field data; continue measuring hydrological properties and plant establishment; continue on-farm testing of new technologies in Niger, Honduras, and other sites where activities are established through the collaborative efforts of USAID missions and host countries.
- Begin to identify benchmark sites for evaluating rejuvenation methods.

Biologically Based Rejuvenation Technologies

- Develop a data base of effective legume and nonlegume species for use in rejuvenating degraded soils.
- Initiate studies to (a) screen legume species and microsymbionts for maximum N-accumulation as it relates to soil rejuvenation, (b) identify establishment requirements, and (c) quantify the N status of soils and initiate microbial monitoring systems for predicting responses to microbial inputs.
- Determine the microbial inoculant delivery system that maximizes soil N accumulation.

Landscape-based Land-rejuvenation Decision Aid

- Conduct a workshop (a) to document the extent of the land-degradation problem, (b) to review current methods of land rejuvenation, and (c) to develop a collaborative research network on land degradation and rejuvenation. Workshop participants will include staff from IARCS, National Centers, NGOs, FAO, UNDP, UNEP, the World Bank, selected host countries, and the SANREM CRSP.

Participants

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Harold van Es
Samir El-Swaify
William Fryrear
Tony Juo
John Kimble
Andrew Manu
Timothy P. McBride
James F. Parr
Padma Somasegaron
Charles Wendt
Keith Cassel, moderator

Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. Reduce land degradation and rejuvenate degraded lands so growing populations can meet their needs and aspirations while preserving these resources for future generations.	1. Developing nations develop proclamations with focus to reduce rate of land degradation and rejuvenate degraded lands.	1. Surveys of arable and severely degraded land rejuvenation programs in LDCs. 2. National land use policies designed to reduce land degradation and reclaim degraded lands.	(Goal to Supergoal) 1. National policy in LDC for increasing production to meet basic needs, decrease land degradation and improve economic well being.
Purpose: 1. Promote economic growth through agricultural productivity by reducing land degradation, and rejuvenating selected degraded lands.	1. LDC institutions adopt practices and develop policies which enhance the productivity of degraded lands. 2. LDC institutions validate problem solving tools for soil management, land rejuvenation, and water resource management.	1. Reports from LDC institutions, technical reports, publications, and collaborating scientists. 2. Requests and dissemination of problem solving tools, user surveys.	(Purpose to Goal) 1. Adoption of improved policies based on the basic products developed. 2. Funds available to LDC qualified scientists, extension personnel and policy makers to implement practices and policies.
Outputs: 1. Computerized GIS-based decision aids to identify and classify degraded land and monitor land rejuvenation processes. 2. Biologically based technology and decision aids for land rejuvenation. 3. Watershed-based land rejuvenation decision aid for use and conservation of severely eroded and polluted lands. 4. Educational materials on land degradation and rejuvenation for policy makers, extension workers and students.	1. Technologies identified or developed for land rejuvenation. 2. Computer software and manuals developed as user guides for land rejuvenation. 3. Some examples of rejuvenation of previously degraded lands.	1. Reliable identification of degraded land, and tracking of land rejuvenation processes. 2. Adoption of one or more biologically based rejuvenation techniques. 3. Proper identification of degradation levels and rejuvenation processes at various landscape positions. 4. Dissemination and adoption of materials for educating policy makers, extension workers and students.	(Output to Purpose) 1. LDCs maintain sufficient interest level to help develop the technology and use it. 2. Adequate biological materials are identified for regional use. 3. Sufficient soil biotic and abiotic component data available to begin decision aid development. 4. Adequately trained LDC personnel available to provide localized input. 5. Trained staff will continue to work to develop products.
Activities: 1. Organize working group addressing land degradtion criteria and rejuvenation practices. 2. Synthesize database on knowledge of the physical and socio-economic attributes of land degradation. 3. Develop quantitative indicators of land degradation and rejuvenation. 4. Evaluate cultivars to rejuvenate degraded	Inputs/Resources: 1. Project Budget $1.30 million 2. Participating universities will match 25% under standard provision regulations and BIFADEC guidelines. 3. Developing countries are expected to provide equal to $1.13 million. 4. Travel to field sites and to institutions to collect unpublished data. 5. Research assistants,	1. Workshop/symposia proceedings. 2. Validation of land degradation indicators. 3. Maps of severity of land degradation, travel reports. 4. Ranking of cultivar performance under various land degradation scenarios, progress reports. 5. Progress reports, ranking of the effect-	(Activity to Output) 1. Program funding sustained for five or more years. 2. Trained IARC and NARC scientists are available and adequately funded. 3. Results from requisite research becomes available. 4. Biological, chemical and physical scientists establish symbiotic working group. 5. Local users have

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
land at benchmark sites. 5. Develop databases for combination of cultivars and symbionts for rejuvenating soils 6. Identify and evaluate promising existing biological, chemical and physical practices to rejuvenate land. 7. Design and evaluate land-rejuvenation systems. 8. Training and workshops on land rejuvenation.	supplies, equipment.	iveness of symbiont combinations for rejuvenating selected degraded land. 6. Educational material produced; reports from users.	adequate background and database to utilize products.

Water Resource Use and Protection

Product Title

Land-management Decision Aids for the Protection and Use of Water Resources.

Relevance to Targeted Problem

The quality and quantity of surface water and groundwater are intricately related to land-use practices. In rainfed agriculture, maximizing rainfall use requires that runoff losses be minimized. Runoff may transport contaminants such as sediment, agricultural chemicals, manures, and wastes to streams, lakes, reservoirs, and estuaries. Chemical leaching may contaminate groundwater, making it unsuitable for consumption. Soil erosion may affect stream flow, especially in steepland watersheds. Loss of soil buffering capacity causes high peak flows (including floods) during wet periods and both low stream flow and spring dry-up during dry periods. Supplemental irrigated agriculture may become unsustainable if groundwater resources are not replenished.

Management of land and water under rainfed conditions is most effective when conducted at the watershed level. Technologies have been developed in CGIAR centers and CRSP institutions to optimize rainwater use for crop production. Within watersheds, land use and water needs may conflict. In a coastal watershed in southern Honduras, for example, slash-and-burn hillside farming causes stream-flow extremes, extends drought periods, and decreases water availability for irrigating the downstream coastal plain. By altering water salinity fluctuations and increasing water sediment and chemical levels, agricultural practices have adversely affected commercial shrimp production and the ecology of mangrove forests.

Effective watershed management assesses the sources of water degradation and evaluates land-management alternatives based on physical, social, cultural, and economic factors. Planners and policy-makers need system-wide information on how various land- and water-use practices affect water quality and quantity. They also need a framework for integrating land-use activities at the watershed scale.

Description of Product Prototypes

Several computer models simulate runoff losses under specified rainfall regimes; they also simulate water and contaminant flows into surface and subsurface

waters at the field scale (e.g., the Curve Number System; LEACHM, the Leaching Estimation and Chemical Movement Model; GLEAMS, the Groundwater Loading Effects of Agricultural Management Systems). The impact of surface vegetation and its management on soil water transfer and fluxes, as well as the impact of soil water status on plant growth and crop yield, can be simulated with dynamic soil-crop-atmosphere simulation models (e.g., General-purpose Atmosphere-plant-soil Simulator—GAPS). The applicability of these models across a wide range of soil, vegetation, and climatic conditions is uncertain. Moreover, evaluating the effects of land management on water resources and agricultural productivity requires integration over the landscape and is thus best done at the watershed scale. Modeling within a GIS framework, where water and contaminants move between landscape cells, is an attractive approach. CRSP institutions have developed GIS-based hydrologic models for small watersheds. Such models are capable of identifying critical runoff management zones within the watershed.

Most states within the U.S. have conducted hydrologic unit area projects with special USDA funding. Considerable expertise has thus been acquired in evaluating the way land-use practices affect water resources at the watershed level.

Critical Information Gaps

- Lack of knowledge on the applicability of existing simulation models for assessing changes in the quality and quantity of water resources. More specifically, this gap concerns (a) the models' applicability as decision aids for managing watersheds, (b) their reliability as predictive tools for a wide range of lands and climates, and (c) their utility for enhancing the productivity of cropping systems.
- Lack of quantitative information on linkages between land- and vegetation-management practices, surface vegetation, and water-resource degradation/enhancement.
- Lack of knowledge on trade-offs among production-driven land-management practices as they relate to water resources.
- Lack of methodologies and decision tools for integrating water-protection concerns into watershed-management strategies.

Tasks for Product Development

Particular attention must be given to the water-quality components of the following tasks:

- Evaluate current activities and available knowledge and decision-support tools for integrated watershed management.
- Identify benchmark watersheds for evaluating integrated watershed-management systems.

- Evaluate the applicability of decision tools in benchmark watersheds and adapt those tools for global use through field assessments or field monitoring.
- Develop a framework for integrated watershed assessment and management.

Anticipated Products[1]

The CRSP will develop a watershed-level assessment and management support system. It will provide a framework to guide decision-makers through the various aspects of water-resource protection. Components of this system will included the following:

- Educational materials for policy-makers and extension agents; these materials will clarify (a) the interrelationship of watershed processes, (b) the relationship between water quality and integrated watershed-management policies and practices, and (c) the ways in which the productivity of rainfed agriculture may be enhanced (131).
- Process-based assessment and management decision aids (e.g., runoff, leaching, and crop production simulation models; tools to assess critical management zones) (132).

Plan of Work for Year 1

- Evaluate current activities and available knowledge and decision tools for efficient rainfall use and water resource protection.
- Identify benchmark watersheds in collaboration with scientists in other CRSPs, IARCs, and NARs.
- Initiate cross-cutting activities within the CRSP, the aim of which is to develop a framework for integrated watershed assessment and management.

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Charles Wendt
Keith Cassel, moderator

[1]The three-digit code refers to actions reported in Appendix I.

Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: Integrate the management of finite soil and water resources to provide present human needs and preserve resource quality for future generations.	1. Developing nations establish proclaimations linking soil conservation with the protection of their water resources.	1. Survey of activities integrating sustainable land management, water quality and environmental protection.	(Goal to Supergoal) 1. LDC and donor commitments to establish R&D programs and policies integrating soil and water resource preservation.
Purpose: Develop integrated soil and water management technologies that promote economic growth and protect the environment.	1. Records of training activities on integrated watershed management, water and environmentr: protection. 2. Initiation of water resource quantity and quality criteria codes. 3. Initiate model and/or methodology activities as training tools to address water quality protection.	1. Framework for intergrated watershed management impact on water availability and quality. 2. Field activities in integrated watershed management.	(Purpose to Goal) 1. Cooperation with host countries and international donors. 2. Continuous financial support from USAID and for collaborators. 3. Recognized relations between on-site management and off-site impacts on water quality.
Outputs: 1. Awareness of relationship between soil management practices by landscape position upon on-site and off-site quality of water resources. 2. Integration of water resource protection in watershed management program methods. 3. Initiation of a water resources quality inventory system for policy makers.	1. Newtwork of scientists focusing on effect of agricultural production practices on water quality. 2. Joint economic growth and environmental quality goals and objectives in collaborative CRSP activities. 3. Increased product development activities that evalute agricultural production effects on environmental quality within developing countries.	1. Requests for CRSP products developed from target-task completions. 2. Countries start to integrate water quality and protection into their developmental policies. 3. Products modified and adapted to specific country needs.	(Output to Purpose) 1. Reconized linkage between USAID agriculture programs and environmental programs. 2. LDCs establishing intergrated watershed programs, and soil conservation and water quality preservation programs. 3. Funding adequate to develop LDC human resources to the critical mass level.
Activities: 1. Review existing decision support tools that integrate watershed management and water quality protection. 2. Develop acceptable criteria and codes for water quality and water resources preservation. 3. Identify and develop tools that will integrate land management effects on water quantity and quality. 4. Human-resource training resources to target the protection of water resources as part of economic growth.	Inputs/Resources: 1. Project Budget $1.30 million 2. Participating universities will match 25% under standard provision regulations and BIFADEC guidelines. 3. Developing countries and collaborating institutions are expected to provide equal to $1.13 million. 4. Three planning workshops on soil, water and nutrient management for sustainability.	1. The number of scientists trained in water resource protection. 2. Education materials that serve to bring awareness to effects of soil management on on-site and off-site water quality. 3. Proceedings from workshop and training activities. 4. Consortium addressing soil, water and nutrient management for sustainability.	(Activity to Output) 1. Research and outreach accepted as most feasible means to accomplish purpose. 2. Cooperation among scientists, donor and policy makers is strong and information is shared. 3. Funds for host country particpation and USAID Mission support is adequate. 4. International soil, water and nutrients for sustainable land management consortium is embraced by USAID and the CGIAR system.

Quality and Degradation Indicators

Product Title
Decision Aids to Predict/Mitigate Land Degradation

Relevance to Targeted Problem
The FAO/UNESCO/UNEP Global Assessment of Soil Degradation provides the following estimates on the causes and extent of human-induced soil degradation: deforestation, 579 million hectares; over-exploitation, 133 million; overgrazing, 679 million; and agricultural activities, 552 million. Although the underlying causes of land/water degradation are socioeconomic, changes to these factors will not automatically restore productivity if the biophysical resource is not maintained. Soil and water management is critically important to ensure that the production of food, fuel, and fiber can be sustained and the environment protected. Efforts to restore land productivity must be coupled with efforts to recognize the productive capacity of soil resources and to identify stresses before productivity is significantly impaired. Causes for stressed systems are numerous and include nutrient removal, acidification, salinization, alkalinization, destruction of soil structure, accelerated wind and water erosion, and loss of organic matter. The term *desertification* is popularly used to describe regions where some or all of these stresses are evident.

Soil-survey information continues to be a high-priority need, particularly as it is used for computer-driven technologies, for decisions concerning the management of degraded lands, and for establishing early-warning indicators of degradation. Soil taxonomy has important applications to this endeavor. Soil-survey interpretations are currently made manually and thus are unable to capitalize on the wide range of expertise available around the world, particularly that which exists on expert systems and related computer technologies. Placing a soils data base on a geographic information system (GIS) and coupling it to an expert system is a powerful tool for predicting and analyzing resource behavior.

Land resource quality is directly linked to quality of life; it is part of the socioeconomic context for sustainability. In the past, the CRSP's focus has been on rehabilitating degraded lands; the refocussed CRSP will supplement these efforts by assessing the potential for land degradation, the resilience

characteristics of land systems, and the technological options best suited to specific resilience properties. Developing *early-warning indicators* and *land-resilience criteria* will thus be crucial to the program. Since both are to some extent site-specific, the task of developing generally useful tools needs to be undertaken by an international network of collaborators.

Description of Product Prototypes

Products will consist of manuals, guidelines, training packages, extension documentation, computer models, and data-base management systems. The CRSP will also develop monitoring systems to evaluate specific properties that enhance or degrade soil quality or that have an impact on soil performance.

Critical Information Gaps

Concepts dealing with soil quality, soil health, and soil resilience are all in the early stages of development. There is, however, no concerted effort to coordinate these efforts; thus, an initial task will be to establish an international network for developing applicable methodologies. There are few methods for predicting the onset of degradation, information crucial to managing stressed systems. The resilience capacity of systems is also not well-established; it must be studied to implement remedial measures that rehabilitate degraded lands.

Although soil-resource information has been used for the above-mentioned purposes in developed countries, in developing countries, either the quality of information or its absence has prevented an effective effort. LDCs have thus been unable to develop diagnostic tools or knowledge bases concerning soil responses to different stresses; LDCs have also been unable to assess the impact of remedial technologies. Solutions to some or all of these problems will help ameliorate the negative environmental impacts of agricultural practices.

Tasks for Product Development

- Develop a network of collaborators to work on land degradation.
- Improve procedures to assess degradation at different scales—global, national, and local.
- Evaluate resilience capacities of the land, and develop methods to assist in implementation.
- Develop indicators of land degradation for use at all planning levels.

Anticipated Products[1]

1. A conceptual framework for land-quality evaluation that could be used not only for assessment but also for monitoring the quality of the resource base (211).

[1]The three-digit code refers to actions reported in Appendix I.

2. Simple early-warning indicators to flag potential stresses and evaluate stressed systems (212).

Plan of Work for Year 1

- Establish network of collaborators to address tasks.
- Initiate research and locate data sets to address aspects of soil degradation.
- Develop initial early-warning indicators and develop methods and guidelines for collaborators to test.

Workshop Participants

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Stanley W. Buol
Thomas Hallmark
Ike Ikawa
Gordon Tsuji
Hari Eswaran, moderator

Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. Help developing nations establish correlations between agriculture production, resource management and environmental protection.	1. Developing nations establish policies for sustainable soil and water management.	1. Review of land quality management policies in collaborating countries.	(Goal to Supergoal) 1. Developing country commitment to environmentally sound land management for sustainable development.
Purpose: 1. To develop assessment methods that serve as early-warning indicators of land-degradation and that help to rejuvenate degraded lands.	1. International committee on land degradation indicators is established. 2. Reports and/or proceedings from committee meetings. 3. Review of case study implementing land quality indicators program.	1. Technical and professional papers and reports from meetings. 2. Reviews by peers of methodologies and country adoptions.	(Purpose to Goal) 1. Developing countries establish policies to reduce rates of land degradation. 2. Rejuvenation of degraded lands understood as a must for sustainable economic growth.
Outputs: 1. Products for diagnosing land degradation as diagnostics for soil rejuvenation to support economic growth and environmental protection. 2. Scientific network establishing and testing early-warning indicators to land degradation.	1. Network reports and proceedings from meetings. 2. Policy makers use CRSP products for formulating land-quality indicator policies. 3. Requests for assistance from USAID and TDY reports.	1. TDY reports, USAID cables, country reports. 2. Network reports and proceedings from meetings. 3. Review of CRSP products developed and number of requests for use.	(Output to Purpose) 1. Contingent upon the establishment of justified need and support from collaborators and countries. 2. Support staff and facilities are available and adequate. 3. Network and participant meetings are supported through cost sharing.
Activities: 1. Provide support facilities for international committee addressing land degradation indicators. 2. Design training and planning workshop to support international initiatives. 3. Identify country with major land degradation problem to be used as case study. 4. Implement a rejuvenation and land quality monitoring system.	Inputs/Resources: 1. Project Budget $1.46 million 2. Participating universities will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing countries are expected to provide equal to 1.13 million. 4. CRSP will coordinate and provide support for committee work. 5. External cost sharing of 10% is expected for workshops and training.	1. Reports from CRSP supported training activities. 2. Review of committee and network activities and meetings. 3. Evaluation of case country testing and evaluating CRSP products.	(Activity to Output) 1. The USDA and universities resource facilities will be available to support project activities. 2. Qualified technical personnel for training are available. 3. Network personnel support committe work and country collaboration assured. 4. Financial resources will be adequate and reliable.

Productivity and Use Options

Product Title

Tools for Land Resource Inventory and Assessment, and for Evaluating Sustainable Land Management (SLM)

Relevance to Targeted Problem

Sustainable land management (SLM) is the key to harmonizing environmental and ecological concerns with the economic realities of producing adequate food and fiber and ensuring a basic minimal quality of life. Although SLM focuses on maintaining the integrity of the biophysical land resource base, it also recognizes that sustainability cannot be achieved unless land users understand the impacts of land-management options so that they can make choices that optimize socioeconomic and environmental benefits. Because insufficient attention has been given to this aspect of SLM, this CRSP will make a concentrated effort to link SLM to on-farm socioeconomic realities. The CRSP will also work to develop the concepts, frameworks, and mechanisms of SLM.

Research on land has traditionally been driven by agricultural imperatives, and though these are still important, ecological concerns and environmental problems are increasing. Finite land resources are undergoing stresses which can limit carrying capacity. In developing countries, the problem is compounded by inadequate assessments of the resource base and an absence of any kind of resource-monitoring system. Knowledge of the resource base and ecologically sound management strategies are the foundation for informed policies.

The thrust of this activity will be as follows:

1. To generate, mobilize, integrate, and process land and environmental data for scientific land-use planning. Team members will take advantage of both indigenous knowledge and the latest advances in information science and digital information technology.
2. To shift research imperatives toward future-oriented issues, such as identifying indices of sustainable land management, as well as the long-term on-site and off-site consequences of agricultural practices.

A Framework for Sustainable Land Management will have widespread applications for agricultural research and development and also for

environmental assessment. It will provide the scientific basis for evaluating the environmental impact of proposed land-use changes. It has the potential to evaluate the consequences of projected changes in global climate. And when coupled with computer technologies such as simulation modelling, GIS, and expert systems, it has the potential to emerge as one of the most powerful tools for achieving sustainable land management.

Description of Product Prototypes

1. A functional framework for evaluating and utilizing SLM.
2. Decision aids for various kinds of experts.

Critical Information Gaps

All work on global resource assessments, especially as it relates to global environmental monitoring, is hampered by a lack of data. At the farm-level, information needed to transfer technology is also absent in most developing countries. As a result, simulation models and computer-driven decision support systems often cannot be used effectively in LDCs.

Agrotechnology transfer to developing countries has generally had mixed success. Germplasm transfer has been more successful, but the transfer of land-management technologies often fails. Part of the reason has been the inability to mesh scientific technology with conventional farming practices; acceptance is generally greater when farmers have participated in the technology development. Thus a major challenge is still the ability to involve farmers in the technology development and implementation process. LDCs lack methods and guidelines that use local knowledge and terminology to generate farm-level soil-resource information which enables extension workers to help farmers manage their soils.

Tasks for Product Development

- Through international cooperation and systematic reviews, assist in the development of a Framework for Evaluating Sustainable Land Management.
- Initiate activities to capture indigenous knowledge in selected countries.
- Compile data bases and link to GIS, simulation models, and expert systems.
- Through networks, test methods in different ecosystems.

Anticipated Products[1]

The framework for SLM would probably be structured as a series of increasingly complex interaction modules. This cascading approach is necessary to fully comprehend and analyze the forces interacting in SLM (221).

[1]The three-digit code refers to actions reported in Appendix I.

Plan of Work for Year 1

- Initiate research to define thresholds in the Framework for Sustainable Land Management.
- Develop computer-aided tools for SLM.
- Develop methods and guidelines for farmer-participatory research.

Workshop Participants

Raymond B. Bryant
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Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. To help developing nations develop land productivity and use options to enhance their economic growth and environmental preservation capabilities.	1. Countries develop policies for sustainable land management. 2. Active collaboration from selected LDC institutions.	1. Review sustainable land management criteria being used in pilot countries. 2. Review of collaborative activities with other developed and developing countries.	(Goal to Supergoal) 1. Developed and developing countries place high priority on sustainable land management as a criteria for economic development.
Purpose: To develop international framework for evaluation for sustainable land management.	1. Developed and Developing countries contribute to development of frame for evaluation of sustainable land management. 2. Developing countries validate prototype framework for sustainable land management.	1. Reports from LDC institutions, feedback and correspondences from collaborating scientists, technical reports and papers.	(Purpose to Goal) 1. There is donor and host country interest and support to develop a framework for the evaluation of sustainable land management.
Outputs: 1. Tools to aid in developing land resource inventories and assessments. 2. A framework for evaluating and implementing sustainable land management.	1. Framework developed and distributed to international collaborators. 2. Developing nations apply modern technology such as GIS, remote sensing, computer technology, etc. for land resource inventory and assessment.	1. Copies of maps, databases, technical reports from LDC institutions, correspondences on framework development. 2. Published document providing information on the framework and application guidelines. A software package developed for computer application. 3. Computer hardware and software purchased, framework utilized by country, technical reports published on findings.	(Output to Purpose) 1. LDC collaborate to develop tools and train staff to utilize tools. 2. LDCs develop reliable databases and make serious attempt to use Framework for national and local planning and development.
Activities: 1. Initate activities to capture indigenous knowledge in selected countries. 2. Compile databases and link to GIS, simulation models, and expert systems. 3. Organize international network to assist in the development of a Frame for Sustainable Land Management (FSLM). 4. Select locations in 4 countries, conduct 4 training courses and two workshops.	Inputs/Resources: 1. Project Budget $1.46 million 2. Participating universities will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing countries are expected to provide equal to $1.13 million. 4. Other developed countries could contribute, in value, equal to 50% or more of the CRSP contribution. 5. LDC scientists dedicated to progam and training requirements.	1. Newtwork meeting records, documents developed, workshop proceedings. 2. CRSP annual Work Plans & Budgets and Executive Summaries submitted to USAID. 3. Training records, reports and proceedings. 4. A functional framework available for global marketing. 5. Peer reviews, and user and mission reports on use framework.	(Activity to Output) 1. Funds are available to the CRSP, collaborating countries and LDCs to collect and generate databases, train personnel to apply advanced computer technology, and show national planners the importanace of this activity. 3. Ethno-scientists available in country and interested in collaborating.

Soils and Environmental Data Bases

Product Title
Biophysical Resource Appraisal Support System (BRASS)

Relevance to Targeted Problem
Technology transfer requires changes not only in the management of people and materials, but also in the management of information. To make technical decisions that are ecologically, economically, and socially responsible, decision-makers in environmentally endangered countries need information sources that are easily available, well-organized, and accurate. Agenda 21 of the 1992 Rio Conference emphasized this fact.

The CRSP's Biophysical Resource Appraisal Support System (BRASS) provides a means of structuring and evaluating the information used by decision-makers. BRASS integrates modern sources of information so that users can make strategic decisions with confidence. BRASS is the product of an expanding computer industry which increasingly offers the decision-maker electronic sources of information.

The CRSP's plan is to develop a scale-sensitive information system that links BRASS to a family of computerized decision support systems. Such a system will serve the network of decision-makers involved in the use and distribution of resources. BRASS developers recognize that decision-makers at all levels of society must participate in the design and implementation of any tool that affects their social, economic, and ecological well-being.

Description of Product Prototypes
We plan to develop a scale-sensitive information system that will serve the vertical network of decision-makers who have access to information concerning the use and distribution of resources. A fully developed BRASS is a number of linked software packages that permit users to access global, state, and local sources of information for decision making. To employ each of these levels of decision-making tools, users must have appropriate data.

Critical Information Gaps
The justification for developing BRASS is that timely and accurate information required for making better decisions and the data base to support this process

are not readily available. In addition, there are no systems that capture the wealth of information currently available. Many decisions are being made with minimal data, inappropriate data, or unreliable data. The user thus has few ways to determine the risk of the proposed solutions. In addition to providing output that directly supports a decision, BRASS will also give a measure of the risk associated with the output. This risk measure allows users to choose the level of confidence associated with a decision.

Another justification for the proposed BRASS is its open modular architecture, which encourages third-party development of data bases and models, thus speeding the transfer of technical information. The modular structure of BRASS also allows core programs to run on a desk-top personal computer. These small computers are easily affordable by most users in developing countries. When fully implemented in the field, the proposed BRASS will represent a long-term investment by the user to ensure that the information needed for decisions will be up-to-date, timely, and relevant.

Additional specific gaps include the following:

- The lack of internationally accepted analytical procedures and classification systems.
- Data base and data-base management systems for specific objectives (e.g., watershed/farm management).
- Pedo-transfer functions and other algorithms to generate missing data.
- Geographic holes in special data bases and statistical methods to interpolate (e.g., krijging).
- The absence of temporal data and methods to determine them (to monitor events, processes, etc.)

Tasks for Product Development

As indicated, many developing countries lack reliable data. Data sets developed for global assessments have few uses for farm-level interpretations. Thus, several kinds of data and data sensitive to scale of implementation must be collected; in addition, appropriate data-base management systems must be made available.

The tasks thus are several:

- Most important is the collation of data bases; in this respect, data base management systems must be ordered according to a function of objectives and the models and/or decision aids they support.
- A review of existing decision aids such as Automated Land Evaluation System (ALES) of Cornell University, Agricultural and Environmental Geographic Information System (AEGIS) of the University of Florida, Decision Support Systems for Agrotechnology Transfer (DSSAT) of University of Hawaii, National Soil Information Systems proliferating in many countries, and others to determine their data needs and data structure.
- Designing BRASS to serve as the data source for all these systems.

Anticipated Products[1]

1. Guidelines for assuring quality of spatial and tabular data (231).
2. A family of computer models for decision making linked to the Biophysical Resource Appraisal Support System (BRASS) (232).

Plan of Work for Year 1

- Assess existing facilities and systems.
- Determine data base needs of different customers.
- Initiate procedures to line models and decision support systems to BRASS.

Workshop Participants

Raymond B. Bryant
Stanley W. Buol
Thomas Hallmark
Ike Ikawa
Gordon Tsuji
Hari Eswaran, moderator

[1]The three-digit code refers to actions reported in Appendix I.

Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. To help environmentally endangered countries make technically based policy decisions that are ecologically and economically sound and socially responsible.	1. Environmentally endangered countries initiate activities that will provide technically and socially acceptable environmental protection policies.	1. Review programs in collaborating countries for initiatives in forming soils and environmental databases to implement environmental protection policies.	(Goal to Supergoal) 1. Environmentally endangered countries' level of commitment to implement programs and policies to correct environmentally destructive land use practices.
Purpose: 1. To develop global soils and environmental databases that will help countries develop national databases needed for environmental management.	1. Commitment from selected countries, through sharing, to the development of internationallly acessible soil and environmental databases.	A International databases hve been formed help permit develop decision aids supporting technically sound, economically viable and socially sound policies.	(Purpose to Goal) 1. Among environmentally endangered countries there is host country and donor support to correct environmentally destructive land use systems.
Outputs: 1. A database management system with broad utility is developed. 2. International database quality and standards network is established.	1. A international network of database suppliers is established. 2. GIS developed for some countries and others receive technical support with methodology.	1. Copies of database descriptions and user acessibility procedures manuals. 2. Copies of maps, technical reports from LDC institutions and proceedings from network activities.	(Output to Purpose) 1. Developed countries, international institutions and developing countries share data. 2. Selected developing countries recognize significance for databases and management systems.
Activities: 1. International workshops and regional training courses organized. 2. Professional and technical consultations to develop software packages. 3. Capture, collation and formation of databases from various sources.	Inputs/Resources: 1. Project Budget $1.46 million 2. Participating universities will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing countries are expected to provide equal value support to $1.13 million. 4. LDC scientists dedicated to program training and sharing databases.	1. CRSP annual Work Plans & Budgets and Executive summaries submitted to USAID. 2. A functional database management system. 3. Workshop and training reports, consultant reports and proceedings.	(Activity to Output) 1. Funds available for CRSP and collaborating institution to generate appropriate databases, complete personnel training to apply advanced computer technology, and national planners and international donors support the activity. 2. Developing country databases can be verified for quality and they can be mergered into the international database.

Amelioration of Acid Soils

Product Title
Soil Acidity Management Decision Aids

Relevance to Targeted Problem
Crop yields in acid soils are frequently reduced to 50% of optimum levels. Among soil chemical problems, acidity and phosphorus deficiency are the only constraints that can reduce yields to zero. Soil acidity destabilizes production by limiting root growth. It also limits the roots' ability to absorb essential nutrients and exacerbates the effects of stresses such as drought. In their attempts to minimize risks of crop failure, subsistence-level farmers in LDCs are unable to capitalize on high-yielding varieties, which are often more vulnerable to such stresses.

Worldwide, 32% of all arable soils are acid, and that figure climbs to 50% in the tropics. Acidity problems are especially prevalent in areas where rainfall exceeds evaporation. Soluble nutrients such as calcium, magnesium, and potassium are leached as water moves down through soils. These nutrients are replaced by aluminum, hydrogen, and manganese—the elements most commonly associated with soil acidity.

Many soils become acidic as human activity is intensified. Cultivated crops take up large quantities of calcium, magnesium, and potassium—which are exported from the land in harvested products. Unless these nutrients are replenished, the soil becomes progressively more acid with succeeding crops. Because legumes are particularly sensitive to soil acidity factors, producers can eventually lose the economic benefits of a low-cost supply of N from biological fixation.

As population increases, more marginal lands with acid soils are being cultivated. If the soil acidity problem is not properly managed, the environmental consequences are readily predicted: land abandonment and further deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands. Furthermore, limited root growth reduces nutrient uptake and the crop's efficiency in using applied fertilizers. Leaching of these excess nutrients increases the risk of groundwater contamination.

Description of Product Prototypes
The complexity of the *soil acidity syndrome* results from numerous combinations of calcium deficiency and excess amounts of toxic aluminum, hydrogen, and

manganese. In order for soil-acidity management tools to provide reliable solutions across a range of location-specific conditions, they must be able to diagnose the extent to which each of these soil factors contributes to the acidity problem. Prescriptions for overcoming a properly diagnosed acidity problem must also account for the differences in crop tolerance to acidity, the resource materials available to ameliorate the problem, and the approximate economic consequences for potential remedial alternatives.

A knowledge-based computer program will be developed to assemble existing information needed for the best possible diagnosis and recommendation of solutions. The Acidity Decision Support System (ADSS), developed by the CRSP for managing soils with aluminum toxicity problems, exemplifies such a product and provides the conceptual framework for building a tool that addresses the combination of factors contributing to the soil acidity syndrome. Enhancements to ADSS will be developed in coordination with similar products for other target/subtarget areas with the intent of eventually linking such tools into an integrated nutrient-management system which shares a global soil and climate data base.

Although an enhanced ADSS will enable users without an extensive soil management background to perform a logical diagnosis and evaluate remedial alternatives to soil acidity problems, most information-transfer agents will only be concerned with the application and relevance of such tools at a regional level. Many targeted users will also have limited access to computers. With user participation, however, estimates can be developed for the regional extent of the major factors contributing to the soil acidity syndrome. In conjunction with the global knowledge base compiled in decision support programs, reliable and practical guides can be produced for local users; these guides will indicate the economic consequences of potential management alternatives for the prevailing cropping systems, cultivars, lime materials, and acid soil conditions in a given region. These types of materials will be produced to facilitate the training and application of CRSP products by users at the regional level.

Critical Information Gaps

Critical information gaps focus on the knowledge needed to improve the accuracy of economic interpretations of remedial soil acidity practices. Additions to the knowledge base seek to optimize economic returns on land, labor, and inputs by improved precision in matching crops with their ameliorant requirements. ADSS is presently designed to address only acidity problems related to aluminum toxicity. To become globally applicable, it must be expanded to evaluate soil conditions with limited calcium and with excess hydrogen and manganese—with or without the presence of aluminum toxicity.

In recent years, the CRSP has gained considerable knowledge about the ameliorative and detrimental effects of organic inputs on soil acidity. Inclusion of this information in ADSS will improve the accuracy of recommendations on

the use of organic amendments. Current predictions as to how long a corrective amendment for soil acidity will last before needing additional replenishment are based on empirical estimates of the soil re-acidification process. These algorithms need to be validated for different acidity-management conditions.

Water and nutrients in subsoils for large land areas remain inaccessible to plants because of subsurface acidity constraints which are not immediately corrected upon amelioration of acidity in surface soil layers. Although subsoils may contain ample water reserves throughout the growing season, limitations in rooting depth can lead to drought stress and substantial yield reductions. Amelioration of subsoil acidity entails a combination of (a) large applications of ameliorants to surface layers with subsequent gradual movement of basic cations to lower horizons and (b) selection of crops tolerant to subsoil acidity. We are currently unable to predict both the magnitude and the time when the ameliorative response will occur in acid subsoils. Recent advances in ion transport models allow new approaches to this problem.

Estimates of ameliorants required to overcome soil acidity constraints must account for differences in species and cultivar tolerance to the targeted acidity factor. Although it is beyond the scope of this CRSP to develop cultivars for site-specific acidity conditions, soil management expertise is an essential component in efforts to quantify cultivar responses to acid soil factors and ameliorative inputs. The regional relevance of ADSS would be enhanced by the development of screening techniques for species/cultivar tolerance to acidity factors; these techniques should be fast, cost-effective, and indicative of plant productivity when exposed to the same acidity conditions at the field level. Such screening endeavors with legumes should include the microsymbiont as well as improved inoculant delivery systems for acid soil conditions.

Tasks for Product Development

1. ADSS

- Review and synthesize recent literature and experiences on diagnosis and recommendations of soil acidity problems.
- Develop models for evaluation and correction of non Al-based acidity problems.
- Develop algorithms to estimate Ca required by plant roots to counteract Al and H toxicity.
- Improve models describing crop nutrient needs and responses to soil acidity factors.
- Characterize organic ameliorants for soil acidity as to their Ca supply and lime neutralization equivalency.
- Evaluate the ion transport model with documented case studies on alleviation of subsoil acidity constraints.

- Standardize the structure for a soil and climate data base in conjunction with decision support programs in other targets/subtargets.
- Translate software and user guides into Spanish and French.

2. *Cultivar selection techniques (in collaboration with plant breeders in commodity CRSPs, IARCs, and NARCs)*

- Develop rapid screening techniques to characterize species and cultivars with respect to soil acidity tolerance and the genetic selectability, inheritance, and transferability of such tolerance.
- Select microsymbionts for survival, persistence, and effectiveness upon exposure to the major soil acidity factors.

3. *Guides for in-country transfer agents*

- Characterize by region the nature and areal extent of acidity constraints.
- Develop practical guides to soil acidity management with emphasis on regional relevance to prevailing agricultural practices, resources, and policies.

Anticipated Products[1]

- A computerized knowledge-based decision aid able to (1) diagnose prevailing acidity problems worldwide; (2) recommend a range of practical management alternatives with considerations for differences in crop tolerance to acidity and resources locally available to ameliorate the problem; and (3) provide reliable estimates of the economic consequences for the proposed remedial practices (311).
- Regionally relevant information guides so that improvements in the knowledge base have an impact on managing acid soils (312).
- Improved techniques for selecting cultivars tolerant to major soil acidity factors and improved methods for characterizing the genetics of such tolerance (313).

Plan of Work for Year 1

1. *ADSS*

- In conjunction with representatives for decision support software in other targets/subtargets, establish designs for program development that (1) ensure compatibility among systems and (2) allow a common soil and climate data base to be shared.
- Synthesize and validate information on the following:
  - Normalizing soil data by depth of lime incorporation.
  - Determining Ca supply and lime neutralization equivalency of organic inputs.

[1]The three-digit code refers to actions reported in Appendix I.

- Refining descriptions of crop yield response to Al saturation percent.
- Predicting the residual value of lime over time after application.
- Refining estimates of the long-term economic benefits of lime.

The synthesis and validation process will include a workshop with direct participation of collaborators from NARCs and IARCs. Ongoing investigations in two CRSP projects have direct relevance to planned activities for ADSS. Project UH-3 focuses on quantifying the lime effect of organic inputs from crop residues, legume cover crops, or legume trees. Project ADSS-1 will provide valuable documentation of ADSS applications in Indonesia and user feedback on recommended modifications.

2. Cultivar selection techniques

Ongoing activities in CRSP projects TAMU-2 and TAMU-3, in collaboration with INTSORMIL and IER Research Center in Cinzana, Mali, will provide initial indications that will help to:

- Quantify interactions between plant genotypes, soil acidity factors, and corrective inputs.
- Evaluate whether desirable acid-tolerance traits in cultivars are selectable and whether their inheritance and transferability are measurable.

Screening studies will also be initiated with legume microsymbionts to determine the survival, persistence, and symbiotic effectiveness of promising materials under major soil acidity conditions.

3. Practical guides for in-country transfer agents

Communications and selected research personnel will meet to develop an outline of the content for such guides and identify individual contributions required for material preparation.

Workshop Participants

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Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. To help growing populations achieve economic growth through amelioration of their acid soils to improve quantity, quality and sustainability of production.	1. Globally applicable tools for diagnosing and solving soil- and water-management constraints are developed.	1. National policy, advisory systems, and user groups employ tools. 2. Surveys of university programs that have requested the acid soils amelioration tool for use in their curriculum. 3. Surveys of national agricultural programs in the targeted countries.	(Goal to Supergoal) 1. National commitment exists in project countries to improve food selection and security, through increasing soil productivity as means to improve economic growth.
Purpose: 1. Promote economic growth and sustainable agricultural productivity through increasing yield capacity of acid tropical soils.	1. LDC institutions, PVOs, and others work to validate acid soil amelioration problem-solving tools in farmer fields.	1. Reports from LDC institutions, feedback from collaborating scientists, technical reports and publications. 2. Demand/distribution of problem solving tools; user surveys in project countries.	(Purpose to Goal) 1. Funds available to LDCs to promote improved policies and practices. 2. Implementation policies facilitate farmer access to market economy needed to ecourage adoption of recommended practices.
Outputs: 1. Globally applicable decision aid to diagnose soil acidity and prescribe economic and practical remedies. 2. Regionally relevant information guides for managing soil acidity. 3. Techniques to select and characterize cultivar/symbionts tolerant to soil acidity.	1. A computer software package for acid tolerant crops and soil amelioration developed. 2. Guides for soil acidity amelioration published for selected regions. 3. Techniques for selecting cultivar and symbiont tolerant to soil acidity developed.	1. Proper diagnosis and prescription of location-specific soil acidity conditions. 2. Level of requests for acid soil amelioration guides. 3. Publications describing techniques, improved knowledge of inheritance and transferability of acid-tolerant traits in germplasm.	(Output to Purpose) 1. LDCs collaborate to develop products and train users. 2. LDCs committed to using products to diagnose and ameliorate soil acidity constraints. 3. National collaborators and trained users remain in positions to continue implementation of tools. 4. Promising cultivars/symbionts available and promoted for local use.
Activities: 1. Synthesize knowledge on soil acidity diagnosis and remediation. 2. Develop models for diagnosis and correction of non Al-based acidity. 3. Characterize organic ameliorants for soil acidity. 4. Develop algorithms for amelioration of subsoil acidity. 5. Develop rapid screening methods for germplasm tolerance to	Inputs/Resources: 1. Project Budget $1.46 million 2. Participating universities will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing countries are expected to provide equal value support to $1.13 million. 4. LDC scientist will dedicate efforts to outreach and validation.	1. Workshop/symposia proceedings. 2. Validation reports when tested under various soil acidity conditions. 3. CRSP annual Work Plans & Budgets and Executive Summaries. 4. Rank in rapid screening corresponds with field performance ranking; progress reports; peer reviews. 5. Guides produced;	(Activity to Output) 1. National planners support the need for the activity. 2. Qualified scientists in IARCs and NARS avialable and funded to collaborate in activity. 3. Program funding is sustained for five years. 4. Research information gaps have been adequately identified. 5. Plant breeders willing to collaborate with multi-institutional team.

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
acidity. 6. Formulate regionally relevant soil acidity management guides.	5. Potential for external support of value to $0.7 million in support of acid soil amelioration.	reports from users; users trained; training course reports.	6. Users have good regional knowledge of soils, climate, agricultural practices, available inputs, and farmer resources.

Integrated Nutrient and Water Management

Productivity on more than half of the world's arable land is limited by soil acidity, phosphorous and nitrogen deficiencies, water deficits, or a combination of these problems. Efforts to increase productivity invariably address several of these constraints. For example, overcoming soil acidity improves root growth and plant access to available soil water and nutrients, but favorable crop yields will not be achieved unless phosphorus and nitrogen are in adequate supply. Similarly, biological nitrogen fixation is a low-cost alternative to inorganic nitrogen fertilizers, but legume sensitivity to soil acidity may restrict farmers' ability to capitalize on this management practice.

Harvested crops remove large quantities of nutrients from the land, making soils progressively more acid and nutrient-poor unless remedial measures are implemented. This problem is often compounded by province- and nation-wide fertilization policies which fail to recognize that individual nutrients must each be applied at specific times, frequencies, and amounts. Centralized policies insensitive to these variables have helped to create, on the one hand, soils with continuing nutrient deficits and low productivity and, on the other hand, soils where excesses of phosphorus and nitrogen threaten to contaminate surface- and groundwater.

As population increases, and pressure mounts on cultivated lands, many farmers are forced onto marginal lands with acid, infertile soils. Their nutrient problems must be corrected before crop production can be optimized. Enhanced productivity through improved nutrient and water management will help reduce land abandonment and deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands.

To achieve such improvements, the CRSP will work to integrate Product Research and Development efforts in three areas:

- Phosphorus management
- Nitrogen management
- Water harvesting and use.

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Product Title
Decision Aids to Manage Soil and Fertilizer Phosphorus

Relevance to Targeted Problem
The world's food supply depends on about 1.5 billion hectares of land. Phosphorus, an essential plant nutrient, limits crop yields on most of these soils. Of 500 soils sampled in a recent survey, 65.1% were highly deficient and 26.6% required phosphate fertilization to maintain productivity. This indicates that about 92% of the soils require phosphorus fertilization to increase or maintain food production. This high proportion occurs because both acid and calcareous soils are plagued by phosphorus deficiency, although by very different mechanisms.

A further concern is that population increases place additional pressure on the existing lands, often forcing farmers onto marginal, already deficient, erosion-prone lands. Ever larger quantities of such lands are needed to produce the same amount of food. Their nutrient-poor condition must be corrected before certain crops can produce at their potential.

While P deficiency is the primary problem, many soils have received excessive phosphate fertilization due to centrally-planned fertilization policies wherein nitrogen and phosphorus fertilizers are applied at the same time and frequency. These policies erroneously assume that application patterns should be the same for both nutrients. Such province or country-wide fertilization policies have resulted in soil P excesses in some areas and continuing deficiencies in others. Recognizing that nutrient-management decisions are best made at the local level, the CRSP's management strategies emphasize the need for site-specific fertilization. CRSP products will strive to combine local knowledge with the best scientific knowledge to make the most appropriate management suggestions for specific fields and cropping systems.

Description of Product Prototypes
A series of products are necessary to solve users' varied needs concerning the management of soil phosphorus. Tools range from decision-aid software to one-page pictorial guides that convey information on problem-solving skills that are compatible with user needs and available resources.

The *Phosphorus Decision Support System* (PDSS) will use local observations, historical records, regional experience, and, where available, analytical data from soils and plants to develop site-appropriate diagnoses and suggestions for improvement. These recommendations include fertilizer material, fertilizer quantity, management practices, or even changing to a crop which is more suited to existing soil P conditions. PDSS will empower users by allowing them to diagnose P deficiencies or excesses using readily available information. When the requisite data are not available, the software enables the users to specify the data necessary to confirm a P deficiency or excess. If a deficiency or excess is

detected, the system helps the user develop a recommendation based on the type of crop, the economic conditions, and the management goals. PDSS software will help relate results and experiences in one region to those in another location, a vexing problem for current phosphorus-management schemes.

Step-by-step *Management Guides* will enable in-country transfer agents to diagnose existing situations and predict future problems. Particular emphasis will be placed on ensuring the local acceptability and relevance of these decision-aids to problem solving and planning. These tools will be designed for situations where the PDSS software is not appropriate. These tools will not be computer-based and may be oriented to illiterate managers.

Cultivar Selection Techniques will provide protocols that enable quick and cost-effective germplasm screening to characterize P efficiency. This tool will be developed in cooperation with other institutes and organizations that direct germplasm development.

Phosphorus Balance Sheets (i.e., budget spreadsheets) will facilitate planning of nutrient inputs and outputs at a variety of scales, including field, farm, watershed, river system, and aquifer levels. The spreadsheets will be useful to policy-makers, NGOs, and others. Sound technical details will be incorporated into formula computations. These nutrient balance sheets would have the additional role of providing early indicators of systems that are unsustainable or detrimental to the environment.

Critical Information Gaps

1. Measurements of soil and plant nutrient status (including phosphorus) on farmers' fields are often not available to generate local, site-specific diagnoses and prescriptions. The current method of obtaining such data depends on regional soil-testing and plant-analysis laboratories with a technical staff to operate them and a transportation mechanism for the samples. While soil and plant tissue testing laboratories are the preferred method, alternative methods of obtaining such data from farmers' fields need to be evaluated.
2. A practical methodology is lacking to assess whether there would be economic benefits from increased vesicular arbuscular mycorrhizae (VAM) activity, either through inoculation, improved cropping rotations, or inclusion of crops leading to increased VAM populations.
3. Fertilization strategies are needed that take into account residual availability over time of applied and native soil P across soils with differing mineralogy, texture, and buffering capacity, together with economic evaluations.
4. At present, phosphorus research is highly site-specific, making extrapolation to other situations difficult. If we understood the reactions and other factors sufficiently we would be better able to extrapolate solutions from one site to others. This knowledge gap presently results in

mismanagement due to inadequate information on P status and management alternatives.

Tasks for Product Development

1. PDSS

- Expand the list of critical P levels for various soil test methods and crops.
- Assess the reliability of clay percentage and other proxy variables that correlate with surface-area measurements; assess the reliability of bulk-density measurements needed to convert volume to weight for fertilization estimates.
- Develop more effective methods of predicting and validating the P buffer coefficient in both acid and calcareous soils.
- Develop an effective method of predicting residual P availability coefficients in acid and calcareous soils.
- Develop a way to assess mycorrhizal status and determine optimal levels for efficient use of soil and fertilizer P.
- Develop a means of assessing site conditions where rock phosphates would be useful and economically productive.
- Evaluate the efficiency of various phosphorus placement strategies.

2. Management guides

- Specify and synthesize the general body of information that should be conveyed to users for step-by-step guides to problem solving and planning for efficient soil and fertilizer phosphorus management; these guides will be designed for areas where the PDSS software is not appropriate.

3. Cultivar selection techniques

- Establish a method/protocol for evaluating, selecting, and transferring P-efficient germplasm in cooperation with institutes responsible for germplasm development and release.
- Characterize P efficiencies in terms of coefficients useful to other decision-aid products such as PDSS.

4. Phosphorus balance sheets

- Determine and develop the information necessary to meet the various goals of the intended users (largely policy-makers) for specified scenarios.
- Specify and synthesize information into spreadsheet form.

Anticipated Products[1]

- A knowledge-based computerized decision aid for providing (1) site-specific diagnoses of P deficiencies and excesses and (2) recommendations

[1]The three-digit code refers to actions reported in Appendix I.

of remedial management practices, including fertilizer quantities and materials based on the type of crop, economic conditions, and management goals (321).

- Step-by-step procedural guides that enable in-country transfer agents to both diagnose existing situations and predict future problems for situations where computer software is not appropriate (322).
- Cost-effective techniques for evaluating, selecting, and transferring P-efficient germplasm between regions with similar P-management constraints (323).
- Phosphorus budget spreadsheets that help plan nutrient inputs and outputs at a variety of project scales; this tool will help planners, policy-makers, NGOs, and other users (324).

Plan of Work for Year 1

1. PDSS

- Release version 1 of PDSS system and begin training and validation activities. Market through Winrock for developed countries and release to LDCs free of charge.
- Synthesize and validate information on the following:
  - Critical P levels for various crops and soil testing methods.
  - Prediction and validation of the P buffer coefficient in both acid and calcareous soils.
  - Prediction of residual P availability in acid and calcareous soils.

To achieve a globally relevant synthesis and validation of required information, national and international collaborators will be invited to participate in a CRSP workshop.

2. Management guides for in-country transfer agents

- Complete *Groundworks 2, Managing Soil Phosphorus*. Provide free-of-charge to targeted LDC institutions; market through Winrock for developed countries.

3. Cultivar screening techniques

- Develop screening techniques to identify phosphorus use efficiency levels in agronomically important crops.
- Develop techniques to: (1) determine selectability and (2) obtain a measure of inheritance and transferability of P use efficiency in crops.
- Evaluate mycorrhizae dependency of selected crops.

4. Phosphorus balance sheets

- Develop budget sheets for major users of CRSP research. The sheets will focus on sustainable agriculture and P's impact on the environment.

- Emphasize the likelihood of nutrient deficiencies based on population needs and the amount of P removed from land under various management-system scenarios.

Workshop Participants

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Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. Develop phosphorus and nutrient management technologies needed to support economic growth, preserve the environmental and improve societal equitability.	1. LDCs establish programs supporting phosphorus and nutrient management to improve economic growth in their agricultural sector.	1. Review of developing nations that have participated in product development, validation and dissemination.	(Goal to Supergoal) 1 1. LDC and donor commitment that phosphorus and nutrient management are key to economic growth in agriculture and improved nutrition of LDC target populations.
Purpose: 1. To empower decision makers with expert knowledge capability to diagnose available plant nutrient deficiencies and excesses needed to formulate integrated nutrient supply and management practices and policies.	1. Acceptance by policy makers, PVOs, NGOs, private sector, extension groups of the value of nutrient decision support systems for balanced plant nutrition and improved productivity.	Review of research programs and policies of developing nations collaborating in the product development and outreach activities.	(Purpose to Goal) 1 1. Continuous financial support from USAID and for collaborators. 2. Acceptance by policy makers that nutrient management technology must become usable knowledge to shift their framers from subsistence level to market-driven producers.
Outputs: 1. Phosphorus and nutrient management decision tools and educational aids. 2. Trained leaders who can use and train others to use decision support tools. 3. Network of scientists focused on integrated nutrient supply and management research and development.	1. A field-functional product with educational aids ready for testing and distribution in two years. 2. Scientists and leaders contributing to phos- phorus and integrated nutrient management research and outreach.	1. Product on the market and in the field being used and under-going continuous validation. 2. Review of network reports and proceedings and feedback suggestions from user groups.	(Output to Purpose) 1 1. LDCs recognizing the importance of phosphorus and nutrient management as key to move agriculture into a market-driven economy. 2. Country leaders accept vale of networking in sharing/gaining from technology base. 3. Data gaps are not too great to hinder product development.
Activities: 1. Multidisciplinary product development team assembling phosphorus and nutrient management product. 2. Review, capture, condense and synthesize existing information and data on phosphorus and integrated nutrient management. 3. Test to validate product with targeted user groups. 4. Conduct research to fill data gaps and expand effective domain of phosphorus decision support system (PDSS). 5. Train PVO, NGO and private sector PDSS to enhance marketing and distribution for use within targeted groups.	Inputs/Resources: 1. Program Budget $1.46 million 2. Participating universi-ties will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing and particpating countries are expected to provide equal value support to $1.13 million. 4. Potential for $0.3 million in external support.	1. Survey of user groups and acceptance for validation and use as decision support tool by target groups. 2. Review of CRSP annual Work Plans & budgets and executive summary reports. 3. Review of scientific papers, training reports and feedback correspondence from validation and user groups.	(Activity to Output) 1 1. Cooperation between scientists, donors, PVOs, NGOs, private sector, and policy makers can be established and remain active. 2. Funds available, host country participation and USAID Mission support is adequate. 3. Fears of computers and distrust of computer-generated information can be overcome through training and participation in product development.

Product Title
Soil Nitrogen Management Decision Aids

Relevance to Targeted Problem
Nitrogen limits production on more than 50% of all cultivated soils. Rice, wheat, maize, sorghum, and millet production are most frequently restricted by N availability. Indeed, N limits production on more than 50% of all cultivated soils. Not only do plants need more N than any other nutrient, but it is also the most expensive input. Since most LDCs cannot afford or do not have access to the resources required to make inorganic N fertilizers, efficient use of their limited imports is essential to increasing productivity. Where inorganic fertilizers are neither available nor affordable, biological N fixation (BNF) from legumes can play an important role in supplying N for cropping systems.

The manufacture and use of N fertilizers affects the global environment more than does the production and use of other nutrients. Nitrate is the most significant nonpoint nutrient source of groundwater contamination. Unless management practices and crop use efficiencies are improved, increased food-crop production demands will require larger and larger amounts of N, a progression that threatens to exacerbate environmental problems. The capture of N through BNF is often an economically efficient means of reducing these risks. In addition to increasing plant yields, N-fixing legumes can also serve as an important source of protein for human consumption.

Description of Product Prototypes
A knowledge-based computer program has been developed by a CRSP institution for use with maize in temperate regions. The CRSP will now use this prototype to develop a Nitrogen Decision Support System (NDSS) for world-wide use by extension agents, agronomists, planners, and producers. NDSS will be able to evaluate N requirements across soil types and climatic regions for various crops and rotations, with a proper accounting of N supplied as fertilizer or as green and animal manures. It will also indicate when and how fertilizers should be applied. NDSS will predict (1) the amount of N that must be added to produce a given yield or (2) the expected yield for a given N status when N is the limiting factor. Enhancements to NDSS will be developed in coordination with the nitrogen dynamics model for cereal, grain, and root-crops in DSSAT (Decision Support System for Agrotechnology Transfer) and with similar products in other target/problem areas. Eventually, the CRSP intends to link such tools into an integrated nutrient-management system which shares a global soil and climate data base.

To respond to the world's growing N needs while reducing reliance on industrially fixed N, the CRSP will also promote, refine, and develop technologies and decision aids that (1) increase the availability of superior legume symbionts and other beneficial microbial inoculants to farmers, (2)

improve the performance of both plant and microbes in less-than-optimal environments, and (3) conserve N derived from either biological or chemical sources. Because of their role in stabilizing the land and improving soil nutrient cycling and physical conditions, legume-based soil management technologies will be closely linked with the CRSP's focus on Conservation and Environmental Protection (Target 1).

To help planners and policy-makers determine a region's long-range N needs, the CRSP will refine and adapt an N balance model that evaluates potential N supply from the soil and from external sources. By allowing users to estimate the effects of prolonged cropping on soil organic N pools, the model will provide an early-warning indicator of N deficiencies and excesses. Short of conducting prolonged fertilizer trials at each site, this model will give planners the best available estimate of long-term fertilizer N needs for a specific area.

Since most information-transfer agents will be concerned primarily with the regional application of N-management information, and since many of these agents will not have access to a computer, the CRSP will also develop users' guides that clarify the N-management strategies best suited to particular economic and environmental conditions. In conjunction with the global knowledge base compiled in decision-support systems, these guides will serve CRSP outreach efforts and encourage the use of CRSP products.

Critical Information Gaps

The most significant information gaps are those which block the application of N-management strategies under specific LDC conditions. Although both the NDSS system and N balance models are currently being used in temperate and tropical regions, they must be calibrated for LDC environments to be most accurate. For the N balance model, such calibrations include acquiring information on the areal extent of soil and climate characteristics, as well as data on soil texture, organic matter, drainage, permeability, and clay type. For NDSS, such calibrations will require information on available soil N, the mineralization rate of organic N, the efficiency of N uptake by the crop, and the possible N losses from the soil. Many of these factors can be estimated from available literature with simulated-testing models such as DSSAT (Decision Support System for Agrotechnology Transfer). In most cases, however, some local data must be available. Concerning system refinements, NDSS needs to be calibrated for crops other than maize, it needs a more refined economic module, and it must consider the consequences of interactions between inorganic N and BNF. NDSS does not currently account for soil-supplied N retained in subsurface layers by anion exchange capacity.

To maximize N fixation for a given cropping system, legume-based soil-management technologies will require additional information on the interactions among species, symbionts, and environments. Effective extension of CRSP products will also require reliable, cost-effective inoculant production and

delivery systems. BNF technologies are currently hampered by a lack of understanding about the synergistic influences which non-N management components can have on N acquired from biological fixation. Legume-based technologies will become more effective once (1) the qualitative and quantitative soil and plant factors influencing N mineralization are clarified and (2) predicted N mineralization rates from legumes are matched with N uptake patterns of crops.

Tasks for Product Development

1. N Balance Model

- Synthesize information on crop N requirements.
- Clarify organic N contributions for major cropping systems.
- Determine transfer coefficients for soil organic and inorganic N sources.
- In conjunction with developers of other decision-aid programs, establish a uniform structure for soil and climate data bases and assure compatibility among programs.

2. NDSS

- Enhance the system's existing temperate-region knowledge base so that it can evaluate crops other than maize, make economic predictions for specific LDC conditions, evaluate multiple crops per year, evaluate interactions between inorganic N and BNF, predict carryover to subsequent crops (i.e., evaluate mineralization, leaching, subsoil nitrate retention), and interface with users more effectively.
- With assistance from national collaborators calibrate/validate the enhanced knowledge base at selected LDC sites.

3. BNF Technologies

- Develop reliable and cost-effective microbial inoculant quality-control methods for industry and soil assessments.
- Develop cost-effective microbial inoculant production and delivery systems that enhance the performance of plant symbionts.
- Provide comprehensive assistance on marketing and private-enterprise development as they relate to planning microbial inoculant production facilities and to evaluating financial and marketing requirements under different stress environments.
- Improve the survival and response of introduced and indigenous symbionts.
- Provide selected and genetically improved microbial germplasm to industry and research institutes.
- Develop the knowledge base and decision aids for cycling and conserving BNF-derived N in ecosystems.
- Develop strategies to optimize BNF by non-N management interactions which maximize BNF-derived N in legume food/cash crop systems.

4. Legume-based Soil Management Technologies

- Screen species/symbionts and identify management requirements for maximum N assimilation and multi-purpose use in major cropping systems and diverse environments.
- Quantify soil and plant characteristics that mediate legume mineralization rates.

5. Local Users' Guides

Specify and synthesize N-management information that should be conveyed to users.

Anticipated Products[1]

- A computerized knowledge-based aid to improve N-management decisions. The diagnosis of soil N deficiencies or excesses will take into account crop requirements, soil types, organic and inorganic N sources; prescriptions will include when and how fertilizer N should be applied and estimates of the economic consequences of proposed remedial practices (331).
- BNF technologies that (1) increase farmer access to superior legume symbionts and other beneficial microbial inoculants, (2) improve the performance of both plant and microbes in less-than-optimal environments, and (3) conserve N derived from biological sources (332).
- Legume-based soil-management technologies that provide alternatives to fertilizer-N inputs (333).
- A nitrogen input/output balance model that enables LDC planners and policy-makers to estimate long-term N needs (334).
- Regionally relevant information guides so that improvements in the knowledge base produce corresponding improvements in N-management practices by users (335).

Plan of Work For Year 1

1. N Balance Model

- Summarize existing information on crop N requirements and N transfer coefficients to crops from inorganic and organic sources.
- Calibrate and validate model for specific target locations based on soils and weather data and local cultivars.

2. NDSS

- In conjunction with representatives for decision support software in other target/problem areas, establish a design for program development that (1) ensures compatibility among systems and (2) allows information on a common soil and climate data base to be shared. This process should include a workshop with direct participation of collaborators from NARCs and IARCs.

[1]The three-digit code refers to actions reported in Appendix I.

- Initiate validation studies in conjunction with collaborators from NARCs and IARCs.

3. BNF Technologies

- Maintain and distribute germplasm for legume inoculants and other beneficial microbes upon request, and evaluate naturally occurring and genetically improved rhizobia for tree legumes.
- Evaluate environmental monitoring and quality-control methods for microbial microsymbionts through user networks, and refine these products based upon feedback.
- Test inoculant production prototypes, inoculant carriers, and delivery systems.
- Provide private-enterprise development assistance for assessment, establishment, and impact analysis of microbial inoculant production facilities.
- Develop regional action plans for enhancing BNF technologies through regional resource centers.
- Provide practical training courses and communications materials on BNF for LDC clients.

4. Legume-based Soil Management Systems

- Synthesize, compile, and analyze existing knowledge on legume multi-purpose functions in conjunction with collaborators from NARCs and IARCs.
- Initiate field validation studies at benchmark sites to (1) screen species/ symbionts for multi-purpose applications, (2) identify management requirements for maximum N assimilation and use in major cropping systems and environments, and (3) quantify soil and plant characteristics that mediate mineralization rates.

5. Local Users' Guides

- Communications and research personnel will meet to outline the content of the guides and identify the individual contributions required to prepare them.

Workshop Participants

David R. Bouldin
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Anthony S. Juo
Timothy P. McBride
Thomas J. Smyth
Gordon Y. Tsuji
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Shaw Reid, moderator

Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: Provide integrated nitrogen management technologies so growing populations can meet their present needs without compromising the ability of future generations to meet their own needs.	1. Nitrogen deficient countries establish active programs in integrated nitrogen management to support environmentally sound economic growth in their agriculture sector.	1. Review of collaborating countries' policies and research and development agendas in integrated nutrient management.	(Goal to Supergoal) LDC and donor committed to integrated nitrogen management as being paramount to environmentally sound economic growth and improved nutrition of low-income populations.
Purpose: 1. Empower decision makers with nitrogen management technolgies to support economic growth and environmental protection.	1. Acceptance by LDC policy makers, PVOs, NGOs of the importance for integrated nitrogen management options to drive economic growth in agriculture.	1. Evaluation of collaborating countries' research and development activities in nitrogen management. 2. Demand and distribution of problem solving tools; user surveys in targeted countries.	(Purpose to Goal) 1. Continuous financial support for the CRSP and for collaborators. 2. LDCs place integrated nitrogen management as a high priority research and development program. 3. Development policies permit economic realization of benefits from integrated nitrogen management.
Outputs: 1. Integrated nitrogen management decision support tools and educational aids. 2. Regionally relevant integraded nitrogen management guides and options. 3. R&D activities to develop technologies and methodologies to advance the utilization of biological nitrogen fixation. 4. Training for leaders to increase the transfer and adoption of integrated nitrogen management technologies.	1. Decision support system(s) to improve economics of production through efficient nitrogen management. 2. Legume-based soil management technologies to provide alternatives to fertilizer-N inputs. 3. BNF technologies that: a) increase farmer access to superior legume symbionts and other beneficial microbial inoculants; b) improve the performance of both plant and microbes in less-than-optimal environments; and, c) conserve N derived from biological sources. 4. Regionally relevant information guides and trained leaders in integrated nitrogen management.	1. Completed review of integrated nitrogen management options and state-of-the-art study. 2. Publications and user guides on integrated nitrogen management. 3. Integrated nitrogen management training records, training manuals and proceedings. 4. Reseach reports and publications.	(Output to Purpose) 1. Adequate level of LDC commitment to advancing technologies and decision aids in integrated nitrogen management. 2. LDCs and private sector collaboration to improve integrated nitrogen management. 3. Support adequate for training courses, and participant numbers adequate to develop a critical human resource mass. 4. Continued LDC and donor support to advance BNF research and development.
Activities: 1. Integrate reseach activities to develop dynamic nitrogen balance model. 2. Develop integrated nitrogen decision support tools and educational aids.	Inputs/Resources: 1. Program Budget $1.46 million 2. Participating universities will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing and partici-	1. Data base to drive input/output model. 2. CRSP annual Work Plans & Budgets and Executive Summaries. 3. Reports from teams and network activities.	(Activity to Output) 1. Funds available, host country participation and USAID mission support are adequate. 2. National planners, PVOs, NGOs, etc. place high priority on environmentally sound integrated nitrogen

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
3. Improve and advance the technologies of and the utilization of biological nitrogen fixation. 4. Develop regional and/or systems appropriate legume-based soil management technologies for economic growth and environmental protection.	pating countries are expected to provide equal value support to $1.13 million. 4. Potential for $0.5 million in external support.	4. Workshop/symposia proceedings. 5. Demonstration of various Integrated nitrogen management technology transfer aids.	management. 3. Funds are adequate to maintain a integrated research program to keep ahead of knowledge gaps. 4. Regional networks participate in formation of nitrogen input/output data base.

Product Title

Decision Aids to Improve Water Capture, Retention, and Use

Relevance to Targeted Problem

Water deficiency is one of the major constraints to plant growth and crop yields. The causes of deficiency range from low rainfall to high runoff, from restricted absorption to inefficient utilization. To combat this problem across agroclimatic zones, users need a variety of tools. Four such tools are proposed for evaluation and refinement: agroforestry systems, raised-bed agriculture, water harvesting, and improved agronomic practices.

Agroforestry systems are particularly relevant where farmers want specific tree products along with an associated food or pasture crop. They are also relevant when the exploration of vertical space (both above and below ground) is feasible and where short- or long-term dynamics impart certain advantages for the growth of crops and the maintenance of the resource base.

Raised-bed agriculture has been practiced with success in indigenous communities in many parts of the world. Attempts to reintroduce such systems are worth pursuing, particularly in light of their potential to sustain crop production in water-sensitive problem areas.

Water harvesting exploits low rates of precipitation accruing over large areas that normally could not support crop growth. Water from a large catchment area is focused onto smaller areas, thus enabling crops to grow on part of the land.

Improved agronomic practices will integrate production systems to produce the best combination of inputs and crops with superior genetic characteristics. By integrating soil science and plant breeding, improved agronomic practices will evaluate a wide range of inputs, resources, management skills, and economic conditions. The practices will minimize environmental impacts and enhance the natural-resource base.

Description of Product Prototypes

The agroforestry-related product prototypes will enable users to determine the feasibility of maintaining agronomic crop production in agroforestry systems. In addition, they will provide a protocol for determining the desirable plant characteristics relative to performance in an agroforestry system. They will also provide guidelines for assessing the economic feasibility of agroforestry systems with specific reference to the value of the tree component.

The raised-bed agriculture product will provide the user with criteria for determining the beds' dimensions under given soil and climatic conditions to ensure optimal soil moisture availability in the root zone while avoiding salinization problems. The product will evaluate cost-effective soil- and plant-management systems.

Water-harvesting systems consist of four components: a catchment basin, a conveyance system, a storage facility, and a distribution system that often

utilizes a cultivated crop or field. The product to be developed will provide the technological basis for designing and constructing the components under various landscape and agroecological conditions.

The agronomic approach will develop (in collaboration with INTSORMIL) crops with (a) multiple stress-tolerances, (b) superior responses to various input levels, and (c) the necessary quality characteristics. Stresses to be emphasized are nutrient deficiencies and water limitations.

Critical Information Gaps

Agroforestry

- Conditions necessary to minimize water constraints to agronomic crop productivity per unit land area when the crop is grown in an agroforestry system.
- Economic feasibility of using agroforestry technology to improve water use efficiently under micro and macro conditions.
- Social acceptance of agroforestry as a means to improve water use.

Raised Beds

- Criteria for determining the optimal dimensions of raised beds and water-filled channels under given soil and climate conditions and for given single and multiple crops.
- Micro- and macro-economic conditions under which the raised-bed technology is economically feasible.
- Response of local farm communities to the increased labor requirements for constructing raised beds.
- Long-term impact of raised-bed agriculture on regional climate.
- Management systems to maximize plant production under raised-bed systems.

Water Harvesting

- Capability to accurately predict the onset, quantity, distribution, and intensity of rainfall.
- Means to evaluate the effectiveness of water-harvesting systems.
- Design analysis to determine the appropriate systems for given land and socioeconomic conditions.

Agronomic Practices

- Understanding and quantifying the interaction between genetic material and levels of nutrient and water stress.

- Strategies for combining genetic material and agronomic practice in ways that increase yields and yield stability and that can be adapted to a wide range of resources.

Tasks For Product Development

Agroforestry

- Determine the feasibility of maintaining agronomic crop production in agroforestry systems.
- Develop and evaluate a protocol to determine the selectability of desirable plant characteristics relative to performance in an agroforestry system.
- Develop a protocol to assess the economic feasibility of agroforestry systems with specific reference to the value of the tree component.

Raised Beds

- Determine key characteristics of water- and heat-transport dynamics in and above raised beds; determine how these are influenced by the nature of the soils, the dimension of the beds, the depth of water in the channels, and the type of crop.
- Develop and test protocol to determine if desirable plant characteristics are selectable.
- Develop a procedure to determine the profitability of raised-bed technology.
- Develop a protocol to analyze the sociological response of local farm communities to the raised-bed technology.

Water Harvesting

- Integrate knowledge of rainfall probability and frequency distribution with information on crop water requirements, soil water storage, and crop water use efficiency.
- Determine the site-specific topographic information needed for different types of water-harvesting schemes.
- Integrate resource information with an evaluation of construction and maintenance costs to determine the economic advantage required for farmer acceptance.

Agronomic Practices

- Quantify three-way interaction between plant genotypes, nutrient levels, and water levels.
- Formulate strategy to obtain information necessary to produce site-specific integrated production systems with the best combination of inputs and genetic material.

Anticipated Products[1]

- Decision aids to determine the feasibility of maintaining agronomic crop production in agroforestry systems and for assessing the economic feasibility of agroforestry systems with specific reference to the value of the tree component (341).
- Guidelines for determining the practical utility of raised-bed agriculture and criteria for determining the beds' dimensions under given soil and climatic conditions (342).
- Decision aids to guide the design, construction, and use of water-harvesting systems involving a catchment basin, a conveyance system, a storage facility, and a distribution system (343).
- Improved techniques for selecting cultivars with (a) multiple stress-tolerances, (b) superior responses to various input levels, and (c) the necessary quality characteristics. Stresses to be emphasized are nutrient deficiencies and water limitations (344).

Plan of Work for Year 1

Agroforestry

- Develop a two-dimensional computer model (a) that represents seasonal and above- and below-ground spatial interactions in agroforestry systems, (b) that will provide testable guidelines for the design of agroforestry systems, and (c) that will produce outputs which can illustrate the dynamics of agroforestry systems under a range of conditions.
- Assess the feasibility of selecting agronomic crops that exhibit high radiation use efficiency under low light conditions.

Raised Beds

- Develop a two-dimensional computer model capable of (a) representing measured field observations with reasonable accuracy and (b) providing the quantitative norms necessary to design raised beds for various locations and conditions.
- Determine how the water- and heat-transport dynamics are influenced by the configuration of raised beds.
- Determine the extent to which crop yields are influenced by the configuration of the raised beds and associated channels.

Water Harvesting

- Survey existing water-harvesting systems and assess their level of success and acceptance by farmers.

[1]The three-digit code refers to actions reported in Appendix I.

- Determine the extent to which rural communities have benefited economically and socially by adapting this technology.
- Determine why some water-harvesting systems have failed (e.g., poor design, inadequate water storage capacity, insufficient ratio of the catchment area to the storage capacity, excessive cost of installation and maintenance).

Agronomic Practices

- Quantify three-way interaction between plant genotypes, nutrient levels, and water levels.
- Develop techniques (a) to screen for and determine if desirable plant characteristics relative to nutrient and water stresses are selectable and (b) to obtain a measure of inheritance and transferability (to be undertaken in cooperation with INTSORMIL).

Participants

Arthur B. Onken
James F. Parr
Susan Riha
Philippe Baveye, moderator

Logical Framework

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: 1. Develop water harvesting and use technologies to improve economic utilization while preserving the quality.	Countries begin to establish R&D efforts for water harvesting and use to enhance agriculture productivity and develop water use policies.	1. Review of collaborating countries'and participating institutions' research, development and outreach activities in water harvesting and use.	(Goal to Supergoal) 1. Global recognition of need to more effectively utilize finite water resources for sustainable development.
Purpose: 1. Improve the productivity from finite global water resources while maintaining the quality.	1. Countries with limited water resources accept and/or improve use of finite water resources.	1. Review of water harvesting and use policies in countries collaborating with the CRSP.	(Purpose to Goal) 1. Recognition that water harvesting and use technologies are important to economic growth, environmental and health goals. 2. Continuous financial support to the CRSP from AID and for the collaborators.
Outputs: 1. Develop protocols for integration of harvesting water into mixed and mono-cropping systems. 2. Develop decision aids adaptable to site specificity to enhance economic returns from harvesting water resources. 3. Develop training materials to improve efficiency of water harvesting and use.	1. CRSP participation in international working group addressing water harvesting and use for economic growth and quality preservation. 2. Development of education aids appropriate for topical areas. 3. Critical ecological domains needing this technology well identified.	1. Minutes, reports and proceedings from working group meetings and training meetings. 2. Products available or in progress focused on target topic. 3. Definition of critical ecological domains and R&D needs documented.	(Output to Purpose) 1. Recognition that water is a finite and a cyclic natural resource. 2. Accessibility to those ecological domains where water is scarce and water harvesting technogies are lacking. 3. Collaborating scientists will be available to participate in training and research activities.
Activities: 1. Review major water harvesting and use R&D needs through state-of-the-art study. 2. Establish appropriate collaborative research linkages. 3. Design decision aid protocols and enter existing data bases to focus on research gaps. 4. Structure research and training to fill knowledge gaps.	Inputs/Resources: 1. Program Budget $1.46 million 2. Participating universities will match 25% under standard provisions regulations and BIFADEC guidelines. 3. Developing countries and participating institutions are expected to contribute equal value support to $1.13 million. 4. Potential for $0.3 million in external funding.	1. CRSP annual Work Plans & Budgets and Executive Summaries. 2. Completed review and state of study on water harvesting and use. 3. Scientists trained, reports, and records. 4. Review of CRSP decision aids available for water harvesting and use.	(Activity to Output) 1. Research, training and outreach approach remain most feasible means to accomplish purpose. 2. USDA and university facilities available for participating scientists. 3. Climatic data bases are adequate and available to the participating scientists. 4. Cooperation among scientists, donor and policy makers remains strong and information is shared. 5. Funds available, host country participation and USAID mission support is adequate.

Outreach Program

Purpose

Unused or irrelevant tools have no impact. To achieve its goals and objectives, the CRSP must develop products that respond to the demands and needs of LDC users. In addition, the CRSP must promote these products and demonstrate their use in site-specific situations.

To this end, the CRSP will implement an Outreach Program that involves LDCs and other intended users of its products in all phases of product development, testing, and promotion. In addition to encouraging the use of indigenous knowledge, broad participation of this sort will assure that products respond to local needs and values. Combined with a vigorous effort to promote product use, such responsiveness is the key to increasing program impact.

The Outreach Program will focus on four primary areas: Policy and Decision Making, Human Resource Development and Communications, Product Development and Impact Assessment, and Technical Assistance and Market Development.

Tasks

Policy and Decision Making

- Establish an integrated capacity for responding to requests from USAID bureaus, field missions, and related groups; devote particular attention to program-planning and assessment matters, policy reviews, and other multi-disciplinary field activities.
- Promote the application of soil-management products to enhance policy formulation and implementation relevant to economic productivity and environmental security.

Human Resource Development and Communications

- Disseminate products to clients, provide follow-up technical assistance, and refine/adapt products to meet client needs.
- Conduct programs that target specific user groups within the public and private sector.

- Develop an international information network that promotes CRSP products among potential implementors and beneficiaries.
- Strengthen CRSP collaborative activities to make product development more cost-effective.
- Coordinate the development of educational and training materials.

Product Development

- Identify client needs and relevant indigenous knowledge in order to guide product design, development, and dissemination.
- Adapt existing CRSP products to client needs.
- Incorporate decision support systems and other products into communications, training, and technical-assistance efforts.
- Enhance private-sector participation in implementing improved soil-management practices.

Technical Assistance and Market Development

- Promote CRSP products and programs through national and international media, in-house publications, and market promotion material.

Leadership

Outreach efforts will be led by a full-time program leader(s). Product-development teams will also play an important role in the Outreach Program.

The responsibilities of the outreach leader(s) will include coordinating all outreach tasks; promoting the use of CRSP products; identifying specific high-priority, high-payoff activities; responding to requests from the public and private sector; serving as a liaison between the Management Entity (ME) and USAID missions and bureaus; serving as a liaison between the ME and product-development teams; arranging and coordinating workshops, training sessions, and other means of demonstrating the potential benefits of CRSP products; assessing the strengths and weaknesses of existing products for product-development teams; and outlining essential product modifications for development teams.

Product-development team members will provide technical support to the outreach leader(s). They will play key roles in workshops, training sessions, and other activities where the products are being explained and demonstrated. They will work with the outreach leader to insure that products respond to user demands and can be readily applied.

Tasks for Year 1

- Determine current demands and needs for problem-solving tools.
- Study mission programs to determine situations where the CRSP can be of service.
- Begin assembling communications materials.
- Visit selected missions and explain the potential benefits of CRSP programs; establish collaborative projects on appropriate topics.
- Communicate with public- and private-sector groups that can use CRSP products to contribute to USAID goals.
- Extend technologies to clients and increase institutional capacity to develop and adopt plant symbiont technologies through human resource development, research, extension, and private-sector assistance.
- Promote the use of land-resource assessment methodologies for guiding the selection of alternative land-use scenarios.
- Develop nutrient-management guides with collaborators from user groups.
- Conduct workshops with collaborators and users to (a) release existing versions of nutrient decision support systems, (b) initiate training in their use, (c) collect and synthesize existing location-specific knowledge that addresses critical information gaps. Three workshops are anticipated, one each for acidity, phosphorus, and nitrogen.
- Convene workshops of potential network collaborators, SANREM CRSP scientists, and active organizations to update state-of-the-art documentation on models and technologies for erosion control, rejuvenating degraded lands, rainwater use, and environmental protection, with emphasis on developing an integrated watershed management perspective.

Field Support to USAID Missions

The Soil Management CRSP is designed to serve U.S. foreign-policy objectives by working with USAID missions and other clientele groups with parallel interests. The refocussed CRSP will give particular attention to USAID's sustainable-development goals as they relate to economic growth and environmental protection. Specific kinds of field-support the CRSP can provide are detailed below.

1. Support to Bilateral Programs

The CRSP can assist bilateral programs (i.e., between USAID missions and host countries) that require technical support on issues involving land use, environmental protection, and natural-resource management. The CRSP is currently providing such services to an alternative-crops project in Bolivia, a land-management project in Honduras, a natural-resource project in Niger, and a watershed-development project in Guinea.

2. Training Activities

As long as developing countries depend on imported technologies, economic productivity will suffer. The Soil Management CRSP has long recognized that investments in human skills and capacities are essential for societies seeking to sustain economic growth and improve the quality of life. To date, more than 100 developing-country students have earned advanced degrees in the CRSP's collaborative training program. In addition, more than 5,000 trainees have benefited from the CRSP's short-term programs. The CRSP also helps the International Agricultural Research Centers fill gaps in their training efforts. The CRSP will continue to involve LDC graduate students and graduates in its programs; the CRSP will also continue to conduct specialized training programs for those who use its products.

3. Workshop Support

By helping to forge a unified approach to complex issues, information-exchange workshops provide an effective means of addressing local and multinational problems. These workshops can also strengthen diplomatic relationships and help to establish international networks capable of producing long-term economic and environmental benefits. The Soil Management CRSP can provide technical and

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organizational leadership for national and international workshops selected and developed in collaboration with USAID missions and host-country institutions.

4. Technical Backstopping

The CRSP can respond to a variety of mission and host-country requests for technical backstopping on land-management issues. Such assistance is are already being provided through the Latin American RISTROP Network. The CRSP has also responded to short-term requests for specialized backstopping in Kenya and El Salvador. Products and technologies developed by the CRSP are provided upon request to institutions in USAID countries. Updates on new products and activities are provided through the CRSP's *Newswire*, a bimonthly publication sent to missions, host-country institutions, PVOs, NGOs, and selected private entrepreneurs.

5. Sector Analysis

As countries develop, new relationships in the global community need to be addressed. The CRSP can draw on its extensive international experience to help USAID missions analyze the economic and agricultural sectors in which these relationships occur. A number of CRSP representatives are already providing this type of support.

6. Collaborative Programs

The Soil Management CRSP's current collaborations will be continued where they are consistent with the program's refocussed goals, and they will be expanded as new opportunities arise. At present, the CRSP collaborates with national institutions in Mali, Niger, Peru, Bolivia, Jamaica, Honduras, Indonesia, Burkina Faso, and Morocco. In addition, the Soil Management CRSP collaborates with the Peanut CRSP in Burkina Faso and Mali, the INTSORMIL CRSP in Niger and Mali, the Small Ruminant CRSP in Bolivia, and the SANREM CRSP in the Philippines and Mali. The Soil Management CRSP also works with the Pond Dynamics/ Aquaculture CRSP to reduce environmental problems in Honduran estuaries.

7. Clientele Services

USAID's clients are also the Soil Management CRSP's clients. Because land-use policies and practices are critical to achieving the missions' goals on environmental and economic issues, input from a broad range of interest groups is essential. CRSP technologies and experience in managing soil resources can be valuable assets to USAID and its clients. For example, maximizing nitrogen fixation by legumes requires the presence of the specific microorganisms; frequently, seed must be inoculated, a process which requires precise technologies for producing and preserving inoculants. The CRSP has developed such technologies and provided them to private-sector producers and distributors. As inoculants become more readily available, farmers benefit, and USAID goals are thus achieved.

3.
Prioritized Work Plan

Program Priorities

Regional Activities

The Soil Management CRSP has the experience to provide technical assistance across a broad range of agroecological zones and geographical regions. Funding realities and other constraints impose the need for priorities to guide the program in a manner that encourages the highest level of achievement.

The CRSP's program is designed to provide field support for USAID missions, either directly, by responding to mission requests, or indirectly, by conducting outreach activities and producing problem-solving tools that support mission goals.

All CRSP products will be globally applicable. However, they will require local data bases for site-specific uses. Funding will determine the extent to which products can be adapted and field-tested. Priorities for various activities within agroecological zones and geographical regions are given in Table 2. Funding level was a primary determinant of activity level. Other considerations are as follows:

- The need for two program-wide activities in most regions: *Field Support to USAID Missions* and *Outreach*. Activity levels for *Targets and Problem Areas* will be judged on their potential for payoff and impact.
- The relative importance of the targets and problem areas to sustainable-development goals, as determined through consultations with LDC scientists.
- National levels of institutional development and human-resource capability within the agroecological zones.
- The development stage of envisioned products and the regions where the products would have the greatest impact.
- The political, economic, and social conditions within agroecological zones. Some nations within an agroecological zone may need the Soil Management CRSP's products, but for various reasons they may also be closed to CRSP participation.
- Activities of IARCs in the agroecological regions.

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Table 2. Matrix of regional activity levels as a function of funding levels. The CRSP can deliver activity-level 1 at 60% of FY93 (Alternative B), levels 1 and 2 at 70% (Alternative A), levels 1, 2, and 3 at 80% (Recommended Program), and levels 1, 2, 3, and 4 at 100%.

Agroecological Zones & Regions / Program-Wide & Product-Development Foci	Humid Regions			Savanna Regions		Semiarid Regions			Temperate Regions	
	Latin Am.	S.E. Asia	Africa	Latin Am.	Africa	Africa	Mideast & Med.	Asia	Europe	NIS
PRODUCT-DEVELOPMENT FOCUS										
1. Conservation and Environmental Protection										
• Water and wind erosion control	1	2	2	4	3	1	3	4	4	4
• Rejuvenation of degraded lands	1	2	3	4	4	1	4	4	4	4
2. Land Resource Quality										
• Quality and degradation indicators	1	2	2	3	3	1	3	4	4	4
• Productivity and use options	1	2	2	3	2	1	3	4	4	4
3. Productivity and Economic Growth										
• Amelioration of acid soils	1	1	4	3	4	1	4	4	4	4
• Integrated nutrient and water management	1	1	3	4	3	1	4	4	4	4
PROGRAM-WIDE FOCUS										
1. Field Support to USAID Missions	1	1	1	1	1	1	1	1	1	1
2. Outreach	1	1	3	3	2	1	2	4	4	4

Product Development

The Basic Work Plan (pages x to y) presents a comprehensive program for addressing USAID's land-management needs. It specifies key targets, critical problems, and the tools necessary to solve these problems.

USAID advised the CRSP to submit a proposal for extension for three funding levels: 80%, 70%, and 60% of FY93 allocations. Hereafter, the programs corresponding to those funding levels will be referred to as the *Recommended Program* (80%), *Alternative A* (70%), and *Alternative B* (60%). The CRSP employed the following prioritization procedure to respond to USAID's request.

1. A 12-member committee prioritized the 35 products identified in the workshops and listed in the Work Plan. The committee consisted of the five workshop moderators (see individual Work Plans), the interim program leaders (2), additional scientists to provide technical balance (3), the USAID program leader (1), and the Management Entity Director.

2. Each committee member placed each product into one of five priority

groups, seven products to a group. Based on a summation of committee rankings, products were then ranked from 1 to 35.

3. From individual rankings, four priority groups were developed for funding consideration. The composition of each group is given in Appendix I.
4. Thirteen products were selected from the highest priority groups for inclusion in the *Recommended Program*. These are listed, in order of ranking, in Table 3.
5. The committee's rankings offer a useful starting point, but they should not be the sole basis for determining product priorities. Other considerations include a product's importance to the overall program, its relationship to other products, and its resource-use efficiency.
6. All 13 products are included in the *Recommended Program*. Products have been deleted from *Alternative A* and *Alternative B*. Deletions were based on a product's relative importance to the overall program—not the rankings in Table 3.
7. Products to be included for each funding level and their relationship to targets and problem areas are given in Table 4.

Subsequent pages present details on the prioritized programs.

Table 3. Products included in the Soil Management CRSP's *Recommended Program*—in order of ranking by a 12-member committee.

1. Phosphorus Decision Support System
2. Acidity Decision Support System
3. Framework for Land Quality Evaluation
4. Nitrogen Decision Support System
5. BNF Technologies
6. Biologically Based Decision Support System for Rejuvenating Degraded Lands
7. Early-warning Indicators
8. Framework for Sustainable Land Management
9. Water Use and Enhancement Decision Aids
10. Biological and Mechanical Controls for Wind and Water Erosion
11. Biophysical Resource Appraisal System
12. Landscape-based Decision Support System for Rejuvenating Degraded Lands
13. Watershed-based Decision Support System for Wind and Water Erosion Control

Table 4. Products for the *Requested Program. Alternatives A* and *B* would exclude the boxed products as indicated.

REQUESTED PROGRAM	
Target 1: Conservation and Environmental Protection	
Problem area: Water and Wind Erosion Control	
Product: Biological and mechanical controls	
Product: Watershed-based decision support system	
Problem area: Rejuvenation of Degraded Lands	
Product: Landscape-based decision support system	
Product: Biologically based decision support system	EXCLUDED FROM *ALTERNATIVE B*
Target 2: Land Resource Quality	
Problem area: Quality and Degradation Indicators	
Product: Biophysical resource appraisal system	
Product: Framework for land quality indicators	EXCLUDED FROM *ALTERNATIVE A* AND *ALTERNATIVE B*
Product: Early-warning stress indicators	
Problem area: Productivity and Use Options	
Product: Framework for sustainable land management	
Target 3: Productivity and Economic Growth	
Problem area: Amelioration of Acid Soils	
Product: Acidity decision support system	
Problem area: Integrated Nutrient and Water Management	
Product: Phosphorus decision support system	
Product: Nitrogen decision support system	
Product: Biological nitorgen fixation technologies	
Product: Water use enhancement decision aids	EXCLUDED FROM *ALTERNATIVE B*

Prioritized Programs

Product Research and Development Focus

Target 1. Conservation and Environmental Protection

Cropping, overgrazing, fuel-wood exploitation, and other agricultural activities account for 99% of the human-induced degradation of the world's vegetated soils. Most of the damage has been done by water and wind erosion. Production-demand pressures, the lack of appropriate technologies, and policies based on exploitation rather than sustainability are among the chief causes of this degradation.

Population projections indicate that another billion hectares of vegetated soils could be degraded by 2025 unless integrated land-management technologies and

policies are implemented. The Soil Management CRSP has identified important products that can help conserve and protect global soil and water resources.

Subtarget 1.1: Water and Wind Erosion Control

Water erosion accounts for 56% of all human-induced degradation of vegetated soils; wind erosion accounts for another 28%. In Africa, the two cause nearly equal amounts of damage. In Latin America and Asia, water erosion is the more pernicious.

Product 111: Biological and mechanical controls for wind and water erosion. Experiences with the IMAW project in Niger, the IRRI hedgerow program in the Philippines, and the mission-sponsored steepland program in Honduras have demonstrated that both biological and mechanical technologies are needed to control wind and water erosion. Research and development for these technologies will focus on three components: (1) benchmark indicators to monitor how soil erosion affects environmental quality, agricultural productivity, and economic growth; (2) biological and mechanical erosion-control technologies that are culturally and economically acceptable; and (3) a scientifically based decision support system that evaluates a range of soils, climates, landscapes, and socioeconomic conditions.

The IMAW project has developed products and methodologies that will be tested and refined in Niger's proposed Inter-CRSP Natural Resource Management project. To extend the impact of these and other products, regional collaboration will be explored with Mali, Ghana, and Burkina Faso in West Africa; with IRRI in Indonesia; and with CIAT in the humid region of Honduras. Products can be disseminated by SANREM and the other CRSPs, IARCs, NARs, NGOs, PVOs, and various conservation programs.

Product 112: Watershed-based decision support system for wind and water erosion control

Long-term solutions to erosion problems require integrated procedures for conserving soil and water resources. At present, many of the empirical and process-based models for predicting wind and water erosion have been developed from data on U.S. soils, climates, and ecosystems. Likewise, current watershed-management decision support systems that incorporate physical, mechanical, and socioeconomic components are rarely applicable in LDC environments. The CRSP's watershed-based decision support system will overcome this deficiency: it will be based on globally applicable principles for controlling erosion both biologically and mechanically (see Product 111 above), and it will provide guidelines for site-specific applications in LDC ecosystems.

Subtarget 1.2: Rejuvenation of Degraded Soils

Over the last 45 years, more than a billion hectares have been degraded, an area roughly equal to India and China combined. Agricultural activities have caused the bulk of this degradation. As population increases, the pressure to meet human needs by intensifying production on marginal lands threatens to exacerbate such problems. Decision aids to prevent land degradation and rejuvenate already degraded lands will thus be essential to the responsible management of the environment.

Product 121: Landscape-based decision support system for rejuvenating degraded lands
Because degradation occurs at the farm level, rejuvenation research needs to involve land users and be informed by a clear vision of their aspirations and long-term needs. The diagnostic component of this product will enable it to capture and organize both socioeconomic and biophysical data through the use of geographic positioning systems (GPS) and geographic information systems (GIS). These tools can be applied to both degraded and comparatively nondegraded ecosystems.

For individual fields or entire landscapes, rejuvenation efforts will employ diagnostic and ameliorative tools developed from related research on enhancing economic and agricultural productivity. Product 121 will be especially helpful to planners, policy-makers, peer scientists, and program implementors (i.e., PVOs, NGOs, extension leaders).

Product 122: Biologically based decision aids for rejuvenating degraded lands
Many degraded soils can be restored to economic productivity once their chemical and physical problems have been diagnosed. CRSP researchers have identified microsymbionts, leguminous species, and nonleguminous species that can rejuvenate soils and that are socially and financially acceptable to farmers. This data base will to be integrated into a comprehensive system applicable to diverse agroecological conditions.

Target 2: Land Resource Quality

When population pressures were low, farmers could readily move to new areas when land productivity declined. Current population pressures do not permit this kind of expansion. As fallow periods shorten and greater strains are placed on marginal lands, the risk of land degradation increases. At a time when misjudgments about long-term sustainability can have dire human and environmental consequences, farmers and policy-makers need a reliable means of predicting the physical and economic consequences of various land-management decisions.

Methods for evaluating soil quality, health, and resilience are all in the early stages of development. The following are among the most urgent needs:

- An international network to coordinate research efforts
- Methods to predict the onset of degradation in stressed systems
- Methods to determine the resiliency of stressed systems
- Reliable soil resource information upon which policies that promote long-term social equity can be based.

Subtarget 2.1: Quality and Degradation Indicators

Sustainable land management (SLM) seeks to harmonize environmental concerns and economic realities. Achieving it requires an understanding of (1) the biophysical resource base and (2) on-farm social and economic conditions.

Product 211: Framework for Land Quality Evaluations

Developing this product will require the generation, mobilization, and integration of data and knowledge about environmental processes. Researchers must employ indigenous knowledge, and take full advantage of the latest advances in information science and technology. Research must focus on long-range issues (e.g., identifying indices of sustainable land management, evaluating on-site and off-site impacts of agricultural practices).

The framework for land quality evaluations will be developed through international collaboration and systematic reviews of research outputs. Collaborators will include the SANREM CRSP, the International Board for Soil Research and Management (IBSRAM), Agriculture Canada, the Food and Agriculture Organization of the United Nations (FAO), the Indian Council of Agriculture Research (ICAR), and the Hungarian Academy of Agriculture. The framework will be able to assess the potential for land degradation, the resiliency of soil systems, and the technological options best suited to particular sites.

Subtarget 2.2: Soils and Environmental Data Bases

To make technical decisions that are ecologically, economically, and socially responsible, LDC policy-makers and producers need information sources that are accessible, well-organized, reliable, and accurate. Decision support systems offer an effective means of structuring information, but to be most effective, these systems require a global soils and environmental data base.

Product 221: Biophysical Resource Appraisal System

The Biophysical Resource Appraisal Support System (BRASS) will integrate information from multiple sources in a manner that allows users to make confident short- and long-range decisions.

BRASS will consist of linked software that enables users to access global, national, and local information. At present, this data is often inaccessible.

Indeed, no current system has captured the wealth of available biophysical resource information in a reliable form. BRASS will overcome this shortcoming by providing (1) decision support information and (2) an assessment of the confidence level users should place in any proposed course of action.

Five major tasks are required to develop BRASS: (1) collate data bases; (2) review existing data bases; (3) determine major data gaps; (4) design BRASS to serve as the data source for a variety of decision support systems; and (5) conduct workshops to train LDC personnel in how to implement BRASS.

PRODUCT 222: EARLY-WARNING STRESS INDICATORS

To minimize the impact of agriculturally induced stress, farmers and policy-makers need diagnostic and predictive tools, information on the soil resiliency, and an understanding of the ameliorative practices appropriate for specific sites.

To address these needs on a global scale, the CRSP will organize an International Committee on Land Degradation (ICOMLAND) with the following charges: (1) improve procedures to assess land degradation at various scales (i.e., global, national, local); (2) evaluate and implement procedures for assessing land resiliency; (3) develop stress indicators that help to avert land degradation for use at all planning levels.

ICOMLAND will include of representatives from LDCs, developed-countries, IARCs, and the CRSPs. The focus will not be to document degradation, but rather to develop a variety of products capable of avoiding problems before they reach a critical stage. Products will include manuals, guidebooks, training packages, extension materials, computer models, and systems for managing data bases. Especially important will be the development of functional monitoring systems to evaluate specific properties that enhance or degrade soil health or exert an impact on soil productivity.

SUBTARGET 2.3 PRODUCTIVITY AND LAND-USE OPTIONS

Land-use research has traditionally been driven by a desire to increase agricultural productivity. Although that imperative is still vitally important, increased concern is being expressed over the environmental impact of agricultural practices. Unless producers and policy-makers have a reliable way of assessing what uses the land will support, they often end up destroying the environment and disseminating poverty. Because LDCs typically lack adequate resource assessment and monitoring systems, their environmental resources are particularly at risk.

A Framework for Sustainable Land Management can be a powerful tool for evaluating the long-term productivity of soil resources. It will provide a scientific basis for evaluating the environmental impact of proposed land-use changes, and it can be used for evaluating the consequences of projected global climate change.

PRODUCT 231: FRAMEWORK FOR SUSTAINABLE LAND MANAGEMENT (SLM)
The following frameworks, methods, and decision aids will be the foci for the Soil Management CRSP's product-development activities: (1) a functional framework for evaluating and using SLM; (2) rapid rural appraisals; (3) decision aids for different kinds of experts; and (4) a Framework for Evaluating Sustainable Land Management (FESLM), developed with international collaborators who will systematically review project outputs. FESLM will be capable of monitoring any land-management activity anywhere in the world.

Institutions who can contribute to FESLM include the SANREM CRSP, the International Board for Soil Research and Management (IBSRAM), Agriculture Canada, the Food and Agriculture Organization of the United Nations (FAO), the Indian Council of Agricultural Research (ICAR), and the Hungarian Academy of Agriculture. Using an international network, researchers will test FESLM in a variety of ecosystems. Preliminaries for this product have already been discussed at international workshops in Thailand (1991) and Canada (1993).

Target 3. Productivity and Economic Growth

Productivity on more than half of the world's arable land is limited by soil acidity, phosphorous and nitrogen deficiencies, water deficits, or a combination of these problems. Efforts to increase productivity invariably address several of these constraints. For example, overcoming soil acidity improves root growth and plant access to available soil water and nutrients, but favorable crop yields will not be achieved unless phosphorus and nitrogen are in adequate supply. Similarly, biological nitrogen fixation is a low-cost alternative to inorganic nitrogen fertilizers, but legume sensitivity to soil acidity may restrict farmers' ability to capitalize on this management practice.

Harvested crops remove large quantities of nutrients from the land, making soils progressively more acid and nutrient-poor unless remedial measures are implemented. This problem is often compounded by province- and nation-wide fertilization policies which fail to recognize that individual nutrients must each be applied at specific times, frequencies, and amounts. Centralized policies insensitive to these variables have helped to create, on the one hand, soils with continuing nutrient deficits and low productivity and, on the other hand, soils where excesses of phosphorus and nitrogen threaten to contaminate surface- and groundwater. As population increases, and pressure mounts on cultivated lands, many farmers are forced onto marginal lands with acid, infertile soils. Their nutrient problems must be corrected before crop production can be optimized. Enhanced productivity through improved nutrient and water management will help reduce land abandonment and deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands.

Subtarget 3.1 Amelioration of Acid Soils

Crop yields in acid soils are frequently reduced to 50% of optimum levels. Soil acidity destabilizes production by limiting root growth. It also limits the roots' ability to absorb essential nutrients and exacerbates the effects of stresses such as drought. In their attempts to minimize the risks of crop failure, subsistence-level farmers in LDCs are unable to capitalize on high-yielding varieties, which are often more vulnerable to such stresses.

As population increases, more marginal lands with acid soils are being cultivated. If the soil acidity problem is not properly managed, the environmental consequences are a foregone conclusion: land abandonment and further deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands.

Product 311: Acidity Decision Support System

ADSS is a computerized knowledge-based decision aid to (1) diagnose soil acidity problems, (2) recommend a range of practical management alternatives for different crops and locally available ameliorants, and (3) provide reliable estimates of the economic consequences of the proposed remedial practices. The complexity of the soil acidity syndrome results from numerous combinations of calcium deficiency and excesses of toxic aluminum, hydrogen, and manganese.

An ADSS prototype has been developed by the CRSP for managing aluminum toxicity problems. It provides the conceptual framework for building a tool which addresses the combination of factors that contribute to the soil acidity syndrome. Future activities seek information necessary to optimize economic returns on land, labor, and inputs through a more precise match of crops and their ameliorant requirements. Diagnosis and recommendations for soil acidity problems in the final product will be based on information synthesized from the most recent literature, including the ameliorative and detrimental effects of organic amendments. Subroutines will be developed for evaluating and correcting non-aluminum-based toxicity. Algorithms will be developed to estimate the calcium required to counteract aluminum and hydrogen toxicity to root growth. Recently developed ion transport models will be used to improve predictions on alleviating subsoil acidity. Software and user guides have been prepared in English and Bahasa Indonesian; they will be prepared in Spanish and French.

Subtarget 3.2 Integrated Nutrient and Water Management

Plants depend on the soil for nutrients and water, the use of which is closely interrelated. The nutrients that most frequently limit plant growth are phosphorus and nitrogen. The Soil Management CRSP will complete its decision aids on individual components (i.e., phosphorus, nitrogen, and water) and then work to develop a single integrated system to guide on-farm management practices.

PRODUCT 321: PHOSPHORUS DECISION SUPPORT SYSTEM (PDSS)
PDSS is a computerized knowledge-based decision aid to (1) diagnose site-specific deficiencies and excesses and (2) recommend remedial management practices (including fertilizer quantities and materials) based on crop type, economic conditions, and management goals.

PDSS allows users to diagnose P deficiencies or excesses from available information. The system helps users relate results and experiences in one region to those in another region, a vexing problem that current P-management schemes often fail to solve. The final product will contain an extensive list of critical P levels for various crops and soil-test methods. Algorithms need to be refined for reliable conversion of data from volume to weight measurements and for use of clay percentages as a proxy for colloid surface area. Existing methods of predicting P buffer coefficients and residual P availability will be validated in both calcareous and acid soils. Criteria will be developed for assessing optimal levels of mycorrhizae for efficient use of P and for determining site conditions where rock phosphate would be economically productive.

PRODUCT 322: NITROGEN DECISION SUPPORT SYSTEM (NDSS)
NDSS is a computerized knowledge-based decision aid to (1) diagnose soil deficiencies and excesses, (2) prescribe when and how fertilizer N should be applied, and (3) estimate the economic consequences of proposed remedial practices. The prototype will be a computer program developed by a CRSP institution for use with maize in temperate regions. NDSS will be able to evaluate N requirements across soil types and climatic regions for various crops and rotations, with a proper accounting of the N supplied as fertilizer or as green and animal manures. Refinements to the existing prototype include calibration for crops other than maize, an improved economic module, estimates of soil N retained in subsurface layers by anion exchange capacity, and algorithms to evaluate the consequences of interactions between inorganic N and BNF.

PRODUCT 323: BIOLOGICAL NITROGEN FIXATION (BNF) TECHNOLOGIES
BNF technologies will (1) increase farmer access to superior legume symbionts and other inoculants, (2) improve legume and microbe performance under stress conditions, and (3) conserve N derived from biological sources.

Technologies are currently hampered by a lack of understanding about the synergistic influences which non-N management components can have on N acquired by biological fixation. Effective extension of BNF products requires reliable cost-effective inoculant quality-control, production, and delivery systems.

CRSP tools will help evaluate financial and marketing requirements for inoculant production facilities under different stress environments. Industry and research institutes will be provided with selected and genetically improved microbial germ plasm. Knowledge on cycling and conserving BNF-derived N in ecosystems and legume food/cash cropping systems will be organized into user-friendly decision aids.

Product 324: Water-use Enhancement Decision Aids

This product will provide guides for the design, construction, and use of water-harvesting systems—including catchment basins and conveyance, storage, and distribution components. The product will account for differences in landscape and agroecological conditions.

Product development entails integrating knowledge of rainfall probability and distribution with information on crop requirements, use efficiency, and soil water storage. Site-specific data requirements need to be defined for each water-harvesting system. Construction and maintenance-cost data will be compiled on different systems to determine the economic advantage required for farmer acceptance.

Mode of Collaboration for Target-3 Products

Software will be designed in close collaboration with product developers from other Soil Management CRSP target areas to insure compatibility among systems and the development of a common soil and climate data base. Information synthesis, product design, field validation, and product testing will be done in collaboration with scientists from NARCs and IARCs, representatives of relevant agribusiness sectors, and regional research networks supported by the Potash and Phosphate Institute. Product-development teams will seek the participation of scientists from the Bean/Cowpea CRSP, the Peanut CRSP, and the Sorghum-Millet CRSP to determine cultivar differences in nutrient requirements and tolerance to soil acidity and water stresses. Collaborative activities will include (1) workshops/symposia to compile state-of-the-art knowledge on product-related topics and (2) field tests and validation of products at benchmark sites representing the global range of ecosystem characteristics and socioeconomic conditions.

Program-Wide Focus

Outreach Program

Purpose

Unused or irrelevant tools have no impact. To achieve its goals and objectives, the CRSP must develop products that respond to the demands and needs of LDC users. In addition, the CRSP must promote these products and demonstrate their use in site-specific situations.

To this end, the CRSP will implement an Outreach Program that involves LDCs and other intended users of its products in *all phases* of product development, testing, and promotion. In addition to encouraging the use of indigenous knowledge, broad participation of this sort will assure that products respond to local needs and values.

The Outreach Program will focus on four primary areas: Policy and Decision Making, Human Resource Development and Communications, Product

Development and Impact Assessment, and Technical Assistance and Market Development.

Tasks

Policy and Decision Making

- Establish an integrated capacity for responding to requests from USAID bureaus, field missions, and related groups; devote particular attention to program-planning and assessment matters, policy reviews, and other multi-disciplinary field activities.
- Promote the application of soil-management products to enhance policy formulation and implementation relevant to economic productivity and environmental security.

Human Resource Development and Communications

- Disseminate products to clients, provide follow-up technical assistance, and refine/adapt products to meet client needs.
- Conduct educational programs that target specific user groups within the public and private sector.
- Develop an international information network that promotes CRSP products among potential implementors and beneficiaries.
- Strengthen CRSP collaborative activities to make product development more cost-effective.
- Coordinate the development of educational and training materials.

Product Development

- Identify client needs and relevant indigenous knowledge in order to guide product design, development, and dissemination.
- Adapt existing CRSP products to client needs.
- Incorporate decision support systems and other products into communications, training, and technical-assistance efforts.
- Enhance private-sector participation in implementing improved soil-management practices.

Technical Assistance and Market Development

- Promote CRSP products and programs through national and international media, in-house publications, and market promotion material.

Leadership

Outreach efforts will be led by a full-time program leader(s). Product-development teams will also serve an important role in the Outreach Program.

The responsibilities of the outreach leader(s) will include coordinating all outreach tasks; promoting the use of CRSP products; identifying specific high-priority, high-payoff activities; responding to requests from the public and private sector; serving as a liaison between the Management Entity (ME) and USAID missions and bureaus; serving as a liaison between the ME and product-development teams; arranging and coordinating workshops, training sessions, and other means of demonstrating the potential benefits of CRSP products; assessing the strengths and weaknesses of existing products for product-development teams; and outlining essential product modifications for development teams.

Product-development team members will provide technical support to the outreach leader(s). They will play key roles in workshops, training sessions, and other activities where the products are being explained and demonstrated. They will work with the outreach leader to insure that products respond to user demands and can be readily applied.

Field Support to USAID Missions

Purpose

The Soil Management CRSP is designed to serve U.S. foreign-policy objectives by identifying land-management problems that impede economic growth, developing products to solves these problems, and working with USAID missions and other clientele groups with parallel interests. The refocussed CRSP will give particular attention to USAID's sustainable-development goals as they relate to economic growth and environmental protection. The kinds of field support the CRSP can provide are detailed below.

1. Support to Bilateral Programs

The CRSP can assist bilateral programs (i.e., between USAID missions and host countries) that require technical support on programs and policy issues involving land use, environmental protection, and natural-resource management. The CRSP is currently providing such field support to an alternative-crops project in Bolivia, a land-management project in Honduras, a natural-resource project in Niger, and a watershed-development project in Guinea.

2. Technical Backstopping

The CRSP can respond to a variety of mission and host-country requests for technical backstopping on land-management issues. Such services are already being provided through the Latin American RISTROP Network. The CRSP has also responded to short-term requests for specialized technical backstopping in Kenya and El Salvador.

3. Workshop Support

By helping to forge a unified approach to complex issues, information-exchange workshops provide an effective means of addressing local and multinational problems. These workshops can also strengthen diplomatic relationships and help to establish international networks capable of producing long-term economic and environmental benefits. The Soil Management CRSP can provide technical and organizational leadership for national and international workshops selected and developed in collaboration with USAID missions and host-country institutions.

4. *Training Activities*

As long as developing countries depend on imported technologies, economic productivity will suffer. The Soil Management CRSP has long recognized that investments in human skills and capacities are essential for societies seeking to sustain economic growth and improve the quality of life. To date, more than 100 developing-country students have earned advanced degrees in the CRSP's collaborative training program. In addition, more than 5,000 trainees have benefited from the CRSP's short-term programs. The extended CRSP will continue this academic and on-the-job training support.

5. *Clientele Services*

USAID's clients are also the Soil Management CRSP's clients. Because land-use policies and practices are critical to achieving the missions' goals on environmental and economic issues, input from a broad range of interest groups is essential. CRSP technologies and experience in managing soil resources can be valuable assets to USAID and its clients. For example, maximizing nitrogen fixation by legumes requires the presence of the specific microorganisms; frequently, seed must be inoculated, a process which requires precise technologies for producing and preserving inoculants. The CRSP has developed such technologies and provided them to private-sector producers and distributors. As inoculants become more readily available, farmers benefit, and USAID goals are thus achieved.

Impact Assessment

The refocussed CRSP will produce tools to solve the real-world problems facing a range of users—from policy-makers to farmers to ranchers. The product-development scientists, outreach leaders, and administrative support teams all recognize that the success of their efforts will be measured in terms of the program's impact on the immediate and long-term needs of LDCs.

Because the CRSP's tools are designed to address site-specific problems, their impacts can be readily identified. Detailed operational plans for developing each product will describe the specific problems to which the tool can be applied, the means by which the tool can help solve those problems, and the criteria by which the tool can be evaluated.

Individual programs will be structured to provide affirmative answers to these kinds of questions:

- Will the product address the technical, social, and economic needs of local people as they define those needs?
- Has indigenous knowledge been used to specify and prioritize the kinds of problem-solving tools that are developed?
- Will adaptation of the products enable developing countries to build capacities for permanently improving their quality of life?
- Will the products serve USAID-supported expatriate and indigenous PVOs and NGOs?
- Will the products enable users to improve soil productivity, decrease soil erosion and degradation, rejuvenate degraded lands, and protect the environment?
- Will the products help formulate policies and support institutions that must implement natural-resource safeguards?

Participants

Personnel

All those who implement the extended CRSP must support its basic objectives. In particular, they must be willing (1) to participate in multi-institutional teams and (2) to develop problem-solving tools. Autonomous, single-institution projects will not be funded, nor will projects unrelated to the development of a prioritized product.

Outreach Leaders and Product-Development Coordinators will oversee broad program areas. Task Leaders will be responsible for individual components of the product-development and outreach efforts. Responsibilities for these various positions are discussed in greater detail under *Administration and Management* (pages 127–128).

Those involved in preparing the *Basic Work Plan* will be the primary resource for determining the technical component of the product-development plans. Additional personnel will be added to address socioeconomic issues. Host-country and other collaborative-institution personnel will be added as details of the *Implementation Plan* emerge.

Participants in the development of the *Basic Work Plan* are as follows:

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TARGET 3. PRODUCTIVITY AND ECONOMIC GROWTH

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Russell Yost, University of Hawaii

Institutions

The primary institutions expected to be involved in the program's initial phase are as follows:

U.S. UNIVERSITIES/ INSTITUTIONS

Cornell University
North Carolina State University
Texas A&M University
the University of Hawaii
the Nitrogen Fixation by Tropical Agricultural Legumes Center

U.S. AGENCIES

USDA, Agricultural Research Service
USDA, Economic Service
USDA, Soil Conservation Service

HOST COUNTRIES

Bolivia
Burkina Faso
Ghana
Honduras
Jamaica
Indonesia
Mali
Niger
the Philippines.

INTERNATIONAL AGRICULTURAL RESEARCH CENTERS

CIAT
CIMMYT
ICRISAT
IITA
IRRI
IBSRAM

COLLABORATIVE RESEARCH SUPPORT PROGRAMS (CRSPs)

SANREM
Sorghum/Millet
Peanut
Bean/Cowpea.

Budget

The objective of the Basic Work Plan was to develop a comprehensive program that focused on high-priority land-management problems. The Basic Work Plan also sought to identify the demand and need for particular tools to solve these problems for site-specific situations. The underlying assumption was that funding would be available in amounts approximating FY93 allocations.

USAID has requested that priorities be established and budgets developed based on 80%, 70%, and 60% of FY93 allocations. The priority grouping of products in Table 4 served as the basis for developing these budgets.

In Tables 5–12, budget details are provided for the three funding levels: Requested (80%), Alternative A (70%), and Alternative B (60%). The data in each table are as follows:

- Table 5. Projected first-year activity budget for three USAID funding levels.
- Table 6. Projected first- and five-year USAID funded object budgets for three funding levels.
- Table 7. Projected first-year activity budget for multiple sources of funding.[§]
- Table 8. Projected first- and five-year activity budgets for all levels and sources of funding.[§]
- Table 9. Projected first-year object budget for Product Research and Development at three USAID funding levels.
- Table 10. Projected first-year object budget for the Outreach Program at three USAID funding levels.
- Table 11. Projected first-year object budget for Field Support to USAID missions at three USAID funding levels.
- Table 12. Projected first-year object budget for the Management Office at three USAID funding levels.

[§] Details on the methods for estimating non-USAID financial support are given in Appendix VI.

Table 5. Projected first- year activity budget at three USAID funding levels.

Activity	Funding levels: Requested Program	Alternative A	Alternative B
	Dollars		
Product development	2,080,000	1,760,000	1,440,000
Outreach	763,000	751,000	742,000
Field support to missions	350,000	250,000	150,000
Administration	283,000	272,000	267,000
Contingency	150,000	150,000	100,000
Total	3,626,000	3,183,000	2,699,000

Table 6. Projected first- and five-year USAID-funded object budgets for three funding levels.

Object	FY95	FY95–99*
	Dollars	
REQUESTED PROGRAM		
Salaries	1,196,000	7,296,000
Benefits	299,000	1,824,000
Travel	403,000	2,458,000
Supplies/Equipment	306,000	1,867,000
Other Direct Costs	288,000	1,757,000
Indirect Costs	984,000	6,002,000
Contingency	150,000	915,000
Total	3,626,000	19,317,000
ALTERNATIVE A		
Salaries	1,028,000	6,271,000
Benefits	257,000	1,568,000
Travel	362,000	2,208,000
Supplies/Equipment	270,000	1,647,000
Other Direct Costs	258,000	1,574,000
Indirect Costs	858,000	5,233,000
Contingency	150,000	915,000
Total	3,183,000	19,416,000
ALTERNATIVE B		
Salaries	884,000	5,392,000
Benefits	221,000	1,348,000
Travel	302,000	1,842,000
Supplies/Equipment	234,000	1,427,000
Other Direct Costs	223,000	1,360,000
Indirect Costs	735,000	4,485,000
Contingency	100,000	610,000
Total	2,699,000	16,464,000

* Includes 5% annual inflation rate.

Table 7. Projected first-year activity budget for multiple sources of funding. Details on methods for estimating non-USAID budget are given in Appendix VI.

Activity	Budget				
	USAID	Cost Sharing	Host Country	External	Total
REQUESTED PROGRAM					
Product Research and Development					
Conservation and Environmental Protection	640,000	160,000	459,000	128,000	1,387,000
Land Resource Quality	720,000	180,000	702,000	144,000	1,746,000
Productivity and Economic Growth	720,000	180,000	459,000	144,000	1,503,000
Subtotal	2,080,000	520,000	1,620,000	416,000	4,636,000
Outreach	763,000	190,000	235,000	153,000	1,341,000
Field Support to USAID Missions	350,000	88,000	0	70,000	508,000
Administration	283,000	0	0	0	283,000
Contingency	150,000	38,000	0	30,000	218,000
Total	3,626,000	836,000	1,855,000	669,000	6,986,000
ALTERNATIVE A					
Product Research and Development					
Conservation and Environmental Protection	640,000	160,000	459,000	128,000	1,387,000
Land Resource Quality	400,000	100,000	438,000	80,000	1,018,000
Productivity and Economic Growth	720,000	180,000	459,000	144,000	1,503,000
Subtotal	1,760,000	440,000	1,356,000	352,000	3,908,000
Outreach	751,000	188,000	725,000	150,000	1,814,000
Field Support to USAID Missions	250,000	63,000	0	50,000	363,000
Administration	272,000	0	0	0	272,000
Contingency	150,000	38,000	0	30,000	218,000
Total	3,183,000	729,000	2,081,000	582,000	6,575,000
ALTERNATIVE B					
Product Research and Development					
Conservation and Environmental Protection	520,000	130,000	330,000	104,000	1,084,000
Land Resource Quality	400,000	100,000	396,000	80,000	976,000
Productivity and Economic Growth	520,000	130,000	354,000	104,000	1,108,000
Subtotal	1,440,000	360,000	1,080,000	288,000	3,168,000
Outreach	742,000	186,000	717,000	148,000	1,793,000
Field Support to USAID Missions	150,000	38,000	0	30,000	218,000
Administration	267,000	0	0	0	267,000
Contingency	100,000	25,000	0	20,000	145,000
Total	2,699,000	609,000	1,797,000	486,000	5,591,000

Table 8. Projected first- and five-year activity budgets for all levels and sources of funding. Details on methods for estimating non-USAID budget are given in Appendix VI.

Activity	FY95 USAID	FY95 Other	FY95 Total	FY95–99 USAID	FY95–99 Other	FY95–99 Total
	Dollars					
REQUESTED PROGRAM						
Product Development	2,080,000	2,556,000	4,636,000	12,688,000	15,592,000	28,280,000
Outreach	763,000	578,000	1,341,000	4,654,000	3,526,000	8,180,000
Field Support to USAID Missions	350,000	158,000	508,000	2,135,000	964,000	3,099,000
Administration	283,000	0	283,000	1,726,000	0	1,726,000
Contingency	150,000	68,000	218,000	916,000	414,000	1,330,000
Total	3,626,000	3,360,000	6,986,000	22,119,000	20,496,000	42,615,000
ALTERNATIVE A						
Product Development	1,760,000	2,148,000	3,908,000	10,736,000	13,103,000	23,839,000
Outreach	751,000	1,063,000	1,814,000	4,581,000	6,484,000	11,065,000
Field Support to USAID Missions	250,000	113,000	363,000	1,525,000	689,000	2,214,000
Administration	272,000	0	272,000	1,659,000	0	1,659,000
Contingency	150,000	68,000	218,000	915,000	414,000	1,329,000
Total	3,183,000	3,392,000	6,575,000	19,416,000	20,690,000	40,106,000
ALTERNATIVE B						
Product Development	1,440,000	1,728,000	3,168,000	8,784,000	10,541,000	19,325,000
Outreach	742,000	1,051,000	1,793,000	4,526,000	6,411,000	10,937,000
Field Support to USAID Missions	150,000	68,000	218,000	915,000	415,000	1,330,000
Administration	267,000	00	267,000	1,629,000	0	1,629,000
Contingency	100,000	45,000	145,000	610,000	274,000	884,000
Total	2,699,000	2,892,000	5,591,000	16,464,000	17,641,000	34,105,000

Table 9. Projected first-year object budget for Product Research and Development at three USAID funding levels.

Object	Requested	Alternative A	Alternative B
	Dollars		
Salaries	780,000	660,000	540,000
Benefits	195,000	165,000	135,000
Travel, international	130,000	110,000	90,000
Travel, national	52,000	44,000	36,000
Equipment/supplies	221,000	187,000	153,000
Other direct costs	117,000	99,000	81,000
Indirect costs	585,000	495,000	405,000
Total	2,080,000	1,760,000	1,440,000

Table 10. Projected first-year object budget for the Outreach Program at three USAID funding levels.

Object	Requested	Alternative A	Alternative B
	Dollars		
OPERATIONS			
Salaries[1]	165,000	165,000	165,000
Benefits	41,000	41,000	41,000
Travel, international	30,000	30,000	30,000
Travel, national	10,000	10,000	10,000
Workshops	25,000	25,000	25,000
Equipment/supplies	15,000	15,000	15,000
Other direct costs	10,000	10,000	10,000
Indirect costs	118,000	118,000	118,000
Subtotal	414,000	414,000	414,000
PRODUCT RESEARCH AND DEVELOPMENT PARTICIPATION			
Travel, international	50,000	50,000	50,000
Travel, national	10,000	10,000	10,000
Workshops	25,000	25,000	25,000
Equipment/supplies	50,000	50,000	50,000
Other direct costs	20,000	20,000	20,000
Indirect costs	62,000	62,000	62,000
Subtotal	217,000	217,000	217,000
COMMUNICATIONS			
Salaries[§]	40,000	40,000	40,000
Benefits	10,000	10,000	10,000
Travel, national	4,000	4,000	4,000
Printing	25,000	20,000	15,000
Equipment/supplies	8,000	7,000	6,000
Other direct costs	7,000	6,000	5,000
Indirect costs	38,000	33,000	31,000
Subtotal	132,000	120,000	111,000
Grand Total	763,000	751,000	742,000

[1] 2 FTE—Technical, 1 FTE—Staff; [§] 1 FTE—Professional

Table 11. Projected first-year object budget for Field Support to USAID Missions at three USAID funding levels.

	Funding levels[1]		
Object	Requested	Alternative A	Alternative B
	Dollars		
Salaries[1]	96,000	48,000	24,000
Benefits	24,000	12,000	6,000
Travel, international	84,000	78,000	48,000
Travel, national	6,000	5,000	4,000
Equipment/supplies	0	0	0
Other direct costs	40,000	35,000	25,000
Indirect costs	100,000	72,000	43,000
Total	350,000	250,000	150,000

[1] Includes salary release, consulting, special hire.

Table 12. Projected first-year object budget for the Management Office at three USAID funding levels.

	Funding levels[1]		
Object	Requested	Alternative A	Alternative B
	Dollars		
Salaries[1]	115,000	115,000	115,000
Benefits	29,000	29,000	29,000
Travel, international	20,000	15,000	15,000
Travel, national	7,000	6,000	5,000
Equipment/supplies	12,000	11,000	10,000
Other direct costs	10,000	9,000	8,000
Board of Directors[§]	6,000	6,000	6,000
External Evaluation Panel[§]	3,000	3,000	3,000
Indirect costs	81,000	78,000	76,000
Total	283,000	272,000	267,000

[1] 1 FTE Director, 1 FTE Administrative Assistant

[§] 1 meeting

Administration and Management

The refocussed Soil Management CRSP will be administered and managed in accordance with the established structure for Collaborative Research Support Programs.

A *Management Entity* (ME) will be responsible for receiving funds from USAID and distributing those funds for program support; the ME will be legally accountable to USAID for the CRSP's programs and finances. *USAID* will play a critical role, guiding the CRSP mandate and acting as a liaison with regional bureaus and overseas missions. A *Board of Directors* will provide guidance on policy and financial issues. An *External Evaluation Panel* (EEP) will assess funding proposals and program performance.

The ME is North Carolina State University. It will maintain a management office led by a director and staffed by such additional personnel as necessary to fulfill its responsibilities.

USAID program officers will help guide CRSP initiatives, identify service opportunities, and clarify matters of protocol.

The current Board of Directors consists of eight members representing USDA (1), universities (2), outside agencies (4), and USAID (1). This configuration was established during a January 27–28, 1993, meeting of representatives from all participating CRSP institutions. Specifics on tenure, functional responsibilities, meeting schedules, and other operational matters are being developed.

EEP members will represent the various scientific disciplines pertinent to the CRSP's focus and success. They will have relevant technical and administrative experience, as well as the time and ability to evaluate detailed performance criteria and technical and financial proposals. The EEP will perform a crucial quality-control function, making evaluations and recommendations that will enable funds to be directed toward productive high-priority problems and programs. To enhance objectivity, EEP members will not be affiliated with any institution participating in the CRSP.

As targets and products have been identified, a general format for the program's technical leadership has evolved. Product development will involve Outreach Program Leaders and multi-institutional teams of scientists; each team will be coordinated by an elected participant. *Product-development coordinators* will moderate meetings to identify products, determine the tasks necessary to

produce these products, assign responsibilities for specific tasks, and evaluate progress. In addition, coordinators will monitor product-development activities and work with participants to make the modifications and adjustments necessary to produce tools that respond to the expressed needs of target audiences. Coordinators will also work with Outreach Program leaders to promote product use.

The *Outreach Program Leader(s)* will be responsible for (a) working with user groups to determine product needs and promote product application at the location-specific level and (b) serving as a liaison between the ME and team scientists, as well as among product-development teams, USAID missions, and host-country collaborators. They will also be responsible for coordinating activities among the various product-development teams to insure that outputs adequately address targeted problems.

Although the basic administrative/management framework and operational strategy are in place, refinements may evolve as the refocussed CRSP addresses specific targets. Such refinements will be determined by their ability to help the CRSP shift from an information-generating focus to a problem-solving focus, from an open-ended grant to a product-focussed cooperative program, and from a group of projects directed by individuals to a group of tasks planned and undertaken by teams. Because many of the contingencies that will affect these transitions are impossible to foretell, the refocussed CRSP has built a degree of flexibility into a carefully structured framework so that administrators, managers, and those involved with day-to-day operational matters can establish guidelines and procedures most conducive to the program's overall success.

Soil Management CRSP Logical Frame

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
Goal: To help growing populations manage their land resources in a way that meets their present needs and aspirations while also protecting the soil and water resources upon which future generations will depend.	1. Developing nations adopt the world soil charter or world soil policy, or similar global soil resources and/or environmental proclamation(s) into their national policies. 2. Developing countries implement policies for sustainable soil and water management. 3. USAID mission and donor funded workshops, strategy meetings and project-related activities.	1. Review of land management and environmental preservation policies, and research agendas of developing nations that are and have participated with the CRSP. 2. Review of government, mission and project reports. 3. Network collaborator site and IARC visits. 4. Review of national policy, advisory systems, and user groups' employment of CRSP products.	(Goal to Supergoal) 1. Developing nations are committed to policies for increasing production of basic needs, decreasing soil degradation, improving economic growth and protecting the environment. 2. The U.S. and other donors are committed to implementing the 27 principles from the Rio Declaration on Environment and Development referred to as "Agenda 21."
Purpose: 1. Soil, nutrient, water, and associated resource management technologies for economic growth and environmental protection.	1. Developing nations' institutions adopt practices and formulate policies which enhance the acceptance of new technologies and use of problem-solving tools. 2. Global requests for CRSP products, technical publications, planning documents, workshop and symposium proceedings. 3. Network collaborators actively engaged in priority target research, decision support systems validation and requisite inputs. 4. Proceedings of international workshops, symposium and planning sessions, and regional training courses published.	1. CRSP annual Work Plans and Budgets, quarterly and annual Executive Summary reports, and technical publications. 2. External Evaluation Panel reports and evaluations completed by USAID. 3. Special surveys and impact studies targeted by the CRSP program coordinators and ME Director. 4. Field activities in progress targeted on CRSP product development areas.	(Purpose to Goal) 1. Developing nations implement policies and programs to improve economic growth, protect the environment and equitably manage of their land resources. 2. Sustainable USAID funding support, USAID Mission support, and other donor support; all adequate to sustain the activities of the CRSP, Collaborators, PVOs, NGOs and other ocperators.
Outputs: 1. Restructuring of the administrative, policy, management and evaluation entities of the CRSP is completed. 2. Product-oriented research and development teams formed, coordinators elected, detailed plans of work prepared and implemented. 3. Research, outreach and impact assessment networks	1. Roles of the CRSP administrative, policy, management and evaluation entities are functioning, by-laws accepted and procedures in place. 2. Intra-institutional collaborative research and development activities under leadership of program coordinators driving the CRSP program.	1. CRSP by-laws and procedural manual. 2. External Evaluation Panel annual reviews of CRSP work plans & budgets, and annual progress reports. 3. CRSP PRODUCTS: - Technical publications - Revised Acid Decision Support System - Phosphorus Decision	(Output to Purpose) 1. Developing nations maintain sufficient interest to participate in preparing program agendas, complete tasks, develop and utilize products. 2. Experienced program coordinators, scientists, collaborators and policy makers remain in position to continue program implementation on use of CRSP products.

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
with NARS, IARCs, NGOs, PVOs and other collaborators organized. 4. CRSP by-laws revised and new policy and procedures manual written, approved and implemented. 5. Research and outreach activities on soil acidity amelioration, nitrogen management and integrated nutrient and water management for increased productivity and economic growth refocused and continued. 6. Research and outreach activities on erosion control, soil rejuvenation and water use for conservation and environmental protection implemented with collaborators. 7. Collaboration in developing land quality indicators, land use options, and soil and environmental data bases is strenghten. 8. Collaborating insititution and other scientists trained with CRSP products.	3. International network of database suppliers is established. 4. Computer based decision support systems developed for validation and marketing. 5. Systems level resource management evaluation framework that can predict on- and off- site impacts of soil and water conservation interventions on network watersheds. 6. External Evaluation Panel annual reviews of CRSP Work Plans & Budgets, and Annual Progress Reports. 7. Regionally relevant educational aids available and distributed to various user groups. 8. Level of CRSP contribution to the international working groups focusing on soil and water resource management and environmental protection. 9. Number who benefited from short-term and degree training.	Support System - Sustainable land management evaluation framework - Soil degradation early-warning indicators - Nitrogen Decision Support System - Special soils maps 4. Mailing lists of CRSP bimonthly NewsWire and responses for CRSP publications. 5. TDY reports, USAID cables, country reports. 6. Proceedings of meetings, copies of special baseline and data-collection activities. 7. Summaries of training activities and reports.	3. Funds dedicated to USAID Mission field support will increase buy-in for CRSP services and capabilities. 4. Baseline and state-of-the-art studies lead to capabilities to obtain outside cooperation and funding. 5. Cooperation among researchers, Board support for program remains strong and information is shared. 6. Outreach activities result in more use of CRSP products and increased donor support for their development. 7. Products developed and training for product utilization have the anticipated and desired level of impact that can be quantified.
Activities: 1. Meetings to complete entities restructuring agreement. 2. Workshops to plan programs, complete detailed plans and elect coordinators. 3. Organize and implement program network activities. 4.1 The CRSP program administration and procedures manual prepared and implemented. 4.2 CRSP By-laws written approved and implemented. 5. Productivity and economic growth programs 5.1. Acidity Decision Support System updated	Inputs/Resources: 1. Project Budget (Million $) I. R & D Activities Prod./Econ. growth 4.392 Cons/Envir. Prot. 3.904 Land Resc. Qual. 4.392 II. Outresch 4.654 III. Mission Supp. 2.135 IV. Adm. 1.726 V. Cont. 0.916 TOTAL 22.119 2. Participating universities will contribute 25% matching under standard provisions regulations and BIFADEC guidelines. 3. Developing countries are expected to provide collaborative support equal	1. CRSP allocation of resources and monthly finacncial status reports. 2. Minutes from Board of Directors meetings and other excutive decision processes. 3. Network and team planning documents and distribution records. 4. Minutes from the Institutional Council. 5. Training-session records, scientists trained and located, and scientists in training. 6. Quarterly reports, External Evaluation Panel reports, progress reports, peer reports, travel reports.	(Activity to Output) 1. The CRSP administrative, policy, management and evaluation needs have been properly articulated. 2. Constraints have been properly identified and analyzed as researchable problems; tasks will produce the needed and usable products. 3. Strong team product development focus is achieved and maintained among the CRSP and collaborating scientists. 4. Funding is continuous and at a adequate level. 5. International scientists conducting soil management resesrch participate in the networking.

Narrative Summary (NS)	Measureable Indicators (OVI)	Means of Verification (MOV)	Important Assumptions
and outreach intensified. 5.2. Phosphorus Decision Support System development. 5.3. Nitrogen Decision Support System Research. 5.4. BNF research and development. 5.5. Water use research and data collection. 6. Conservation and environmental protection. 6.1. Water and wind erosion research. 6.2. Research watersheds establishments. 6.3. Landscape based soil rejuvenation research. 6.4. Biological soil rejuvenation research. 7. Land Resource Quality. 7.1. Land quality verification. 7.2. Land biophysical appraisal development. 7.3. Stress indicators research. 7.4. Sustainable land management parameters. 8. Training activities. 8.1. Graduate degree training. 8.2. Short-term participant training.	to $11.316 million. 4. Expected external funding of about $4.081 million through buy-ins and outside grants. 5. External Evaluation Panel to guide the program balance and the management of the CRSP. 6. CRSP Board of Directors 7. CRSP Institutional Ccuncil. 8. CRSP Management Entity Office Director and support staff. 9. Communications component to support outreach and product development. 10. Human resources dedicated from CRSP insitutions, NARS, IARCs and other collaborators.	6. Annual budget summaries submitted with work plans. 7. Report from the in-depth evaluation of CRSP activities and resource utilization by External Evaluation or other nonpartisan panel. 8. Report of the review of the Management Enitity Institutions and Management office.	6. Capacity of some host countries to participate in landscape/watershed level of research. 7. Data bases can be shared across national boundaries. 8. Qualified rsearchers available for advanced training.

4.
Scope of Work

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Scope of Work

NOTE ON THE SCOPE OF WORK: *USAID advised the Soil Management CRSP to submit a Proposal for Extension for three funding levels: 80%, 70%, and 60% of FY93 allocations. The three programs are referred to hereafter as the* Recommended Program *(80%),* Alternative A *(70%), and* Alternative B *(60%).*

All three programs are based on the same fundamental concepts: they focus on land-management problems that impede economic growth and environmental quality; they develop tools to solve these problems; they promote the use of these tools through an aggressive Outreach Program; and they provide field support to USAID missions.

The programs differ only in activity level. To avoid redundancy, the Scope of Work for the Recommended Program *will be described in detail, and* Alternatives A *and* B *will be described in terms of what has been omitted from the* Recommended Program.

During 13 years of collaboration with NARCs, IARCs, and USAID missions, the CRSP has increased the land-management knowledge base and developed a broad range of human resources. These efforts have reshaped our understanding of soils and created a global network of soil-management expertise. They also provide the foundation for an innovative program to develop and promote problem-solving tools.

In the *Proposal for Extension,* the Soil Management addresses USAID's prerequisites and presents a restructured organization and a refocussed emphasis. Rather than working as individual institutions to expand the knowledge base, the CRSP will now establish multi-institutional teams of scientists to develop problem-solving tools. This change reflects a widely recognized reality: our understanding of soil and water systems has improved dramatically over the last 13 years, and as a result, our principal challenge has become using what we know to solve basic soil-management problems. The essential features of the program follow.

Objective

To achieve sustainable increases in soil and water resource productivity so that developing countries can satisfy their needs and aspirations, improve their economic well-being, enhance the natural-resource base, and improve environmental quality.

Goal
Land users employ soil and water management tools that improve food security and enhance economic productivity.

Outputs
The CRSP will generate products (i.e., tools) for diagnosing and solving specific problems in ways that increase soil and water resource productivity, promote economic growth, and enhance environmental quality.

Beneficiaries
The CRSP will work with technology-adoption personnel to reach the initial beneficiaries of its products—farmers. In addition, benefits will accrue to all those who depend on the land for food, fuel, fiber, and construction materials (i.e., society as a whole). By safeguarding the land, a nonrenewable resource, the CRSP's products will also protect the interests of future generations.

Program Strategy
CRSP programs will be conducted by multi-institutional teams rather than by individual institutions. Teams activities will be led by program coordinators and outreach leaders; together, they will be responsible for assuring that products meet client needs and improve land-management practices.

Target problems will be identified with LDC collaborators, USAID field missions, PVOs, NGOs, and IARCs. Once problem-solving tools have been developed, an Outreach Program will explain and promote their use to LDC users and other clientele. The CRSP will provide field support to USAID missions on land-management issues and encourage the use of problem-solving tools in missions' bilateral programs.

Program Structure
The program is organized around three basic components:

1. Developing problem-solving tools (i.e., products)
2. Promoting the use of those tools
3. Providing field support to USAID missions.

Details concerning each of these components are presented below.

1. Product Research and Development
Problem-solving tools will be developed through a process involving targets, products, and tasks.

Targets are problem areas with a high potential for being reduced by CRSP programs and for producing significant beneficial impacts on soil-management practices once they are reduced. Each target will have a technical, a socioeconomic, and an outreach component.

Products are knowledge-based tools that enable users to diagnose and solve problems, as well as to monitor changes. Product attributes will vary depending on the nature of the problem, the magnitude of the information gaps, and the targeted users. All products will have a global dimension and thus be applicable wherever the targeted problem occurs. Moreover, each product will provide guidance for use at a location-specific level. Products will be developed by multi-institutional teams.

Tasks are activities leading to the development of a product. They may range from summarizing and integrating published and unpublished literature, to conducting applied field experiments, to undertaking basic research. The specifics will depend on what activities are required to produce a reliable product.

A series of workshops involving more than 35 participants were held to identify the major problem areas that should be targeted and the products needed to solve those problems (details are provided elsewhere in this proposal). Table A lists the products selected for inclusion in the prioritized programs.

Table A. Products included in the Soil Management CRSP's *Recommended Program*—in order of ranking by a 12-member committee.[5]

1. Phosphorus Decision Support System
2. Acidity Decision Support System
3. Framework for Land Quality Evaluation
4. Nitrogen Decision Support System
5. BNF Technologies
6. Biologically Based Decision Support System for Rejuvenating Degraded Lands
7. Early-warning Indicators
8. Framework for Sustainable Land Management
9. Water Use and Enhancement Decision Aids
10. Biological and Mechanical Controls for Wind and Water Erosion
11. Biophysical Resource Appraisal System
12. Landscape-based Decision Support System for Rejuvenating Degraded Lands
13. Watershed-based Decision Support System for Wind and Water Erosion Control

[5] This is Table 3 from the *Prioritized Work Plan.*

All 13 products are included in the *Recommended Program*. Selected products have been deleted from *Alternative A* and *Alternative B*. Deletions were based on a product's relative importance to the overall program. The following sections (1) clarify the relationship between products and targeted problems and (2) detail the specific features of each product. USAID's portion of the first-year Research and Development Program Budget is given in Table B.

Target 1. Conservation and Environmental Protection

Problem statement and justification : Cropping, overgrazing, fuel-wood exploitation, and other agricultural activities account for 99% of the human-induced degradation of the world's vegetated soils. Most of the damage has been done by water and wind erosion. Production-demand pressures, the lack of appropriate technologies, and policies based on exploitation rather than sustainability are among the chief causes of this degradation.

Population projections indicate that another billion hectares of vegetated soils could be degraded by 2025 unless integrated land-management technologies and policies are implemented. The Soil Management CRSP has identified important products that can help conserve and protect global soil and water resources.

Subtarget 1.1: Water and Wind Erosion Control

Water erosion accounts for 56% of all human-induced degradation of vegetated soils; wind erosion accounts for another 28%. In Africa, the two cause nearly equal amounts of damage. In Latin America and Asia, water erosion is the more pernicious.

Product 111: Biological and mechanical controls for wind and water erosion. Experiences with the IMAW project in Niger, the IRRI hedgerow program in the Philippines, and the mission-sponsored steepland program in Honduras have demonstrated that both biological and mechanical technologies are needed to control wind and water erosion. Research and development for these technologies will focus on three components: (1) benchmark indicators to monitor how soil erosion affects environmental quality, agricultural productivity, and economic growth; (2) biological and mechanical erosion-control technologies that are culturally and economically acceptable; and (3) a scientifically based decision support system that evaluates a range of soils, climates, landscapes, and socioeconomic conditions.

The IMAW project has developed products and methodologies that will be tested and refined in Niger's proposed Inter-CRSP Natural Resource Management project. To extend the impact of these and other products, regional collaboration will be explored with Mali, Ghana, and Burkina Faso in West Africa; with IRRI in Indonesia; and with CIAT in the humid region of Honduras. Products can be disseminated by SANREM and the other CRSPs, IARCs, NARs, NGOs, PVOs, and various conservation programs.

Product 112: Watershed-based decision support system for wind and water erosion control

Long-term solutions to erosion problems require integrated procedures for conserving soil and water resources. At present, many of the empirical and process-based models for predicting wind and water erosion have been

developed from data on U.S. soils, climates, and ecosystems. Likewise, current watershed-management decision support systems that incorporate physical, mechanical, and socioeconomic components are rarely applicable in LDC environments. The CRSP's watershed-based decision support system will overcome this deficiency: it will be based on globally applicable principles for controlling erosion both biologically and mechanically (see Product 111 above), and it will provide guidelines for site-specific applications in LDC ecosystems.

Subtarget 1.2: Rejuvenation of Degraded Soils

Over the last 45 years, more than a billion hectares have been degraded, an area roughly equal to India and China combined. Agricultural activities have caused the bulk of this degradation. As population increases, the pressure to meet human needs by intensifying production on marginal lands threatens to exacerbate such problems. Decision aids to prevent land degradation and rejuvenate already degraded lands will thus be essential to the responsible management of the environment.

Product 121: Landscape-based decision support system for rejuvenating degraded lands

Because degradation occurs at the farm level, rejuvenation research needs to involve land users and be informed by a clear vision of their aspirations and long-term needs. The diagnostic component of this product will enable it to capture and organize both socioeconomic and biophysical data through the use of geographic positioning systems (GPS) and geographic information systems (GIS). These tools can be applied to both degraded and comparatively nondegraded ecosystems.

For individual fields or entire landscapes, rejuvenation efforts will employ diagnostic and ameliorative tools developed from related research on enhancing economic and agricultural productivity. Product 121 will be especially helpful to planners, policy-makers, peer scientists, and program implementors (i.e., PVOs, NGOs, extension leaders).

Product 122: Biologically based decision aids for rejuvenating degraded lands

Many degraded soils can be restored to economic productivity once their chemical and physical problems have been diagnosed. CRSP researchers have identified microsymbionts, leguminous species, and nonleguminous species that can rejuvenate soils and that are socially and financially acceptable to farmers. This data base will to be integrated into a comprehensive system applicable to diverse agroecological conditions.

Target 2: Land Resource Quality

Problem Statement and Justification: When population pressures were low, farmers could readily move to new areas when land productivity declined. Current population pressures do not permit this kind of expansion. As fallow periods shorten and greater strains are placed on marginal lands, the risk of land degradation increases. At a time when misjudgments about long-term sustainability can have dire human and environmental consequences, farmers and policy-makers need a reliable means of predicting the physical and economic consequences of various land-management decisions.

Methods for evaluating soil quality, health, and resilience are all in the early stages of development. The following are among the most urgent needs:

- An international network to coordinate research efforts
- Methods to predict the onset of degradation in stressed systems
- Methods to determine the resiliency of stressed systems
- Reliable soil resource information upon which policies that promote long-term social equity can be based.

Subtarget 2.1: Quality and Degradation Indicators

Sustainable land management (SLM) seeks to harmonize environmental concerns and economic realities. Achieving it requires an understanding of (1) the biophysical resource base and (2) on-farm social and economic conditions.

Product 211: Framework for Land Quality Evaluations

Developing this product will require the generation, mobilization, and integration of data and knowledge about environmental processes. Researchers must employ indigenous knowledge, and take full advantage of the latest advances in information science and technology. Research must focus on long-range issues (e.g., identifying indices of sustainable land management, evaluating on-site and off-site impacts of agricultural practices).

The framework for land quality evaluations will be developed through international collaboration and systematic reviews of research outputs. Collaborators will include the SANREM CRSP, the International Board for Soil Research and Management (IBSRAM), Agriculture Canada, the Food and Agriculture Organization of the United Nations (FAO), the Indian Council of Agriculture Research (ICAR), and the Hungarian Academy of Agriculture. The framework will be able to assess the potential for land degradation, the resiliency of soil systems, and the technological options best suited to particular sites.

Subtarget 2.2: Soils and Environmental Data Bases

To make technical decisions that are ecologically, economically, and socially responsible, LDC policy-makers and producers need information sources that are accessible, well-organized, reliable, and accurate. Decision support systems offer an effective means of structuring information, but to be most effective, these systems require a global soils and environmental data base.

Product 221: Biophysical Resource Appraisal System

The Biophysical Resource Appraisal Support System (BRASS) will integrate information from multiple sources in a manner that allows users to make confident short- and long-range decisions.

BRASS will consist of linked software that enables users to access global, national, and local information. At present, this data is often inaccessible. Indeed, no current system has captured the wealth of available biophysical resource information in a reliable form. BRASS will overcome this shortcoming by providing (1) decision support information and (2) an assessment of the confidence level users should place in any proposed course of action.

Five major tasks are required to develop BRASS: (1) collate data bases; (2) review existing data bases; (3) determine major data gaps; (4) design BRASS to serve as the data source for a variety of decision support systems; and (5) conduct workshops to train LDC personnel in how to implement BRASS.

Product 222: Early-warning Stress Indicators

To minimize the impact of agriculturally induced stress, farmers and policy-makers need diagnostic and predictive tools, information on the soil resiliency, and an understanding of the ameliorative practices appropriate for specific sites.

To address these needs on a global scale, the CRSP will organize an International Committee on Land Degradation (ICOMLAND) with the following charges: (1) improve procedures to assess land degradation at various scales (i.e., global, national, local); (2) evaluate and implement procedures for assessing land resiliency; (3) develop stress indicators that help to avert land degradation for use at all planning levels.

ICOMLAND will include of representatives from LDCs, developed-countries, IARCs, and the CRSPs. The focus will not be to document degradation, but rather to develop a variety of products capable of avoiding problems before they reach a critical stage. Products will include manuals, guidebooks, training packages, extension materials, computer models, and systems for managing data bases. Especially important will be the development of functional monitoring systems to evaluate specific properties that enhance or degrade soil health or exert an impact on soil productivity.

Subtarget 2.3 Productivity and Land-use Options

Land-use research has traditionally been driven by a desire to increase agricultural productivity. Although that imperative is still vitally important, increased concern is being expressed over the environmental impact of agricultural practices. Unless producers and policy-makers have a reliable way of assessing what uses the land will support, they often end up destroying the environment and disseminating poverty. Because LDCs typically lack adequate resource assessment and monitoring systems, their environmental resources are particularly at risk.

A Framework for Sustainable Land Management can be a powerful tool for evaluating the long-term productivity of soil resources. It will provide a scientific basis for evaluating the environmental impact of proposed land-use changes, and it can be used for evaluating the consequences of projected global climate change.

Product 231: Framework for Sustainable Land Management (SLM)
The following frameworks, methods, and decision aids will be the foci for the Soil Management CRSP's product-development activities: (1) a functional framework for evaluating and using SLM; (2) rapid rural appraisals; (3) decision aids for different kinds of experts; and (4) a Framework for Evaluating Sustainable Land Management (FESLM), developed with international collaborators who will systematically review project outputs. FESLM will be capable of monitoring any land-management activity anywhere in the world.

Institutions who can contribute to FESLM include the SANREM CRSP, the International Board for Soil Research and Management (IBSRAM), Agriculture Canada, the Food and Agriculture Organization of the United Nations (FAO), the Indian Council of Agricultural Research (ICAR), and the Hungarian Academy of Agriculture. Using an international network, researchers will test FESLM in a variety of ecosystems. Preliminaries for this product have already been discussed at international workshops in Thailand (1991) and Canada (1993).

Target 3. Productivity and Economic Growth

Problem Statement and Justification: Productivity on more than half of the world's arable land is limited by soil acidity, phosphorous and nitrogen deficiencies, water deficits, or a combination of these problems. Efforts to increase productivity invariably address several of these constraints. For example, overcoming soil acidity improves root growth and plant access to available soil water and nutrients, but favorable crop yields will not be achieved unless phosphorus and nitrogen are in adequate supply. Similarly, biological nitrogen fixation is a low-cost alternative to inorganic nitrogen fertilizers, but legume sensitivity to soil acidity may restrict farmers' ability to capitalize on this management practice.

Harvested crops remove large quantities of nutrients from the land, making soils progressively more acid and nutrient-poor unless remedial measures are implemented. This problem is often compounded by province- and nation-wide fertilization policies which fail to recognize that individual nutrients must each be applied at specific times, frequencies, and amounts. Centralized policies insensitive to these variables have helped to create, on the one hand, soils with continuing nutrient deficits and low productivity and, on the other hand, soils where excesses of phosphorus and nitrogen threaten to contaminate surface- and groundwater. As population increases, and pressure mounts on cultivated lands, many farmers are forced onto marginal lands with acid, infertile soils. Their nutrient problems must be corrected before crop production can be optimized. Enhanced productivity through improved nutrient and water management will help reduce land abandonment and deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands.

Subtarget 3.1 Amelioration of Acid Soils

Crop yields in acid soils are frequently reduced to 50% of optimum levels. Soil acidity destabilizes production by limiting root growth. It also limits the roots' ability to absorb essential nutrients and exacerbates the effects of stresses such as drought. In their attempts to minimize the risks of crop failure, subsistence-level farmers in LDCs are unable to capitalize on high-yielding varieties, which are often more vulnerable to such stresses.

As population increases, more marginal lands with acid soils are being cultivated. If the soil acidity problem is not properly managed, the environmental consequences are a foregone conclusion: land abandonment and further deforestation in the humid tropics, desertification in the semiarid tropics, and erosion and siltation in the steeplands.

Product 311: Acidity Decision Support System

ADSS is a computerized knowledge-based decision aid to (1) diagnose soil acidity problems, (2) recommend a range of practical management alternatives for different crops and locally available ameliorants, and (3) provide reliable estimates of the economic consequences of the proposed remedial practices. The complexity of the soil acidity syndrome results from numerous combinations of calcium deficiency and excesses of toxic aluminum, hydrogen, and manganese.

An ADSS prototype has been developed by the CRSP for managing aluminum toxicity problems. It provides the conceptual framework for building a tool which addresses the combination of factors that contribute to the soil acidity syndrome. Future activities seek information necessary to optimize economic returns on land, labor, and inputs through a more precise match of crops and their ameliorant requirements. Diagnosis and recommendations for

soil acidity problems in the final product will be based on information synthesized from the most recent literature, including the ameliorative and detrimental effects of organic amendments. Subroutines will be developed for evaluating and correcting non-aluminum-based toxicity. Algorithms will be developed to estimate the calcium required to counteract aluminum and hydrogen toxicity to root growth. Recently developed ion transport models will be used to improve predictions on alleviating subsoil acidity. Software and user guides have been prepared in English and Bahasa Indonesian; they will be prepared in Spanish and French.

Subtarget 3.2 Integrated Nutrient and Water Management

Plants depend on the soil for nutrients and water, the use of which is closely interrelated. The nutrients that most frequently limit plant growth are phosphorus and nitrogen. The Soil Management CRSP will complete its decision aids on individual components (i.e., phosphorus, nitrogen, and water) and then work to develop a single integrated system to guide on-farm management practices.

Product 321: Phosphorus Decision Support System (PDSS)

PDSS is a computerized knowledge-based decision aid to (1) diagnose site-specific deficiencies and excesses and (2) recommend remedial management practices (including fertilizer quantities and materials) based on crop type, economic conditions, and management goals.

PDSS allows users to diagnose P deficiencies or excesses from available information. The system helps users relate results and experiences in one region to those in another region, a vexing problem that current P-management schemes often fail to solve. The final product will contain an extensive list of critical P levels for various crops and soil-test methods. Algorithms need to be refined for reliable conversion of data from volume to weight measurements and for use of clay percentages as a proxy for colloid surface area. Existing methods of predicting P buffer coefficients and residual P availability will be validated in both calcareous and acid soils. Criteria will be developed for assessing optimal levels of mycorrhizae for efficient use of P and for determining site conditions where rock phosphate would be economically productive.

Product 322: Nitrogen Decision Support System (NDSS)

NDSS is a computerized knowledge-based decision aid to (1) diagnose soil deficiencies and excesses, (2) prescribe when and how fertilizer N should be applied, and (3) estimate the economic consequences of proposed remedial practices. The prototype will be a computer program developed by a CRSP institution for use with maize in temperate regions. NDSS will be able to evaluate N requirements across soil types and climatic regions for various crops and rotations, with a proper accounting of the N supplied as fertilizer or as

green and animal manures. Refinements to the existing prototype include calibration for crops other than maize, an improved economic module, estimates of soil N retained in subsurface layers by anion exchange capacity, and algorithms to evaluate the consequences of interactions between inorganic N and BNF.

Product 323: Biological Nitrogen Fixation (BNF) Technologies

BNF technologies will (1) increase farmer access to superior legume symbionts and other inoculants, (2) improve legume and microbe performance under stress conditions, and (3) conserve N derived from biological sources.

Technologies are currently hampered by a lack of understanding about the synergistic influences which non-N management components can have on N acquired by biological fixation. Effective extension of BNF products requires reliable cost-effective inoculant quality-control, production, and delivery systems.

CRSP tools will help evaluate financial and marketing requirements for inoculant production facilities under different stress environments. Industry and research institutes will be provided with selected and genetically improved microbial germ plasm. Knowledge on cycling and conserving BNF-derived N in ecosystems and legume food/cash cropping systems will be organized into user-friendly decision aids.

Product 324: Water-use Enhancement Decision Aids

This product will provide guides for the design, construction, and use of water-harvesting systems—including catchment basins and conveyance, storage, and distribution components. The product will account for differences in landscape and agroecological conditions.

Product development entails integrating knowledge of rainfall probability and distribution with information on crop requirements, use efficiency, and soil water storage. Site-specific data requirements need to be defined for each water-harvesting system. Construction and maintenance-cost data will be compiled on different systems to determine the economic advantage required for farmer acceptance.

Mode of Collaboration for Target-3 Products

Software will be designed in close collaboration with product developers from other Soil Management CRSP target areas to insure compatibility among systems and the development of a common soil and climate data base. Information synthesis, product design, field validation, and product testing will be done in collaboration with scientists from NARCs and IARCs, representatives of relevant agribusiness sectors, and regional research networks supported by the Potash and Phosphate Institute. Product-development teams will seek the participation of scientists from the Bean/Cowpea CRSP, the Peanut CRSP, and the Sorghum-Millet CRSP to determine cultivar differences in nutrient requirements and tolerance to soil acidity and water stresses. Collaborative activities will include (1) workshops/symposia to compile state-of-the-art knowledge on product-

related topics and (2) field tests and validation of products at benchmark sites representing the global range of ecosystem characteristics and socioeconomic conditions.

Table B. USAID portion of the first-year budget for the Soil Management CRSP's Research and Development Program. [1]

	First-Year USAID Budget		
	Recommended	Alternative A[§]	Alternative B[¶]
		Dollars	
Target 1. Conservation and Environmental Protection	640,000	640,000	520,000
Biological and mechanical controls for wind and water erosion (116)			
Watershed-based decision support system for wind and water erosion control (118)			
Landscape-based decision support system for rejuvenation of degraded lands (123)			
Biologically based decision support aids for rejuvenation of degraded lands (122)			
Target 2. Land Resource Quality	720,000	400,000	400,000
Framework for land quality evaluations (211)			
Biophysical resource appraisal system (232)			
Early-warning stress indicators (212)			
Framework for sustainable land management (221)			
Target 3. Productivity and Economic Growth	720,000	720,000	520,000
Acidity decision support system (311)			
Phosphorus decision support system (321)			
Nitrogen decision support system (331)			
BNF technologies (332)			
Water use enhancement decision aids (343)			
Total	2,080, 000	1,760,000	1,440,000

[1] Adapted from Table 7 in the *Prioritized Work Plan.*

[§] Does not include:
Framework for land quality evaluation
Early-warning stress indicators.

[¶] Does not include:
Framework for land quality evaluation
Early-warning stress indicators
Biologically based decision aids for land rejuvenation
Water use enhancement decision aids.

2. Outreach Program

Purpose

Unused or irrelevant tools have no impact. To achieve its goals and objectives, the CRSP must develop products that respond to the demands and needs of LDC users. In addition, the CRSP must promote these products and demonstrate their use in site-specific situations.

To this end, the CRSP will implement an Outreach Program that involves LDCs and other intended users of its products in *all phases* of product development, testing, and promotion. In addition to encouraging the use of indigenous knowledge, broad participation of this sort will assure that products respond to local needs and values.

The Outreach Program will focus on four primary areas: Policy and Decision Making, Human Resource Development and Communications, Product Development and Impact Assessment, and Technical Assistance and Market Development.

Tasks

Policy and Decision Making

- Establish an integrated capacity for responding to requests from USAID bureaus, field missions, and related groups; devote particular attention to program-planning and assessment matters, policy reviews, and other multi-disciplinary field activities.
- Promote the application of soil-management products to enhance policy formulation and implementation relevant to economic productivity and environmental security.

Human Resource Development and Communications

- Disseminate products to clients, provide follow-up technical assistance, and refine/adapt products to meet client needs.
- Conduct educational programs that target specific user groups within the public and private sector.
- Develop an international information network that promotes CRSP products among potential implementors and beneficiaries.
- Strengthen CRSP collaborative activities to make product development more cost-effective.
- Coordinate the development of educational and training materials.

Product Development

- Identify client needs and relevant indigenous knowledge in order to guide product design, development, and dissemination.
- Adapt existing CRSP products to client needs.

- Incorporate decision support systems and other products into communications, training, and technical-assistance efforts.
- Enhance private-sector participation in implementing improved soil-management practices.

Technical Assistance and Market Development

- Promote CRSP products and programs through national and international media, in-house publications, and market promotion material.

Leadership

Outreach efforts will be led by a full-time program leader(s). Product-development teams will also serve an important role in the Outreach Program.

The responsibilities of the outreach leader(s) will include coordinating all outreach tasks; promoting the use of CRSP products; identifying specific high-priority, high-payoff activities; responding to requests from the public and private sector; serving as a liaison between the Management Entity (ME) and USAID missions and bureaus; serving as a liaison between the ME and product-development teams; arranging and coordinating workshops, training sessions, and other means of demonstrating the potential benefits of CRSP products; assessing the strengths and weaknesses of existing products for product-development teams; and outlining essential product modifications for development teams.

Product-development team members will provide technical support to the outreach leader(s). They will play key roles in workshops, training sessions, and other activities where the products are being explained and demonstrated. They will work with the outreach leader to insure that products respond to user demands and can be readily applied.

The first-year USAID-funded Outreach budget is given in Table C.

Table C. USAID portion of the first-year budget for the Soil Management CRSP's Outreach Program. [1]

Object	Recommended	Alternative A	Alternative B
		Dollars	
Operations	414,000	414,000	414,000
Product Development	217,000	217,000	217,000
Communications	132,000	120,000	111,000
Total	763,000	120,000	111,000

[1] Adapted from Table 10 in the *Prioritized Work Plan.*

3. Field Support to USAID Missions

The Soil Management CRSP is designed to serve U.S. foreign-policy objectives by identifying land-management problems that impede economic growth, developing products to solves these problems, and working with USAID missions and other clientele groups with parallel interests. The refocussed CRSP will give particular attention to USAID's sustainable-development goals as they relate to economic growth and environmental protection. The kinds of field support the CRSP can provide are detailed below.

1. Support to Bilateral Programs

The CRSP can assist bilateral programs (i.e., between USAID missions and host countries) that require technical support on programs and policy issues involving land use, environmental protection, and natural-resource management. The CRSP is currently providing such field support to an alternative-crops project in Bolivia, a land-management project in Honduras, a natural-resource project in Niger, and a watershed-development project in Guinea.

2. Technical Backstopping

The CRSP can respond to a variety of mission and host-country requests for technical backstopping on land-management issues. Such services are already being provided through the Latin American RISTROP Network. The CRSP has also responded to short-term requests for specialized technical backstopping in Kenya and El Salvador.

3. Workshop Support

By helping to forge a unified approach to complex issues, information-exchange workshops provide an effective means of addressing local and multinational problems. These workshops can also strengthen diplomatic relationships and help to establish international networks capable of producing long-term economic and environmental benefits. The Soil Management CRSP can provide technical and organizational leadership for national and international workshops selected and developed in collaboration with USAID missions and host-country institutions.

4. Training Activities

As long as developing countries depend on imported technologies, economic productivity will suffer. The Soil Management CRSP has long recognized that investments in human skills and capacities are essential for societies seeking to sustain economic growth and improve the quality of life. To date, more than 100 developing-country students have earned advanced degrees in the CRSP's collaborative training program. In addition, more than 5,000 trainees have benefited from the CRSP's short-term programs. The extended CRSP will continue this academic and on-the-job training support.

5. Clientele Services

USAID's clients are also the Soil Management CRSP's clients. Because land-use policies and practices are critical to achieving the missions' goals on environmental and economic issues, input from a broad range of interest groups is essential. CRSP technologies and experience in managing soil resources can be valuable assets to USAID and its clients. For example, maximizing nitrogen fixation by legumes requires the presence of the specific microorganisms; frequently, seed must be inoculated, a process which requires precise technologies for producing and preserving inoculants. The CRSP has developed such technologies and provided them to private-sector producers and distributors. As inoculants become more readily available, farmers benefit, and USAID goals are thus achieved.

The first-year USAID funded budget is given in Table D. Table E gives a projected first-year budget for all activities and sources of funding.

Table D. USAID portion of the first-year budget for the Soil Management CRSP's Field Support to USAID Missions.[1]

Object	Recommended[2]	Alternative A[3]	Alternative B[4]
		Dollars	
Field Support	350,000	250,000	150,000

[1] Adapted from Table 11 in the *Prioritized Work Plan.*

[2] Includes 320 days of personnel time, travel, and associated costs.

[3] Includes 160 days of personnel time, travel, and associated costs.

[4] Includes 80 days of personnel time, travel, and associated costs.

Table E. Projected first-year activity budget for multiple sources of funding. Details on methods for estimating non-USAID budget are given in Appendix I. [5]

Activity	Budget				
	USAID	Cost Sharing	Host Country	External	Total
REQUESTED PROGRAM					
Product Research and Development					
Conservation and Environmental Protection	640,000	160,000	459,000	128,000	1,387,000
Land Resource Quality	720,000	180,000	702,000	144,000	1,746,000
Productivity and Economic Growth	720,000	180,000	459,000	144,000	1,503,000
Subtotal	2,080,000	520,000	1,620,000	416,000	4,636,000
Outreach	763,000	190,000	235,000	153,000	1,341,000
Field Support to USAID Missions	350,000	88,000	0	70,000	508,000
Administration	283,000	0	0	0	283,000
Contingency	150,000	38,000	0	30,000	218,000
Total	3,626,000	836,000	1,855,000	669,000	6,986,000
ALTERNATIVE A					
Product Research and Development					
Conservation and Environmental Protection	640,000	160,000	459,000	128,000	1,387,000
Land Resource Quality	400,000	100,000	438,000	80,000	1,018,000
Productivity and Economic Growth	720,000	180,000	459,000	144,000	1,503,000
Subtotal	1,760,000	440,000	1,356,000	352,000	3,908,000
Outreach	751,000	188,000	725,000	150,000	1,814,000
Field Support to USAID Missions	250,000	63,000	0	50,000	363,000
Administration	272,000	0	0	0	272,000
Contingency	150,000	38,000	0	30,000	218,000
Total	3,183,000	729,000	2,081,000	582,000	6,575,000
ALTERNATIVE B					
Product Research and Development					
Conservation and Environmental Protection	520,000	130,000	330,000	104,000	1,084,000
Land Resource Quality	400,000	100,000	396,000	80,000	976,000
Productivity and Economic Growth	520,000	130,000	354,000	104,000	1,108,000
Subtotal	1,440,000	360,000	1,080,000	288,000	3,168,000
Outreach	742,000	186,000	717,000	148,000	1,793,000
Field Support to USAID Missions	150,000	38,000	0	30,000	218,000
Administration	267,000	0	0	0	267,000
Contingency	100,000	25,000	0	20,000	145,000
Total	2,699,000	609,000	1,797,000	486,000	5,591,000

[5] This is Table 7 from the *Prioritized Work Plan.*

Impact Assessment

The refocussed CRSP will produce tools to solve the real-world problems facing a range of users—from policy-makers to farmers to ranchers. The product-development scientists, outreach leaders, and administrative support teams all recognize that the success of their efforts will be measured in terms of the program's impact on the immediate and long-term needs of LDCs.

Because the CRSP's tools are designed to address site-specific problems, their impacts can be readily identified. Detailed operational plans for developing each product will describe the specific problems to which the tool can be applied, the means by which the tool can help solve those problems, and the criteria by which the tool can be evaluated.

Individual programs will be structured to provide affirmative answers to these kinds of questions:

- Will the product address the technical, social, and economic needs of local people as they define those needs?
- Has indigenous knowledge been used to specify and prioritize the kinds of problem-solving tools that are developed?
- Will adaptation of the products enable developing countries to build capacities for permanently improving their quality of life?
- Will the products serve USAID-supported expatriate and indigenous PVOs and NGOs?
- Will the products enable users to improve soil productivity, decrease soil erosion and degradation, rejuvenate degraded lands, and protect the environment?
- Will the products help formulate policies and support institutions that must implement natural-resource safeguards?

Participants

Initially, Soil Management CRSP programs will be led by personnel from institutions who have been primary collaborators. Additional leaders will be added and current leaders removed as the program changes and needs arise.

The CRSP will collaborate extensively with PVOs, NGOs, private-sector groups, and USAID missions. Additional information about collaborators appears in Appendix II.

The primary institutions expected to be involved in the program's initial phase are as follows:

- *U.S. Universities/ Institutions:* Cornell University, North Carolina State University, Texas A&M University, the University of Hawaii, the Nitrogen Fixation by Tropical Agricultural Legumes Center (NifTAL).
- *U.S. Agencies: U.S. Department of Agriculture:* Agricultural Research Service, Economic Research Service, Soil Conservation Service.

- *LDCs:* Bolivia, Burkina Faso, Ghana, Honduras, Jamaica, Indonesia, Mali, Niger, the Philippines.
- *IARCs:* CIAT, CIMMYT, ICRISAT, IITA, IRRI, IBSRAM
- *CRSPs:* SANREM, Sorghum/Millet, Peanut, Bean/Cowpea

5.
Appendices

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Appendix I: *Proposal Development—Process and Participants*

Process

In 1990, USAID made an administrative decision to combine its four soil and water programs under the administrative leadership of the Soil Management CRSP. Those programs are:

- *NifTAL:* The Nitrogen Fixation for Tropical Agricultural Legumes Center
- *TSMM:* The Technology for Soil Moisture Management Program (USDA/ARS and USDA/ERS)
- *SMSS:* The Soil Management Support Services (USDA/SCS)
- *TropSoils:* The Soil Management CRSP.

Funding for all four programs is scheduled to terminate in September of 1994. During the intervening period, 1990–94, each program was authorized to continue along its established course, but it was also asked to seek opportunities for initiating and developing collaborative activities. The USAID directives to combine the four programs specified that funding beyond 1994 commitments would require the development of a unified program.

In February 1991, a detailed agenda of actions and dates was developed to bring about the unification of the four programs; to restructure the Board of Directors, the Technical Committee (TC), and the External Evaluation Panel; and to outline a process for developing a five-year proposal. The target date for submitting the proposal to BIFAD and USAID was February 1994.

In September 1991, the Board of Directors was expanded to include two representatives from USDA. The TC was initially expanded to include representation from TSMM, SMSS, and NifTAL; later, it was further expanded to include a representative from both components of TSMM: USDA/ERS and USDA/ARS. The Board of Directors also approved the request from the Director of the Management Entity Office to establish the Assistant Director position, using special administrative funds budgeted to help cope with the expanded program's leadership and administrative duties.

In October 1991, the new global and strategic planning process was initiated. Follow-up meetings were held in February, March, June, August, and September of 1992; the Global Planning Workshop was held in January of 1993. This

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workshop brought together representatives from collaborating host countries, USAID, IARCs, PVOs, NGOs, the World Bank, and potential participating institutions. One of the workshop's main objectives was to identify global issues pertinent to USAID's goals and to target host-country needs. This baseline information would help the CRSP develop a unified program. Workshop results have been published in the CRSP's *Workshop Record: The Soil Management CRSP Global Planning Session.*

In January 1993, USAID proposed changes in the CRSP's administrative structure. Due to the controversial nature of these changes, the CRSP's Board of Directors decided in February to delay the established procedures for developing the extension proposal.

A series of meetings between USAID and the Board of Directors ensued. In April, work on the proposal resumed under a new set of procedures. An additional member joined the planning staff (Charles McCants, former Director of the Soil Management CRSP) and the program's focus was re-examined in light of USAID's contention that major changes in structure and focus be implemented. The new deadline for submitting the proposal was set for December 1, 1993.

In May and June, McCants and Ray Meyer (USAID program leader for the CRSP) visited with scientific and administrative personnel from the four universities, the three federal agencies, and NifTAL. These meetings sought to gather information on how the CRSP might be modified to respond more effectively to USAID's needs. Meyer's and McCants' findings and recommendations were submitted to and approved by the Board of Directors on June 30, 1993. These actions established two Interim Program Leaders to help guide the development of the extension proposal. Subsequently, a Planning Committee was appointed to lead the proposal-development effort. The Committee members were Interim Program Leaders, Goro Uehara, and Thomas J. Smyth; Director of the Management Entity, Roger G. Hanson; USAID Project Officer, Charles Sloger; and Chairman, Charles B. McCants. The deadline date for submitting the proposal did not change.

The basic thrust of the planning effort was to refocus and restructure the program: rather than working primarily to expand the knowledge base, the CRSP would now concentrate on using existing knowledge to develop tools that could be used by USAID and other groups to solve location-specific problems. Inherent in this approach was a dramatic shift from previous precedents and procedures—away from block grants awarded to separate institutions for funding individual projects and toward targeted funds that support the development of problem-solving tools by teams of multi-institutional scientists.

Refocusing the CRSP in this fashion required a collaborative effort to identify target problems, to specify the products capable of solving those problems, and to outline the tasks necessary to produce the products. Through a series of memoranda and personal visits by the Planning Committee, scientists currently involved in the program had an opportunity to make inputs into each of these three vital areas. The Planning Committee reviewed this information, along with

the input on LDC needs gathered at the Planning Workshop, and selected the general target problems and specific target areas identified in the proposal.

Subsequently, the Planning Committee arranged a series of workshops, each of which focussed on a specific target area. CRSP scientists interested in these targets were brought together to identify products and tasks. Moderators were selected for each workshop based on their technical expertise and leadership qualities. In one instance, the group focusing on a target area was unable to meet, and the products and tasks were thus identified by correspondence. Outputs from these workshops are included in the Basic Work Plan. Priority groupings for guiding Product Research and Development are listed in Table 14.

In the *Prioritized Work Plan*, the imposition of a 13-product limit (Table 4) was based in part on the number of *financial units* required to develop a product. A *financial unit* is defined as salary, benefits, operating costs, and indirect costs for one full-time professional (or equivalent) for one year. The projected cost per financial unit is based on the estimates listed in Table 13.

Table 13. Estimated budget for a Product Research and Development *finanical unit.*

Object	Budget
Salaries	60,000
Benefits	15,000
Travel, international	10,000
Travel, national	4,000
Equipment	5,000
Supplies	12,000
Other direct costs	9,000
Indirect costs	45,000
Total	160,000

In estimating contributions to the budget by collaborating institutions, we employed current guidelines and historical precedents. According to CRSP guidelines, participating U.S. institutions are to provide in-kind financial support in amounts not less than 25% of the amount received from USAID. Thus, we have placed inputs from participating U.S. institutions under the cost-sharing heading and calculated the amount as 25% of the associated USAID input.

During the past two years, the estimated contribution from external sources (i.e., IARCs, the private sector, and elsewhere) is 20% of the USAID input. Estimates of host-country contributions are based on expected personnel levels, on-site activities, and other forms of collaboration if purchased on U.S. standards. (See Appendix VI for determinants of collaborator funding).

Table 14. Priority groupings for guiding Product Research and Development.

Priority Group I

1. Conservation & Environmental Protection

Water and Wind Erosion Control

116 Biological and mechanical controls

118 Watershed-based decision support system

Rejuvenation of Degraded Lands

122 Biologically based decision aids

123 Landscape-based decision support system

Water Resource Use and Protection

131 Water use/quality enhancement decision aids

2. Land Resource Quality

Quality and Degradation Indicators

211 A framework for land-quality evaluation

Soils and Environmental Data Bases

232 Biophysical Resource Appraisal Support System

Productivity and Use Options

221 Framework for sustainable land mgmt.

3. Productivity and Economic Growth

Amelioration of Acid Soils

311 Acidity Decision Support System

Phosphorus and Nutrient Management

321 Phosphorus Decision Support System

Integrated Nitrogen Management

331 Nitrogen Decision Support System

332 BNF technologies

Priority Group II

1. Conservation & Environmental Protection

Water and Wind Erosion Control

113 Determinants for farm systems–erosion relationships

114 Measures of erosion impact on crop production

Rejuvenation of Degraded Lands

121 GIS-based decision aid

122 Biologically based decision aids

2. Land Resource Quality

Soils and Environmental Data Bases

231 Data-base quality guidelines

3. Productivity and Economic Growth

Integrated Nitrogen Management

333 Legume-based alternatives to fertilizer N

Water Harvesting and Use

341 Agroforestry crop-production decision aids

Priority Group III

1. Conservation & Environmental Protection

Water and Wind Erosion Control

111 Models for erosion prediction and control

115 Baseline erosion assessment standards

2. Land Resource Quality

Soils and Environmental Data Bases

212 Early-warning stress indicators

3. Productivity and Economic Growth

Phosphorus and Nutrient Management

324 Input/output budget spreadsheets

Integrated Nitrogen Management

334 Input/output budget spreadsheets

Water Harvesting and Use

343 Decision aids for water-harvesting systems

Priority Group IV

1. Conservation & Environmental Protection

Water and Wind Erosion Control

112 *Wind*-erosion prediction model

Water Resource Protection

132 Decision aids on water-resource protection

3. Productivity and Economic Growth

Amelioration of Acid Soils

313 Cultivar screening techniques

Phosphorus and Nutrient Management

323 Cultivar screening techniques

Water Harvesting and Use

342 Guidelines for raised-bed agriculture

344 Cultivar screening techniques

[5] Products identified in the text and not included in this table will be incorporated into the Outreach Program.

Participants in the Planning Process

Throughout the planning process, scientists and administrators at participating institutions have been enthusiastic, patient, and supportive. They recognize the need for refocusing the CRSP in a manner that insures scientific integrity and helps USAID achieve its goals. Given adequate financial resources and administrative leadership, this CRSP can and will fulfill those objectives.

Planning Committee

Roger G. Hanson
Charles Sloger
Thomas J. Smyth
Goro Uehara
Charles B. McCants, Chairman

Participants

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Abbreviations

CU:	Cornell University
UH:	University of Hawaii
ME:	Management Entity
NifTAL:	Nitrogen Fixation for Tropical Agricultural Legumes Center
NCSU:	North Carolina State University
TAMU:	Texas A&M University
USDA/ARS:	U.S. Department of Agriculture/Agricultural Research Service
USDA/ERS:	U.S. Department of Agriculture/Economic Research Service
USDA/SCS:	U.S. Department of Agriculture/Soil Conservation Service

Appendix II: *Collaborators*

Collaborative is more than a word in the CRSP acronym: it is also the most revealing program descriptor. Our collaborators have been active partners in planning and implementing the program's diverse activities. They have also been major contributors to the CRSP's achievements. Intended collaborators for the Outreach and Product-Development activities are listed below.

The initial phase of the refocussed program is expected to involve the collaborators listed below. Others will be added as the program progresses.

Outreach Program Collaborators

U.S. Institutions

LiphaTech, Research Seeds, and United AgriProducts will help the CRSP evaluate its products for use in U.S. industries and for export potential.

LDCs

The CRSP will work with institutions in the following countries to develop and transfer the tools generated in its three Product-Development Programs: Bolivia, Burkina Faso, Costa Rica, Ecuador, Ghana, Honduras, Indonesia, Jamaica, Mali, Mexico, Niger, Panama, Peru, Philippines, Thailand, and Zambia. The CRSP will also provide germplasm support to more than 60 LDC institutions.

IARCs

- Centro Internacional de Agricultura Tropical (CIAT), Centro Internacional de Majoramiento de Maiz y Trigo (CIMMYT), International Board for Soil Research and Management (IBSRAM), International Crops Research Institute for the Semi-arid Tropics (ICRISAT), International Institute of Tropical Agriculture (IITA), and International Rice Research Institute (IRRI)—transfer of nutrient-management products.
- International Center for Research in Agroforestry (ICRAF)—support new microbial germplasm resources unit.
- IITA, CIMMYT, ICRAF, IFDC—transfer of Conservation and Environmental Protection products.
- FAO, ISRIC, ICRISAT, and IBSRAM—transfer of Land Resource Quality products.

- International Fertilizer Development Corporation (IFDC)—participation in training courses on soil nutrient management.

Other CRSPs

- Support to the Bean-Cowpea, Sorghum-Millet, and Peanut CRSPs in developing germplasm with improved tolerance to nutrient and water stresses.
- Site characterization support for the INTSORMIL and the Peanut CRSP.
- Landscape management support for the SANREM CRSP.

PVOs

The CRSP will provide training in applied BNF technology to the following: Bangladesh, GraminaBank; Canada, Plenty; India, ATI, BAIF; Indonesia, MBM , Save the Children; Nepal, Care, Peace Corps, Save the Children, Winrock International; Philippines, Intl. Inst. Rural Reconstruction, ATI; Sri Lanka, ATI; and Uganda, ACDI.

Private Sector

- The CRSP will work with the following organizations to provide technical assistance on designing inoculant-production facilities, production protocols, quality-control methods, and market-development strategies: Bangladesh, Biolink; India, Mayco Ltd., Rallis Ltd.; Indonesia, Rhizofin Pty.; Jamaica, Bauxite Mining Company; Kenya, Kenya Seed; Nepal, Immortal Enterprises; Uganda, Madvani Group; Bangkok Seed Company, Thailand; Nestle, Philippines.
- The CRSP will work with Texasgulf, Inc., and regional office networks of the Potash and Phosphate Institute (e.g., POTAFOS in Brazil, INPOFOS in Andean countries) to identify regions where North Carolina rock phosphate might serve as an affordable means of overcoming P deficiencies.
- The CRSP will work with the ALCAN Bauxite Mining Company in Jamaica on a land-reclamation project.
- The CRSP will market its expert systems through Winrock International (for developed countries).

USAID Mission Projects

- Bolivia, Chapare Regional Alternative Development Program—transfer and adapt humid tropical technologies from Peru to Bolivia to promote agricultural alternatives to coca production.
- Costa Rica—environmental protection and support for economic growth.
- Honduras—LUPE Project and Watershed Management Project to reduce on-site degradation and off-site environmental pollution.
- Indonesia—PVO training.

- Jamaica—program support on land reclamation after bauxite mining.
- Mali—SPAR Project for institutional development.
- Nicaragua—inoculant facilities design, privatization training.
- Nepal—private-sector and market development for inoculants.
- Niger—InterCRSP Project (currently being planned).
- Senegal and Uganda—Africa Bureau On-farm Productivity Enhancement Project.

Product-Development Collaborators

LDCs

- Bolivia, IBTA Chapare
- Brazil, Institute of Agronomy
- Costa Rica, National University and CATIE
- Ethiopia, Soil Conservation Department
- Honduras, Ministry of Natural Resources
- India, Central Soil and Water Conservation Institute, ICAR
- Indonesia, Center for Soil and Agroclimatic Research
- Malaysia, MARDI
- Jamaica, Agricultural Research Program
- Mali, Institut d'Economie Rurale
- Niger, Institut National de Recherches Agronomiques
- Thailand, Land Development Department
- Venezuela, Central University

IARCs

- CIAT—the development of biological and mechanical erosion-control methodologies; the development of nutrient-management products; collaborators in the Management of Acid Soils Consortium.
- CIMMYT—the development of nutrient-management products.
- IBSRAM—the development of nutrient-management products; development of Land Resource Quality products; networking; methodology standardization.
- International Center for Agricultural Research in the Dry Areas (ICARDA)—technologies for controlling wind erosion.
- ICRAF—the development of biological and mechanical erosion-control methodologies.
- ICRISAT—watershed-based soil and water conservation planning; development of nutrient-management products; development of Land Resource Quality products; collaborators in the Working Group on Acid Soils.

- IITA—rain erosivity and soil erosion information; biological conservation measures; the development of nutrient-management products.
- IRRI—conservation planning in upland farm systems; the development of nutrient-management products; development of Land Resource Quality products; collaborators in the Working Group on Acid Soils.

Other CRSPs

The Soil Management CRSP will work with SANREM on sustainability indicators for soil and water conservation planning.

PVOs

- National Soil Science and Conservation Societies—networking, host-country benchmark site selection, information gathering.
- World Association for Soil and Water Conservation—networking activities; coordination of regional work plans.

Private Sector

Agri-lab, Guatemala—management of acid soils.
Biocare, Australia—nitrogen management.
LipaTech, U.S.—test products for effectiveness in tropical soils.
Potash and Phosphate Institute, U.S.—phosphorus management.
Texasgulf, U.S.—phosphorus management.

USAID Mission Projects

- LUPE Project, Honduras
- Erosion Control Project, Nepal
- Erosion Control Project, India
- Niger InterCRSP Project, Niger (currently being planned)
- SPAR Project, Mali
- Upland Conservation Project, Indonesia

Appendix III: *Representative Achievements*

- Research on high-input systems in Peru has shown that yields can be sustained for 43 successive crops while also conserving the soil and enhancing fertility.
- Researchers have developed a low-input system that can extend the slash-and-burn cycle from two or three crops with quickly declining yields to five or six crops with stable yields. Following this cycle with a legume cover crop promises to provide essential weed control, supply nitrogen, and permit further cropping without an extended natural fallow. By reducing the need to clear new land, every hectare placed under a sustainable system saves five to ten hectares of tropical rain forest.
- Research has revealed that liming is essential for high yields and full exploitation of soil water. Even in the humid tropics of Indonesia, drought may be a problem when roots cannot penetrate acid subsoils and the plant is dependent on the small amount of water in the thin topsoil.
- A four-year experiment in Mali demonstrated that fertilization combined with various ridged-tilling practices can increase sorghum and cowpea grain yields by 157% and 123%, respectively.
- Researchers have identified drought-resistant legumes that can become an important part of savanna cropping systems. Without displacing food or cash crops, such legumes would increase the N in the agricultural system through biological nitrogen fixation. They will also help prevent the progressive land degradation that occurs when neither legumes nor crops stabilize the dry-season landscape.
- Soil acidity and active aluminum have been identified as primary constraints to crop production at Niamey, Niger. Evidence suggests that this is a serious problem throughout the country, as well as in much of the Sahel.
- The value of mulching has been demonstrated in natural forest reseeding, weed control, and plant nutrient conservation. The return of plant residues can be equivalent to a generous application of fertilizer.
- Soil Management CRSP researchers have helped farmers maximize biological nitrogen fixation inputs, thereby increasing food production and

reducing the need for expensive nitrogen fertilizers. Cost-efficient delivery systems have also been developed.

- Through national and regional workshops, on-site instruction programs, and a variety of training publications, the Soil Management CRSP has helped more than 55 countries improve their soil resource inventories, monitor resource degradation and rejuvenation, and apply consistent soil taxonomy criteria.
- Researchers have developed multi-disciplinary analytical methodologies that integrate soil data and agronomic, agroclimatic, and economic data as they relate to the long-term productive capacity of the resource base.
- Researchers have clarified the way that national policies on such variables as land use, agricultural prices, credit, and private enterprise influence soil management and environmental quality.
- The USAID/Niger-CRSP project on the Integrated Management of Agricultural Watersheds (IMAW) has produced a methodology for using local knowledge, customs, and preferences to develop integrated soil-, plant-, and animal-management systems.
- In collaboration with ICRISAT, IFDC, and Niger's National Institute for Agronomic Research, the CRSP has developed technologies to harvest wind-borne sediment as a way to reduce erosion and increase production. Results show that the sediment which forms around the mulch of various tree species is 120% more productive than other parts of the farmers' fields.
- In Peru, the CRSP has clarified the impact of various land-clearing practices on resource productivity. Follow-up projects in Peru and Indonesia have identified reclamation strategies for areas where inappropriate land-clearing methods have degraded the soil.
- The CRSP's IMAW project in Niger has developed on-farm strategies for increasing production on small intensively farmed plots so that large areas of land can be allowed to regenerate. The IMAW project has also developed a farmer-implemented strategy for reforesting degraded common lands.
- The CRSP has a comprehensive and reliable data base on world soils. This resource is used by IBSNAT, IARCs, U.S. universities, and LDC institutions.
- Institutions within the CRSP have developed a variety of decision support tools that can be useful to LDCs. The Fertility Capability Classification System (FCC) allows planners to group soils according to fertility-management problems. The Automated Land Evaluation System (ALES) enables planners to assess the physical and economic consequences of various land-management choices. The Erosion Productivity Impact Calculator (EPIC) and the Revised Universal Soil Loss Equation can also have a tremendous impact in LDCs.

- The U.S. Army Corps of Engineers has financed a CRSP-directed project to bridge the gap between the two most important soil classification systems: (1) the legend of the FAO-UNESCO Soil Map of the World and (2) Soil Taxonomy. To achieve this link, the CRSP is developing an expert system which will eliminate the expense of reclassifying soils and retraining researchers; the system will also improve the quality of information available to those without an extensive background in soil classification. Those modelling global climate change will thus be able to monitor more accurately the impact of various resource-management and environmental-protection programs.
- CRSP research has helped to quantify the ability of various soils to store organic carbon. Such information enables scientists to focus on soils that potentially emit the highest levels of carbon dioxide when cultivated.
- Advanced technologies to improve the effectiveness of biological nitrogen fixation have been developed by the CRSP and are being extensively promoted. They provide an environmentally enhancing source of essential N.
- In collaboration with the Thailand Department of Agriculture, CRSP institutions have developed a Biological Nitrogen Fixation Research Center that has successfully transferred BNF technology to the private sector with an annual production capacity of 200 metric tons.
- CRSP institutions have developed an interactive computer program—Financial Analysis for Inoculant Manufacturing Enterprises (FAIME) to help entrepreneurs evaluate financial and technical variables as they relate to establishing or redesigning inoculant manufacturing facilities.
- CRSP institutions maintain one of the world's most comprehensive repositories of rhizobial strains. This collection helps to identify the most effective rhizobia for legumes used in agroforestry systems.
- CRSP institutions are clarifying which legumes and management strategies are suitable for specific environmental conditions. In areas where drought had constrained legume use, for example, the CRSP has identified a number of drought-resistant legumes that grow rapidly at the onset on the rainy season and provide over 100 kg/ha of N to the following nonlegume crop.
- Nitrogen-fixing trees that increase crop yields more dramatically than low-growing groundcover legumes are being identified. In Peru, a 4.5-year enriched fallow containing *Inga edulis* trees produced crop yields 34% greater than the natural fallow treatment.
- In humid Indonesia, researchers found that soil acidity inhibited root growth and thus prevented plants from exploiting the substantial amounts of water stored in the region's sandy-textured soils; by neutralizing acidity,

the deep placement of lime improved root growth and dramatically improved water use efficiency and crop yields.

- In the Sahel, the CRSP has found that a management strategy called Contour Strip Rainfall Harvesting can be used to direct rainfall from covered runoff areas to cultivated strips. By moving rainfall to areas where it will do the most good, researchers found that they could increase millet and sorghum yields by as much as 119% and 59%, respectively, over traditional methods.
- The CRSP has also developed a General-Purpose Atmosphere-plant-soil Simulator (GAPS) that has improved our understanding of the way water moves though the soil-plant-atmosphere continuum. The system helps policy-makers and researchers evaluate risks and remedies for a wide range of moisture-management problems.

Appendix IV: *InterCRSP Activities*

The Soil Management CRSP led the effort to create a CRSP Council, drafting the present bylaws and the InterCRSP Memorandum of Understanding. The S.M. CRSP has also promoted the interCRSP concept as a problem-solving source of expertise for the Agency and other donors. Part of that effort involved preparing the current *CRSP Council Bulletin*, as well as printing and mailing the document to all USAID bureaus and missions.

InterCRSP activities enable scientists from host-countries and various CRSPs to provide technical problem-solving services that draw on the comparative strengths of each organization. Such integration reduces duplication and improves overall project efficiency. The S.M. CRSP's activities in this category include the following:

- A collaboration with INTSORMIL and the Institut d'Economie Rurale (IER) in Mali on a soil/cultivar-selection program. The basic problem is this: a once highly productive sorghum-producing region in central Mali has switched to growing lower yielding millet because the sorghum seedling survival rate is very low. The S.M. CRSP leads the soil chemical and physical research and INTSORMIL the research on selecting sorghum cultivars. Preliminary results indicate that soil acidity and low available soil phosphorus may be important components of the problem.
- A collaboration with the Peanut CRSP in Burkina Faso, where the S.M. CRSP provides soil characterization services for various research sites. The S.M. CRSP's role is expanding as field research attempts to overcome soil chemical and nutrient deficiencies in ways that increase the income of small peanut growers.
- A collaboration with the Pond Dynamics/Aquaculture CRSP and the INTSORMIL CRSP to increase the income of small hillside farmers in southern Honduras, reduce soil erosion and off-site shrimp estuary pollution, and sustain economic growth in the shrimp industry and in agriculture. These collaborations were initiated at the request of the Honduran Ministry of Natural Resources and the USAID mission in Honduras.
- Collaborations with the Small Ruminant CRSP and host institutions in Peru, Indonesia, and (most recently) Bolivia. Activities have focussed on overcoming practical animal-productivity problems to increase incomes for

farmers with small-ruminants. The S.M. CRSP's expertise in improving tropical pastures, forages, and fodder production complements the improved animal-management technologies developed by the Small Ruminant CRSP. Bolivia's Ministry of Agriculture has also asked these two CRSPs to provide technical assistance for small farmers in the Chapare region.

- A collaboration in which the S.M. CRSP provides the soil characterization expertise for the Sustainable Agriculture and Natural Resource Management (SANREM) CRSP, on a cost-sharing basis, for SANREM's landscape-management initiative in the Philippines. Upon request, the S.M. CRSP has agreed to provide these same services to the SANREM CRSP in Burkina Faso and Ecuador, as well as to the Peanut, Bean/Cowpea, INTSORMIL, and Small Ruminant CRSPs on an as-needed basis. The S.M. CRSP and SANREM are providing joint leadership for a 1994 Land-Quality Indicators Workshop .

The S.M. CRSP recognizes that the CRSPs need to combine their comparative strengths by working through the Council and searching for program opportunities with USAID and other donors. Based on program focus, one CRSP would be elected as the lead institution and would link with other CRSPs through subagreements. Three opportunities for this kind of activity have occurred since the CRSP Council was formed in December 1989. The Mali mission's attempt to establish an interCRSP effort gave way to a bilateral program, and efforts in Honduras have been placed on an as-needed basis for the time being. The third opportunity, in Niger, is currently being evaluated.

A 1990 review by the USAID Niger mission's Agricultural Development Office revealed that three CRSPs operating in Niger worked independently and that each has separate Memorandums of Agreements (MOAs) with the Institut National de Recherches Agronmiques du Niger (INRAN). Because two other CRSPs were also interested in working in Niger, the mission encouraged the development of an interCRSP project. The S.M. CRSP's Integrated Management [illegible]rshed (IMAW) project provided the mission with an [illegible] CRSP's might be linked.

[illegible]ct involved multi-disciplinary work on agropastoral [illegible]uvenation, and resource management in the Hamdallaye w[illegible]orty kilometers from Niamey. To implement the project, the Soi[illegible]CRSP gathered and evaluated indigenous knowledge, econo[illegible]e data, and physical and biological inventories—all of which have since been published. Scientists from ICRISAT, ILCA, IFPRI, the University of Niamey, and the Natural Resources and Forestry Divisions of the host institution (INRAN) all participated in the work.

Based on the success of the IMAW methodology, the USAID Niger mission asked the S.M. CRSP to provide technical input for an InterCRSP Natural Resource Management (NRMs) project, which is now seeking approval and funding. The S.M. CRSP will share its experiences and work jointly with the USAID Niger mission, INRAN, and other CRSPs to insure the project's success.

Appendix V: *A Brief History of the Soil Management CRSP*

TropSoils

Founded in 1981 under Title XII of the United States Foreign Assistance Act, the Soil Management CRSP (referred to as *TropSoils* until 1992) consisted of four institutions: *Cornell University, North Carolina State University, Texas A&M University,* and the *University of Hawaii.* This partnership was designed to tap the repository of scientific expertise housed in these U.S. land grant universities. Acting in concert with USAID and developing nations, researchers targeted a formidable problem: how can we become more efficient stewards of the world's soil and water resources?

Significant progress was made in providing some basic answers to questions regarding the following subjects:

- Reclaiming degraded lands
- Managing low-input systems
- Developing agroforestry systems
- Characterizing soil resources
- Overcoming soil-nutrient and soil-acidity constraints
- Managing soil nitrogen
- Developing improved soil and water conservation practices
- Designing continuous-cultivation strategies
- Improving pastures
- Preserving biodiversity
- Producing paddy-rice.

Training and education have been important components of these problem-solving efforts. More than 100 people from more than two dozen countries have received advanced instruction through the universities. Many graduates have returned home to assume important research and decision-making roles.

1992 Expansion

In 1992, the Soil Management CRSP expanded to include four additional organizations: the Nitrogen Fixation by Tropical Agricultural Legumes Center (NifTAL), the USDA/Soil Conservation Service (SCS), the USDA/Economic Resource Service (ERS), and the USDA/Agricultural Research Service (ARS).

NifTAL

Established in 1975, NifTAL was initially designed to help farmers maximize BNF inputs, thereby increasing food production and reducing the need for expensive nitrogen fertilizers. Over the years, the organization has become a center for symbiotic plant-microbe research and development. From its state-of-the-art science to its cost-efficient delivery systems, NifTAL enhances the Soil Management CRSP's ability to:

- Develop genetic technologies that improve the rhizobium/legume symbiosis for both crops and trees
- Develop methods for monitoring soil and plant microorganisms
- Develop environmental data bases for predicting rhizobia performance
- Establish regional symbiotic resource centers
- Provide technical assistance for commercial inoculant producers.

SMSS

An expanded relationship with the USDA/SCS brought the Soil Management Support Services Project (SMSS) under the auspices of the Soil Management CRSP. Founded in 1979, SMSS was designed to classify soils and soil-distribution patterns in developing countries—where the lack of such information was (and is) constraining efforts to conserve resources, increase productivity, and establish sound management practices. Through national and regional workshops, on-site instruction programs, and a variety of training publications, SMSS has helped more than 55 countries improve their soil resource inventories, monitor resource degradation and rejuvenation, and apply consistent soil-taxonomy criteria. The merger between the CRSP and SMSS formalizes a partnership that has existed for many years. The new relationship helps to provide developing countries with data essential to the generation and transfer of environmentally sound land-development policies.

USDA/ERS & USDA/ARS

As a result of a new relationship with the USDA/ARS and the USDA/ERS, the expanded Soil Management CRSP now includes the Technology for Soil Moisture Management Program (TSMM). The ARS component draws on its more than 50 years of experience in coping with the extreme soil and agroclimate problems associated with arid and semi-arid environments. That experience enhances the Soil Management CRSP's ongoing efforts to overcome soil degradation and declines in environmental productivity.

The ERS contribution helps the CRSP develop sustainable technologies compatible with local farming systems and economic settings. More specifically, ERS has the capability to develop multi-disciplinary analytical methodologies that integrate soils, agronomic, agroclimatic, and economic data as they relate to the long-term productive capacity of the natural-resource base. ERS input will also help to clarify the way that national policies on such variables as land use, agricultural prices, credit, and private enterprise influence soil management and environmental quality.

Expanded Capabilities

The cumulative effect of the merger is clear: the Soil Management CRSP can now conduct a more broad-based research and development program than has heretofore been possible. Applying expertise from both the social and natural sciences, we will seek a holistic understanding of the biophysical and socioeconomic constraints to sustainability. Not only will this integration allow us to evaluate the complex costs and benefits of various soil and water management strategies, but it will also provide a mechanism for refining and reassessing program priorities to ensure that they remain responsive to needs and aspirations of local users.

Equally important, the new structure invigorates the connection between our research and outreach activities. In addition to enhancing the scientific capabilities of our core universities, the new members provide a service-oriented dimension that will help us transfer research results to the people who need them in forms they can use. More effectively than ever before, we will be able to address what the National Research Council sees as the most conspicuous obstacle to sustainable land management: the dissemination of research findings to the local and regional levels.

Appendix VI: *Determinants of Collaborator Funding*

The CRSP will engage many participants in the implementation phase of its refocussed program. Each participant will commit resources, the type and monetary value of which will vary. In estimating the monetary contributions of each group of collaborators, the CRSP employed the following procedures.

USAID

The amounts represent estimated requirements to employ support personnel, purchase supplies and equipment, and cover other direct costs, including the travel expenses of all collaborators. In the *Prioritized Work Plan*, the imposition of a 13-product limit (Table 4) was based in part on the number of *financial units* required to develop a product. A *financial unit* is defined as salary, benefits, operating costs, and indirect costs for one full-time professional (or equivalent) for one year. The projected cost per financial unit is based on the estimates listed in Table 13.

U.S. Institutions

They will provide leadership personnel and other resources in amounts equal to 25% of USAID funding levels. Contributions from U.S. institutions are referred to as cost-sharing in the budget tables.

External Support

For the past two years, the calculated equivalent of this support is 20% of USAID funding.

Host-Country Support

Estimates concerning the number of personnel involved, the U.S. salary equivalents, and the value of facilities are provided below.

Estimated salary and benefits costs in U.S. equivalents.

A. Human Resources	
Project leader—BS degree	$24,000/year
Project leader—MA degree	$32,000/year
Project leader—PhD degree	$48,000/year
Technician	$14,000/year
Clerical support	$16,000/year
B. Facilities and in-kind contributions	
Based on 50% indirect costs of the human resource contribution.	

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Recommeded Program

Step 1 for calculating host-country contributions: projected distribution of professional services by target area.

Program Area	Project Leader BS	Project Leader MS	Project Leader PhD	Technician	Clerical	Potential Countries
	FTE					*Number*
Cons. & Environ. Protect	3	2	2	3	2	6
Land Resource Quality	4	2	3	6	5	10
Prod. and Econ. Growth	3	2	2	3	2	6
Outreach	8	4	3	4	3	25
Totals	18	10	10	16	12	—

Step 2 for calculating host-country contributions: projected contributions of professional services by target area.

Program Area	Project Leader BS	Project Leader MS	Project Leader PhD	Technician	Clerical	Potential Countries
	$ (000)					
Cons. & Environ. Protect	72	46	96	42	32	306,000
Land Resource Quality	96	64	144	84	80	468,000
Prod. and Econ. Growth	72	64	96	42	32	306,000
Outreach	192	128	96	42	48	506,000
Totals	432	320	432	210	192	1,586,000

Step 3 for calculating host-country contributions: facilities and human-resources.

Program Area	Human Resources	Facilities	Total
	$ (000)		
Cons. & Environ. Protect	306,000	153,000	459,000
Land Resource Quality	468,000	234,000	702,000
Prod. and Econ. Growth	306,000	153,000	459,000
Outreach	506,000	253,000	759,000
Totals	1,586,000	793,000	2,379,000

Alternative A

Step 1 for calculating host-country contributions: projected distribution of professional services by target area.

Program Area	Project Leader BS	Project Leader MS	Project Leader PhD	Technician	Clerical	Potential Countries
	FTE					*Number*
Cons. & Environ. Protect	3	2	2	3	2	6
Land Resource Quality	2	1	2	4	2	5
Prod. and Econ. Growth	3	2	2	3	2	6
Outreach	8	3	2	3	3	22
Totals	16	8	8	16	9	—

Step 2 for calculating host-country contributions: projected contributions of professional services by target area.

Program Area	Project Leader BS	Project Leader MS	Project Leader PhD	Technician	Clerical	Potential Countries
	$ (000)					
Cons. & Environ. Protect	72	64	96	42	32	306,000
Land Resource Quality	48	32	96	84	32	292,000
Prod. and Econ. Growth	72	64	96	42	32	306,000
Outreach	168	96	96	42	48	450,000
Totals	360	256	384	210	144	1,354,000

Step 3 for calculating host-country contributions: facilities and human-resources.

Program Area	Human Resources	Facilities	Total
	$ (000)		
Cons. & Environ. Protect	306,000	153,000	459,000
Land Resource Quality	292,000	146,000	438,000
Prod. and Econ. Growth	306,000	153,000	459,000
Outreach	450,000	275,000	725,000
Totals	1,354,000	727,000	2,081,000

Alternative B

Step 1 for calculating host-country contributions: projected distribution of professional services by target area.

Program Area	Project Leader BS	Project Leader MS	Project Leader PhD	Technician	Clerical	Potential Countries
	FTE					*Number*
Cons. & Environ. Protect	2	2	1	2	2	5
Land Resource Quality	2	1	2	4	2	5
Prod. and Econ. Growth	2	1	2	2	2	5
Outreach	7	3	2	3	3	21
Totals	13	7	7	11	9	—

Step 2 for calculating host-country contributions: projected contributions of professional services by target area.

Program Area	Project Leader BS	Project Leader MS	Project Leader PhD	Technician	Clerical	Potential Countries
	$ (000)					
Cons. & Environ. Protect	48	64	48	28	32	220,000
Land Resource Quality	48	32	96	56	32	264,000
Prod. and Econ. Growth	48	32	96	28	32	236,000
Outreach	196	96	96	42	48	478,000
Totals	340	224	336	154	144	1,198,000

Step 3 for calculating host-country contributions: facilities and human-resources.

Program Area	Human Resources	Facilities	Total
	$ (000)		
Cons. & Environ. Protect	220,000	110,000	330,000
Land Resource Quality	264,000	132,000	396,000
Prod. and Econ. Growth	236,000	118,000	354,000
Outreach	478,000	239,000	717,000
Totals	1,198,000	599,000	1,797,000