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An Evaluation of the USAID and Universities Collaborative Research Support Programs

Project No. 936-4200

Submitted to
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Submitted by
Tropical Research and Development, Inc.
Gainesville, Florida, USA

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Acronyms

AID	Agency for International Development
BIFAD	Board for International Food and Agricultural Development (renamed BIFADEC)
BIFADEC	Board for International Food and Agricultural Development and Economic Cooperation (originally BIFAD)
CCPP	Contagious caprine pleuropneumonia
CIAT	Centro International de Agricultura Tropical
CIMMYT	International Maize and Wheat Improvement Center (Centro Internacional de Meframento de Maiz y Bigo)
DNA	Deoxyribonucleic acid
IBSRAM	International Board for Soil Resources and Management
ICARDA	International Center for Agricultural Research in Dry Areas
ICLARM	International Center for Living Aquatic Marine Resources Management
ICRAF	International Centre for Research on Agroforestry
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IDRC	International Development Research Centre, Canada
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
IPGRI	International Plant Genetics Research Institute
IRRI	International Rice Research Institute
ISNAR	International Support to National Agricultural Research
ISPAN	Irrigation Support Project for Asia and the Near East
KARI	Kenyan Agricultural Research Institute
NCSU	North Carolina State University, Raleigh
NifTAL	Nitrogen Fixation by Tropical Agricultural Legumes
RAPD	Random amplified polymorphic DNA
UCD	University of California, Davis
UN-L	University of Nebraska, Lincoln
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

NOTE: Annex N contains an extensive list of acronyms and abbreviations, which are used more freely in annexes A through M of this document.

Preface

USAID has allocated a large proportion of its development assistance budget to international agricultural research. One mechanism is the Collaborative Research Support Program (CRSP) involving U.S. and host-country universities and other research organizations. Seven of the eight original programs receiving funds from USAID were agricultural in nature and were managed through the Office of Agriculture in the Center for Economic Growth of the Bureau of Global Programs, Field Support and Research. These CRSPs, focusing on subsistence crops (beans, cowpeas, sorghum, millet, and peanuts), soil management, small ruminants, and fish, were judged to have the greatest potential for impact in developing countries and are the focus of this evaluation. Through fiscal year 1993, USAID had allocated $209.6 million to the CRSPs.

While the major thrust of a CRSP is the generation of solutions to priority global problems through research, a concomitant objective is the development of research capability in the countries where the CRSP is functioning so that the developing countries can increasingly carry out independent research and assist neighboring countries. As stated in the CRSP Guidelines, "While the CRSP effort itself is not the principal vehicle to extend research results, it can and should establish scientific linkages and disseminate information to facilitate extension." The guidelines further state that each CRSP effort should include a component to demonstrate, on a pilot basis, the applicability of the research results obtained and that CRSP personnel should continue to manage research results until they can be passed along to an agency suitable for extending them. This may be accommodated through workshops, conferences, linkages with international centers, publications, and institutional programs in the United States. Application of results should take place where results were generated, in the developing countries or in the United States, as appropriate.

The effectiveness of the CRSPs is of increased interest as USAID seeks greater focus and concentration in its assistance programs. The CRSPs in reality are more than "projects" with indefinite completion dates—they are program frameworks for providing financial and technical support over an extended period.

The goal of this evaluation was to provide an objective assessment of the degree to which each of the CRSPs has had an impact on increasing agricultural production, fostering development, and improving natural resource management through the development and dissemination of new or more appropriate agricultural technologies. The evaluation assessed the extent to which the CRSP framework has responded to past USAID expectations and objectives and whether the CRSP model could be used to respond to continuing Agency needs and requirements.

Acknowledgments

The evaluation team wishes to acknowledge the assistance of the CRSP program directors and their staffs and the country coordinators, who worked most conscientiously and often for long hours to ensure the success of the evaluation. Within USAID, most of the burden of coordination and logistic support fell on the shoulders of Harry Rea, project officer for the pond dynamics and aquaculture CRSP. He accompanied the team on its visits to Thailand, the Philippines, and Honduras. His commitment to the task and continuing encouragement and support were appreciated and are thankfully acknowledged. Joyce Turk, project officer for the small ruminant CRSP and the bean/cowpea CRSP monitored the team's visits and provided logistical assistance and advice in Senegal, Niger, Kenya, and Indonesia. Charles Sloger, project manager for the soil management CRSP, accompanied the technical expert on soils on visits to Cornell and North Carolina State Universities and the team leader and the technical expert on soils on a visit to the University of Hawaii. Tropical Research and Development, Inc., and the Animal and Plant Health Inspection Service of USDA provided most of the logistic and administrative support throughout the evaluation.

The work of TR&D's John McLachlan-Karr, Carolina Zumaran, and Faith Knutsen is gratefully acknowledged.

Executive summary

THIS EVALUATION concerns the Collaborative Research Support Programs (CRSPs)—mandated in Title XII of the International Development and Food Assistance Act of 1975—between USAID and U.S. universities and other research organizations. Seven of the original CRSPs were agricultural in nature and focused on beans, cowpeas, sorghum, millet, peanuts, small ruminants, fish, and soil management. They are the subject of the evaluation.

The CRSPs were primarily oriented toward the generation of research solutions to priority global problems. They were intended additionally to strengthen research capabilities in developing countries. CRSP research was to be designed on a programmatic basis and was to address multisectoral, biological, physical, social, and economic constraints. CRSPs were to include components to demonstrate the applicability of results obtained. They were expected to make contributions to agriculture in both developing countries and the United States.

The goal of this evaluation is to provide an objective assessment of the degree to which the CRSPs have had an impact on increasing agricultural production, promoting economic development, and improving natural resource management. The evaluation assesses the extent to which the CRSP framework responded to USAID priorities and whether the CRSP model should be used to respond to future USAID needs.

In accordance with the CRSP concept, a lead university was chosen by the participating U.S. institutions to serve as a management entity, with policy direction coming from a Board of Directors elected by the participating institutions. The management entity was responsible for the program of work and was held accountable for USAID funds. A technical committee was established for each CRSP to develop work plans and budgets, review the technical progress of the research program, and propose modifications in the technical approach. The membership of a technical committee was generally drawn from the principal scientists engaged in the work of the CRSP. For each CRSP, there was an external evaluation panel to evaluate the status, funding, progress, and plans of the CRSP. The external evaluation panel members were appointed by the management entity after a process of consultation, which included the Board of Directors and USAID.

The evaluation team concludes that the minimum structure of management entity, Board of Directors, and technical committee are necessary for the proper management and governance of a CRSP and that a well-functioning external evaluation panel is critical to a CRSP's running smoothly and successfully. We believe that some of the management entities could manage larger programs than they have managed and that boards would benefit by the inclusion of external members. The tendencies for the technical committees to generate a level of expectancy and dependency

and to resist the inclusion of new scientists and institutions need to be dealt with. **External evaluation panels should be allowed greater opportunities to review the CRSPs as a whole, the frequency of reviews should be reduced, but the scope and intensity of each review should be increased.**

As reported to the evaluation team, the individual CRSPs received USAID authorizations to spend a total of $209,549,962, and they have disbursed $198,121,324 of those monies to date. Thus that the six CRSPs remaining of the seven evaluated (the fisheries stock assessment CRSP has reached its date of completion) currently have at their disposal a total of $11,428,638 in USAID funds to discharge all remaining obligations.

The management entities reported an aggregate CRSP cost-sharing contribution of $49,077,442. All participating universities reported matching their required cost-sharing contributions, and several stated that they have contributed at higher percentage levels. **The evaluation team concludes that these university contributions to support of the CRSPs are very positive indications of the universities' strong commitment to them. We believe that the contributions have been effectively used to meet well-defined CRSP objectives.**

Although the USAID CRSP grant agreements imposed no formal cost-sharing requirement on countries hosting CRSP collaborative research activities, four of the CRSPs reported a total of $55,33,306 in cash and in-kind cost-sharing contributions from the host tries in which they were working.

The major conclusion of the evaluation team with respect to financial management is that the management entities and the university and institute budgeting and accounting units charged with supporting CRSP research activities discharged their responsibilities in a professional manner. This performance is particularly impressive given the significant stresses incurred by USAID, the management entities, the participating universities, and the host-country agricultural research systems in an era of rapidly shrinking development resources.

The major problem cited by the CRSP management entities was USAID's inability to honor its financial commitments to the CRSPs in full and on time. That is, they lamented the gap of approximately $20 million to date between the original grant appropriations and actual grant authorizations. Funding cuts led directly to difficult decisions to discontinue specific research activities, close operations in host countries, prematurely discharge CRSP scientists and staff, and effectively eliminate entire CRSP components. Most of the management entities also voiced strong concerns about the persistent and inexplicable delays they experienced in receiving their annual funding authorizations from USAID. **The evaluation team concludes that CRSP operational efficiency has been seriously eroded by the instabilities inherent in USAID's overall operations. We believe most of these problems are solvable and that USAID management at the most senior level should eliminate the blockages in the existing system with dispatch.**

Each CRSP developed a broad program goal or a set of objectives as part of its initial grant proposal. **We conclude that the CRSPs have largely achieved their stated objectives.** They have educated many scientists from the United States, host countries, and other developing countries. They produced a massive quantity of research results and information, improved crop cultivars that were released for farmer use and made substantial contributions to the body of knowledge concerning tropical soils, agriculture, and fisheries. New techniques were developed that should substantially improve the efficiency and accuracy of fishery stock assessments and the productivity of pond aquaculture. New methods have been developed to identify, and in some cases to control, a wide variety of pests and diseases of crops and animals. Methods include the use of biological controls and integrated pest management to reduce the future use of pesticides and the detection of dangerous mycotoxins in harvested peanuts. New techniques developed in plant and animal breeding using modern techniques of DNA analysis and genetic engineering. Several CRSPs developed new computer software designed to improve the accuracy and timeliness of management interventions in commodity production.

Some objectives remain to be achieved. Uncompleted objectives include: the development of new food products of significant commercial value and the development of a multivalent vaccine for small ruminants. The pond dynamics and aquaculture (PD/A) CRSP has not completed the analyses of the results of its Global Experiment, and the soil management (SM) CRSP has not achieved its objectives to develop methods of technology transfer. USAID and the management entities of the CRSPs should determine which of the uncompleted objectives can be met before the grant activity completion dates, and USAID funds should be provided as necessary to bring them to fruition.

CRSP projects in U.S. universities were not particularly responsive to changing USAID priorities because they were established with long-term goals and tended to be oriented toward increasing the stock of scientific knowledge. The U.S. producer already has the institutional means available to translate that knowledge into marketable products. CRSP projects in the developing countries are more applied in nature and in several countries are fully in line with USAID Mission priorities.

Although CRSPs were discouraged from involving themselves in extension work, they had operational objectives relating to the transfer of technology. They were specifically permitted to expend funds on pilot projects to test the validity of new or improved technologies, and they were expected, over time, to become integrated into USAID's country strategies. There have been a sufficient number of Mission buy-ins to CRSP activities to prove that the CRSPs are responding to changing USAID priorities in developing countries. **We believe that the output from this type of activity has been satisfactory. There are other technological packages already developed by the CRSPs that could have impact over the next three to five years. They will require the involvement of persons and organizations outside the CRSPs for their utilization. We conclude that USAID should seriously consider assisting a follow-up, utilization phase of activities beyond the CRSPs.**

The CRSP model is already being used to address USAID's current priority emphasis on environmental protection. The new sustainable agriculture and natural resources management CRSP and the integrated pest management CRSP are tackling major environmental concerns. The soil management, pond dynamics and aquaculture, and fisheries stock assessment CRSPs targeted problems of resource degradation and the destruction of coastal ecosystems. They could become well aligned with and contribute to the new priorities if their research were more participatory. The commodity CRSPs and the pond dynamics and aquaculture CRSP serve USAID's emphasis on economic growth. They have contributed to growth in agro-industry and smallholder agriculture.

For purposes of this evaluation, CRSP impacts are understood to be the incremental net gains in efficiency or equity accruing to third parties from their adoption and use of technologies and management techniques developed through the use of CRSP resources. Some of the quantifiable CRSP impacts have included the financial gains to shrimp producers in Honduras from their adoption of lower-cost feeding techniques; the financial gains to Texas and Oklahoma sorghum growers and the economic gains to American consumers from adoption of CRSP-developed sorghum varieties with Greenbug resistance; the financial gains to smallholder farm families in Kenya who have obtained dual-purpose goats bred through the small ruminants CRSP; the financial gains to dry bean producers and the economic gains to societies in the United States, Mexico, Honduras, the Dominican Republic, and other countries who have adopted new bean cultivars and thereby improved domestic food security or exploited new export markets.

The evaluation team concludes that the pond dynamics and aquaculture, bean/cowpea, and small ruminant CRSPs to date have had the most impact per dollar spent in the developing countries. The sorghum/millet, bean/cowpea, and peanut CRSPs have had the most impact per dollar spent within the United States. Impact variability is inherent in both the differing objectives of the individual CRSPs and in the nature of the technologies they were attempting to generate over time. For example, the fisheries stock assessment CRSP was specifically designed to produce a manual on how to do stock assessments of marine fish populations. In the case of the soil management CRSP, the overall lack of quantifiable impacts to date is at least in part due to the long gestation period needed to develop and test technically sound and financially attractive soil management technologies under tropical condition.

All CRSPs to varying degrees enunciated their beliefs in multidisciplinary approaches to the planning and implementation of research projects and to the development and dissemination of appropriate and tested research results. Yet budget cuts more often than not meant that resources for the social science and economic components of an individual CRSP were the first to be cut. In some cases, entire university support programs in the social sciences were dropped. When questioned about these apparently disproportionate cuts, personnel at several management entities and universities said they supported the cuts on the advice of BIFAD officials and because USAID had never consistently pressed the CRSPs to monitor, evaluate, and document the impacts of their research activities. **The evaluation team concludes that future CRSP programs, particularly if they**

maintain their global focus, must be truly multidisciplinary, involving biological, physical, and social scientists in an integrated, mutually reinforcing way.

Nearly all the CRSPs viewed the enhancement of human capital for agricultural research as their most important achievement. More than 1,700 persons have received academic degrees with some level of CRSP support. Over the years CRSP-trained scientists have advanced in their careers, and many now head national research units and institutes, university departments, national research planning departments, and even national research agencies. **We conclude that the CRSPs have helped to create a legacy of scientific personnel, most of whom returned to their home institutions to continue their contributions to agricultural research management and national development policy.**

Research program directors in every country visited by the evaluation team stressed the importance of continued CRSP funding to sustaining their activities. Most recounted deteriorations in the capacities of their own governments to provide research funding significantly beyond what is necessary merely to pay salaries and benefits costs for existing researchers. While CRSP funding ameliorated these situations for certain disciplinary work on a temporary basis, **we conclude that the CRSPs have not been very successful to date in fostering greater governmental recurrent cost support for local research institutions.**

The direct beneficiaries of the CRSPs were predominately male. In some countries, few, if any, females were identified for long-term foreign training, especially at the Ph.D. level. Most of the U.S. professors involved in the CRSPs were also male. **The evaluation team concludes that the goal of gender equity was not clearly articulated from the outset and that accountability for it was not demanded by USAID project managers during the life of the program activities.**

Except for the peanut and bean/cowpea CRSPs, the CRSPs initially maintained expatriate country coordinators and scientists at their major host-country sites. Over time, most of these have been withdrawn—for budgetary reasons or because qualified national scientists (often trained by the CRSPs) became available to assume their responsibilities. USAID Missions and host-country principal investigators were generally not convinced of the value of expatriate scientists. **The evaluation team concludes that expatriate country coordinators and scientists are now seldom necessary or advisable. Where they still exist, a time-bound training program should be instituted for their replacement.**

There is much advantage to be gained from CRSP involvement with developing country universities that have strong postgraduate programs and the ability to train future scientists to do research on resource management and CRSP commodities. **We recommend that the CRSPs work to ensure a critical mass of scientists in a range of disciplines, trained in several universities—and increasingly at the best national and regional ones—with at least the minimum of equipment, facilities, and communication links to be effective.** As host-country agricultural research systems and universities gather

strength, in part because the CRSPs have increased the professional skills of their scientists, and as the CRSPs move toward regionality, the significance of research and information networks is bound to increase. **We conclude that the CRSPs should, in future, be more active in supporting appropriate regional networks.** Because the international agricultural research centers also support such networks and complement the work of the CRSPs in other ways, **we further conclude that the CRSPs and the international agricultural research centers should actively pursue opportunities for more intensive, mutually beneficial cooperation including the formulation of collaborative research projects.**

The CRSPs have done much to increase knowledge of tropical agricultural systems and helped participating U.S. universities gain knowledge, experience, and access to improved technologies for several commodities. **We conclude that the CRSPs clearly increased the institutional capacities of U.S. universities.** The U.S. producers of beans, peanuts, sorghum, millet, sheep, goats, shrimp, and fish have been the beneficiaries.

The evaluation team's recommendations include:

(a) USAID should continue to give high priority to agricultural and agribusiness development, including agricultural research.

(b) The implementation of the provisions of Title XII of the Foreign Assistance Act through the CRSP model, having yielded substantial benefits to U.S. and developing country agriculture, should be continued.

(c) The operative CRSP model has certain deficiencies: resource allocations are not sufficiently based on a rigorous evaluation of the merits of research proposed or undertaken; management structures are duplicative and therefore more costly than necessary; and there is a perception of an entitlement without time bounds and without periodic accountability. We have made recommendations to overcome these deficiencies.

(d) In allocating the remaining resources available to the CRSPs, high priority should be given to projects that protect the investments already made in trained personnel of the national agricultural research systems and universities in developing countries.

(e) If additional funds are provided to support the existing CRSPs, they should be allocated to the following items in priority order as listed:

    (i) research on major global or regional problems that require long-term, concentrated multidisciplinary efforts;

    (ii) collaborative and cooperative projects with selected universities in developing countries;

    (iii) regional networks for applied agricultural research and for information exchanges; and

    (iv) formal collaborative projects between CRSP institutions and the international agricultural research centers.

(f) CRSP *programs* should have specific objectives and should include statements of anticipated benefits for developing countries and the United States, and CRSP *projects* should provide specific statements of expected research project outputs.

(g) If USAID wishes to assess the impacts generated by CRSP-like activities in the future, the overall budget for the program should contain a specific line item allocating funds that can only be used for conduct of impact assessments.

(h) Selection of host-country site for CRSP activities should consider the probable efficacy of each country's sectoral infrastructure for dissemination of projected CRSP research outputs, and USAID missions should be represented in substantive planning of these activities to increase the likelihood of technology transfer.

(i) USAID should provide funding to projects designed to promote the utilization of proven technology packages developed by the CRSPs by U.S. and developing country producers and in host-country program supported by USAID missions.

(j) USAID should issue a new policy statement on the roles within the organization of livestock and fisheries research and promotion.

The evaluation team considers that lessons learned for the future include:

(a) Title XII legislation has led to a perception of "entitlement" among participating institutions that is not always a positive force in research design and implementation.

(b) The CRSPs as designed and implemented have faced unresolved dichotomies between research and development activities, and in allocating resources between global and local research needs.

(c) When new scientific knowledge is sought through CRSP projects, it should have a strategic character, applicable within a reasonable time to ameliorating targeted development constraints.

(d) Universities have placed great emphasis on the training outputs of the CRSPs, and USAID needs to recognize that universities are more likely to produce high quality training outputs than generate technological outputs.

(e) Activities directed at dissemination of CRSP research outputs and generation of impacts cannot be effectively mounted by CRSP scientists alone but require the active participation of persons with additional skills and perspectives.

Evaluation Report

1. Introduction

WORLD TRADE in crop, livestock, fishery, and forest products amounts to $500 billion a year, with developing countries accounting for one quarter of exports and a little less of imports. Most commercial crops and animals traded in the world today have their origins in the developing countries. Wheat, rice, and potatoes are three of the most obvious examples. Many countries produce the same crops, grow the same livestock, and catch the same fish. The United States is both a major exporter and importer of foodstuffs, often importing and exporting different varieties of the same commodity.

Increased agricultural trade increases the possibility of transporting diseases and pests throughout the world. Annual global losses in crop production due to pests and diseases are on the order of U.S. $300 billion. The cost of pesticides used for their control is estimated by FAO to be in the region of $20 billion annually, and the portion of this cost borne by developing countries is a major drain on their financial reserves. It has been estimated that pests destroy one-third of the potential harvest in the United States, which means the losses in grain exceed the quantities available for export. These losses have tended to increase in absolute terms and as a percentage of the crop since the 1940s because of changes in production practices, including the shift from crop rotations to monocultures, the increased use of fertilizers and irrigation, and, by no means least, the continuing importation of exotic pests. The well-publicized periodic outbreaks of fruitfly infestations in California serve to underline the importance of this problem. Many pests and diseases that attack crops elsewhere remain outside the United States, and although they represent only a potential threat, it is a wise precaution to study the biology and control of these organisms where they are presently located against the likelihood of their arriving, unwelcome, in the United States. Two examples illustrate the point. In the southern United States a recent outbreak of a peanut virus disease was controlled because, fortuitously, a scientist from India, expert in the disease and its biology, was working there temporarily and was able to advise growers and scientists on suitable control measures. Rinderpest, a devastating disease of cattle, has not yet appeared in the United States. If it were to be introduced, vaccines developed for Africa could be used to reduce its incidence.

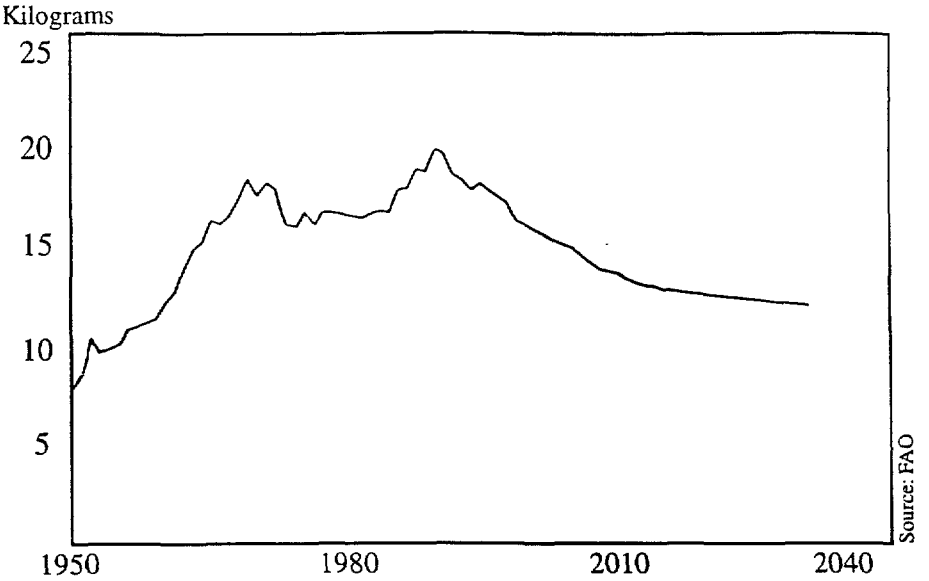
Notwithstanding the substantial increases in productivity and production of agricultural commodities over the last fifty years, global food insecurity is accelerating. World grain production and fishery catches per person have decreased in the last few years and are projected to decline substantially over the next twenty to thirty years (figure 1, p. 5). The trends are of particular concern in the developing world where agriculture is the key to reducing rural poverty and to sustainable development. Most of the poor in developing countries live in rural areas and most are smallholder farmers or agricultural laborers. In their desperation poor people put increasing stress on marginal natural resources, public institutions, and the public order. Development that includes these side effects is not sustainable.

In the past, declining resource productivity and soil degradation have been largely

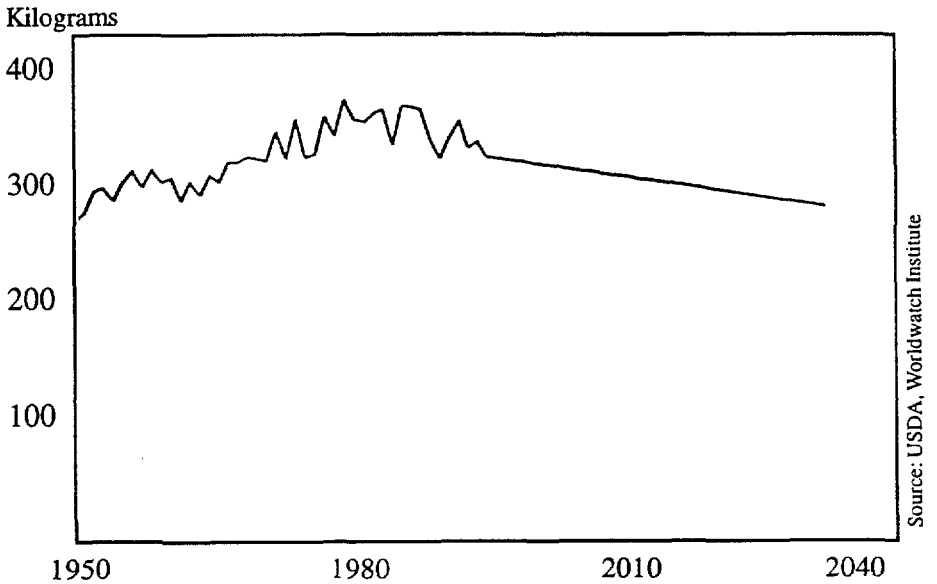
regarded as physical problems. In recent years, however, it has been recognized that these threats to human welfare are not only physical but also social and institutional in origin. The measures to counter them require both multidisciplinary and integrated strategies and include adjustments in policies, values, and institutional structures. Elliot Berg, editor of the 1993 publication *Rethinking Technical Cooperation Reforms for Capacity Building in Africa*, quotes the Development Advisory Committee of OECD as follows:

> Progress toward sustained, more equitable, and self-reliant development depends critically on the strength and quality of a country's institutional capacity. Contributing to this objective must therefore be an essential purpose of development cooperation in general and technical cooperation in particular. An aid activity cannot be regarded as successful unless it has contributed to strengthening the local institutions through which and for which it works.

Figure 1. Projections of World Fish and Grain Harvests per Capita



World fish harvest per person, 1950–92 (projected to 2030)



World grain output per person, 1950–93 (projected to 2030)

Source: *State of the World 1994*, Lester R. Brown, et al. (New York: W.W. Norton 1994), pp. 182, 186.

2. The collaborative research support programs

2.1. Origin and organization of CRSPs

In 1975, the United States Congress amended the Foreign Assistance Act of 1961 to include a new Title XII on famine prevention and freedom from hunger. The Congress declared that the United States should strengthen the capacity of the land grant and other eligible universities in program-related agricultural institutional development and research and improve their participation in U.S. government efforts to apply agricultural sciences to the goal of increasing world food production. They recognized the substantial contributions made by the land grant universities to agricultural progress in this country. Congress also recognized that agricultural research abroad contributes to the agricultural productivity of this country and that the universities were increasingly involved in international programs. The universities needed dependable sources of funds to continue and expand these efforts in the developing world. In order to implement these policy directives, the executive branch was requested by Congress to involve the land grant universities in cooperative government efforts with agricultural institutions in developing countries and with regional and international agricultural research centers. These efforts were to be directed at building and strengthening the institutional capacities and human resource skills of developing countries in agricultural instruction, research, and extension. For the purposes of this Act, agriculture was defined to include marine fisheries and aquaculture. The Act provided program support for long-term, collaborative university research on food production, distribution, storage, marketing, and consumption.

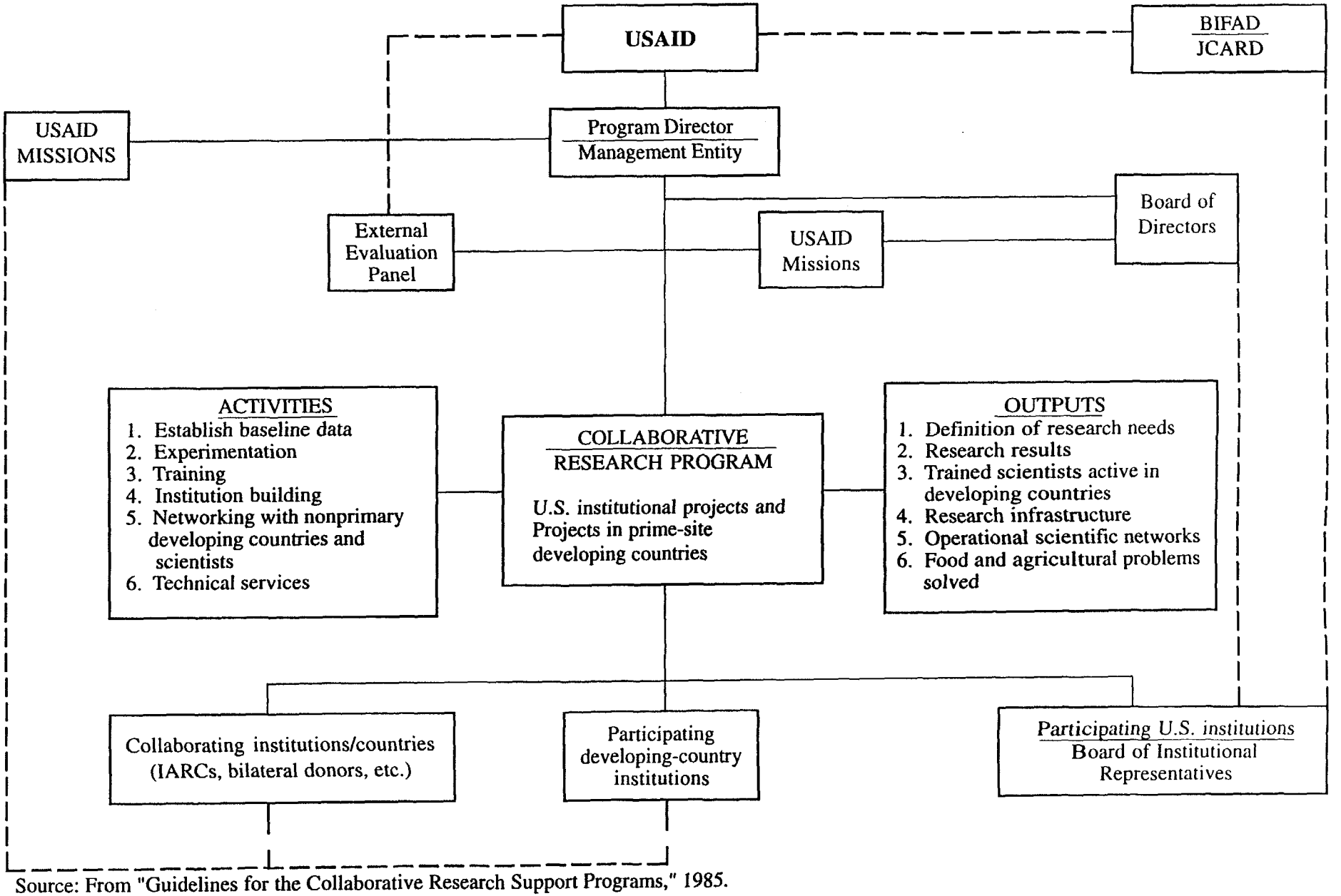
To assist in the administration of the programs authorized under the Act, Congress provided for a permanent Board for International Food and Agricultural Development (BIFAD, later known as BIFADEC). BIFAD was to participate in the formulation of basic policies, procedures, and criteria for program design, implementation, monitoring, and evaluation. It was to recommend which developing countries would most benefit from the program and to identify those that would be capable of participating in them. To the maximum extent possible, programs were to be designed to achieve the most effective international dissemination of the land grant model of instruction, research, and extension in agriculture. They were to focus on local problems and farmer needs and be carried out in developing countries. Finally, programs were to take into account their value to U.S. agriculture and integrate their research as practicable with that supported by other federal and state resources. BIFAD was authorized to establish such subordinate units as it deemed necessary to assist it in carrying out its responsibilities. Congress authorized the use of funds additional to any allotments or grants that might have been made under other authorizations and specifically stated that the "universities may accept and expend funds from other sources, public and private, in order to carry out the purposes of the Title [XII]." The administration of USAID and the leadership of the land grant colleges responded to the establishment of this new initiative in foreign technical assistance. BIFAD was established with a Secretariat provided by USAID. Two committees, later combined, were set up for research and country development. After much con-

sultation between the universities, the concept of the Collaborative Research Support Program was developed and implemented in carrying out the provisions of the Act. The latest guidelines for the program, developed jointly by BIFADEC and USAID, set forth these directives:

- CRSPs are to have the goal of improving agriculture, both in the developing countries and the United States;
- the participating universities would agree to match at least 25 percent of the domestic cost of the CRSP from state or other nonfederal resources;
- CRSPs would achieve collaboration between scientists of participating U.S. and developing country institutions;
- host-country governments would contribute to the program from their resources in cash or kind;
- the research would be designed on a program, rather than a project, basis and address biological, physical, social, and economic constraints;
- for each CRSP, the participating U.S. universities would choose a lead institution to serve as a management entity, with policy directions coming from a Board of Directors elected by the participating institutions;
- USAID would exercise its management responsibilities through the management entity which was, in turn, to be responsible for the program of work and accountable for the use of obligated funds;
- the aim of each CRSP would be to become integrated into USAID's country strategies and provide scientific research support to related, in-country U.S. technical assistance programs;
- linkages would be established with the international agricultural research centers, with research institutions of developed countries, and with scientists in nonparticipating U.S. universities; and,
- the research work of each CRSP was to be evaluated periodically by an external evaluation panel composed of highly qualified scientists from institutions not involved in the program.

The organization, activities, and outputs of a typical CRSP are shown in the accompanying diagram (figure 2). Each CRSP was required to have a global plan, updated periodically, stating the objectives and strategies for achieving the agreed objectives. In selecting country sites, the commodity, fishery, or other subject to be researched must have been shown to be important to the economy of that country. The chosen countries also were expected to have sufficient institutional capacities for collaboration. Commitment and support by the host-country (HC) government was to be demonstrated. The

Figure 2. Organization, Activities, and Outputs of a Typical Collaborative Research Support Program



Source: From "Guidelines for the Collaborative Research Support Programs," 1985.

USAID Regional Bureau and appropriate Missions were to agree, in advance, that the programs could proceed. To ensure cost effectiveness, the major research efforts were to be carried out in a minimum number of countries for each CRSP. Various linkage mechanisms were to be devised and utilized to spread the outputs and results.

The alleviation of world problems of food, nutrition, and poverty requires considerable expansion of the body of relevant scientific knowledge and of proven agricultural technologies. When the CRSPs were established, developing countries, particularly in Africa, required much more assistance in resource- and institution-building before they could realistically expect to be fully involved in solving their agricultural and fishery production problems.

2.2. Methodology of the evaluation

To evaluate this set of programs, USAID assembled a team with wide experience in agricultural research and extension in the tropical world. Tropical Research and Development, Inc., provided six members of the team: the team leader, agricultural economist, and four experts in research, one each on soils, crops, small ruminants, and marine fisheries. The United States Department of Agriculture provided a social scientist and an expert in aquaculture. This team assembled in Washington, D.C., in late April 1994 to plan its itinerary and procedures. The team received a statement of work (annex A) developed through in-depth discussions within USAID, and was presented with a tentative itinerary planned jointly by USAID and Tropical Research and Development, Inc. The itinerary required travel to ten universities involved in the CRSPs, mainly those where the management entities (MEs) were located, and eight developing countries, in each of which two or more of the CRSPs were or had been active. The intent was that the core team, composed of the team leader, agricultural economist, and social scientist, should visit all universities and countries and that the technical experts would travel more selectively, each visiting only locations where a CRSP related to his expertise was active.

At USAID headquarters, the team and the CRSP project managers attended an initial briefing by the acting director of the Office of Agriculture. The team later met with the project managers, along with representatives of the Board for International Food and Agricultural Development and Economic Cooperation (BIFADEC) Secretariat, the international organization staff of the Office of Agriculture, and representatives of the central Program Office, and the Regional Bureaus.

The agreed-upon itinerary was largely followed by the team, but it was enlarged to include several more universities and one additional country (annex J). Six days were provided for planning, design of procedures and questionnaires, and team discussions. The preparatory phase was followed by three weeks of travel within the United States with a maximum of two days at any one university followed by eight weeks of travel overseas with approximately one week in each country. The team traveled as a unit as much as possible. Within a country, because several CRSP sites had to be visited in only four or five days, the team was required to split into smaller parties. When such divisions occurred, at least two members of the team went together, normally one member of the core team and the appropriate technical expert.

A pattern of meetings was established early in the travels and was generally followed in the visits to U.S. universities. At the beginning of a visit, the team participated in an open meeting with the program director and staff of the management entity, the Board of Directors, technical committee (TC) representatives, principal investigators (PI) from the host university and from other universities, graduate students, and representatives of the university administration. Following the open meeting, the core team generally met with the program director and representatives of the Board of Directors; it also visited the office of the management entity. Technical experts went with technical committee representatives and principal investigators to review research programs in depth and visit and examine facilities and equipment provided to the CRSP or obtained with CRSP funds. Generally, the team leader or core team met with the director of international agriculture programs, the director of the agricultural experiment station and extension service where available, the dean or vice-chancellor of agriculture, and, in some instances, with the president or chancellor of the university system. The team agricultural economist spent time with the contracts administration of the university, and the team social scientist and technical experts discussed training experiences with the students who were available. At several universities, representatives of U.S. producer associations and private firms were present in the open meetings and made comments and presentations to the team. The program directors of the management entities or, in their absence, the directors for international agricultural programs, made the arrangements for these contacts and meetings. At the universities without management entities, lead principal investigators undertook this responsibility.

Similar meetings were organized and held in the eight host countries visited. Responsibilities for coordinating the country visits were assigned by the CRSP Council to program directors of the CRSPs as follows: the sorghum/millet CRSP for the visits to Mali, Niger, and Honduras; the small ruminant CRSP for the visits to Kenya and Indonesia; the pond dynamics and aquaculture CRSP for the visit to Thailand; and the peanut CRSP for the visit to the Philippines.

Over the life of the program, forty-two U.S. universities and forty-two countries have been involved or are currently involved in the seven CRSPs. Because visits to all of them were out of the question, the team developed a set of questionnaires during its days in Washington and while in traveling status within the United States to elicit answers to questions raised in its statement of work. Questionnaires were sent to each management entity, the lead principal investigators at all participating universities, the lead principal investigators in host-country universities and national agricultural research systems, USAID Missions in countries where CRSPs were active, the directors-general of the international agricultural research centers with collaborative projects or close contact with the CRSPs, and to nongovernmental and private voluntary organizations. Completed questionnaires have been reviewed and analyzed by team members (the statement of work is appended as annex A).

This report has been prepared in accordance with USAID's Handbook sections on evaluation methodology and report format. The major sections of the report conform with the Handbook definitions and requirements for their format and contents.

3. Findings

IN THIS section, we present information and data we have obtained about the more important scientific achievements, technological outputs, training outputs, linkages, and management structure of the CRSPs. Our assessment of this information is found in chapter 4, "Analysis and conclusions."

3.1. Scientific achievements and technological outputs

The CRSPs have produced a wealth of scientific achievements and technological output. These include scientific publications, chapters in books, proceedings of scientific conferences and seminars, new scientific methods, improved varieties of plants and breeds of animals and improved technological packages. These outputs are described in annexes B through H. The following is a brief selection.

3.1.1. Small ruminant CRSP accomplishments

- Developed and registered a dual-purpose composite goat for milk and meat production in farming areas of higher potential.
- Developed the Sei Putih breed of hair sheep (composed of 50 percent Sumatra, 25 percent St. Croix, and 25 percent Barbados Blackbelly) intended for grazing under tropical tree crops.
- Developed a test in Brazil for identifying immune response to the bacterium that causes caseous lymphadenitis, a worldwide disease of sheep and goats.
- Developed a new vaccine against contagious caprine pleuropneumonia (CCPP).
- Developed a grazing scheme for sheep under rubber trees in Sumatra, which has reduced weed infestations as well as cutting the use of herbicides by 50 percent.
- Evaluated forage crops from various parts of Kenya and other tropical countries to determine their suitability for western Kenyan conditions.
- Demonstrated that nutrient supplementation of tropical grasses improved growth and reproduction of Javanese Thin Tail sheep and growth of Kacang goats.

3.1.2. Sorghum/millet CRSP accomplishments

- The sorghum conversion program initiated at Texas A&M University, partially funded by the CRSP, allowed breeders to develop sorghum varieties of various heights and degrees of sensitivity to daylength, making them adaptable anywhere in the world.

- Developed parental lines with characteristics that include:

  Pearl millet

  - Cytoplasmic male sterility
  - Improved downy mildew resistance
  - Greater tolerance to drought

  Sorghum

  - Downy mildew resistance
  - Head smut resistance
  - Anthracnose resistance
  - Sorghum midge resistance
  - Greater tolerance to heat, drought, and salinity
  - Reduced tannin content for improved consumer acceptability
  - Improved bird resistance
  - Improved nutritional quality

- Released varieties in joint effort with International Crops Research Institute for the Semi-arid Tropics (ICRISAT), other international agricultural research centers, or the national agricultural research system include:

  - Malisor 84-7 headbug resistant sorghum for Mali
  - Sorghica Real 40 and Real 60 acid-soil tolerant sorghums for Columbia
  - Sureño, Tortillero, and Catracho hybrids for Honduras
  - SRN 39 striga tolerant sorghum for Sudan and Niger
  - Hageen-Dura 1 (HD-1) high food-quality sorghum for Sudan
  - Dwarf grain pearl millet (Nebraska)
  - NAD-1 and Sepon-82 (released in Niger based on Texas sorghum germplasm)
  - Greenbug (Biotype E) resistant sorghum used in many commercial sorghum releases

3.1.3. Bean/cowpea CRSP accomplishments

- Crossed tepary bean and common bean (*Phaseolus* spp.) for the first time carrying the heat tolerance of tepary bean into *Phaseolus*.

- Made significant impact in microbial management of insect pests of cowpea in Brazil.

- Developed a low-cost method to manufacture cowpea flour requiring shorter cooking time in Africa.

- Developed and successfully tested a simple low-cost technical package of storage practices that can destroy all stages of the cowpea weevil in stored cowpeas.
- Released PC-50, a high-yielding rust-resistant dry bean with fine quality grain preferred by consumers in the Dominican Republic.

- Developed several new varieties for bean producers in Michigan, New York, Nebraska, Colorado, and Wisconsin.

3.1.4. Soil management CRSP accomplishments

- Enhanced understanding of important soil processes, including soil erosion processes by water and wind, nutrient cycling by legumes, trees, and dust, and macropore flow with attendant effects on water and nutrient transport in the soil.

- Helped collaborators improve their soil inventories and their overall understanding of the land resource base.

- Experiments at Yurimaguas, Peru, developed several alternatives to slash-and-burn agriculture. Each hectare under sustainable management practices saved many more hectares per year from deforestation. These savings included 11 hectares with irrigated rice system, 4.6 hectares with the low-input systems, 8.8 hectares with continuous cropping, and 10.5 hectares with legume-based pastures. These systems also can enable farmers to grow as many as seven consecutive staple crops where previously they could grow only one or two.

- Identified constraints including high acidity, aluminum toxicity, calcium deficiency, low phosphorus availability, and subsoil compaction, and developed simple technologies to alleviate these constraints, thereby revolutionizing agriculture in the Cerrado region of Brazil and in acid savanna ecosystem elsewhere in Latin America.

- Mixed farming systems for sustainable management of acid soils in Sumatra, Indonesia, include fallowing *Mucuna* to prevent erosion, improve nitrogen availability, and control *Imperata cylindrica*; establishing vegetative barriers on the contour; developing paddy rice systems for lowlands; and identifying agrisilvicultural systems for upland areas.

- Conducted experiments that showed experimental plots cleared with chain saws and machetes produced yields 22 percent higher than plots cleared with bulldozers. (In addition to scraping away topsoil, bulldozers caused subsoil compaction and accelerated soil erosion.)

3.1.5. Peanut CRSP accomplishments

- Made interspecific cross of the wild *Arachis* species with domestic peanuts to achieve greater resistance to nematodes and viral diseases.

- Isolated genetic materials exhibiting high or low fatty acid characteristics.

- Developed a rapid, accurate, low-cost method for detection of aflatoxin in peanuts.

- Developed a more complete genome map of the peanut, paving the way for more efficient genetic transformation.

- Developed a low-cost method using clay absorption to detoxify aflatoxin in peanuts.

- Release of Fleur II variety in Burkina Faso.

- Release of NC9, NC10, and NC11 black rot resistant Virginia Market lines for North Carolina.

- Release of drought resistant Spanish market type and runner type peanuts for Texas and Oklahoma.

3.1.6. Pond dynamics and aquaculture CRSP accomplishments

- Developed the world's largest standardized database on tropical aquaculture with over 1.5 million observations on 96 variables.

- Conducted 41 different production system experiments in Honduras to determine which pond management systems are appropriate for various intensities of production, then determined economic returns and performance from enterprise budget analyses.

- Determined that relatively low water temperatures in ponds in Rwanda affect fish growth directly rather than indirectly through a reduction of phytoplankton productivity.

- Released the expert systems PONDCLASS versions 1.1 and 1.2 that are designed to provide practical guidelines for fertilization and stocking rates for fish ponds.

- Developed economically efficient fertilizer strategies for Thailand to maximize tilapia production.

- Developed five fish production systems in Honduras and evaluated each for economic optimization and biological efficiency.

- Developed lower cost shrimp feeding regimes in Honduras for different stages of the growing-out process.

3.1.7. Fisheries stock assessment CRSP accomplishments

- Reports of scientific achievements are included in the book *Advances in Stock Assessment of Artisanal Fisheries* (in press). Chapter titles included: Age Determination in Fisheries Biology, Coral Reef Sampling Methods Relevant to Fisheries Management, Hydroacoustic Methods, Time Series Analysis, and Empirical Methods and Models for Multispecies Situations.

- Designed the Catch at Size Analysis (CASA) programs to determine the optimum gill

net mesh size and fishing effort to obtain optimum yield from a fishery while dealing with the need to maintain an adequate spawning biomass.

- Created new empirical methods and analytical models that permit the assessment of multispecies tropical fish stocks from existing fisheries databases.

- For widely used and well-known techniques in fisheries stock assessment, compiled programs into a set of computer software with a relatively simple user interface. Documentation and instructions (purpose of each assessment method, nature and format of data involved, program output) accompany the software.

3.2. Training outputs by CRSPs

3.2.1. Introduction

The CRSPs conducted a wide variety of training programs as a part of their overall activities. Indeed, the representatives of the universities interviewed by team members invariably stated that academic training was the strongest point of the delivery of outputs by the CRSPs. Another important aspect of CRSP training was the use of workshops, seminars, symposia, and short courses to extend the results of research to scientists, managers, producers, and other key participants. This section of the report discusses both academic and outreach aspects of CRSP training.

3.2.2. Formal training

A major output of the CRSPs was trained people. According to statistics provided to the technically expert team members, a large number of trainees received CRSP support for academic degrees. According to the information provided to the evaluation team by the management entities, 1,770 trainees distributed among all seven of the evaluated CRSPs received CRSP support. The sorghum/millet CRSP trained the most, 622; followed by small ruminants with 384; bean/cowpea with 318; peanut with 145; soil management with 122; pond dynamics and aquaculture with 121; and fisheries stock assessment with 56 (tables 1 and 2). Not all the CRSPs collected data on trainees in the same way, but it can be stated that, overall, 30 percent of the degree recipients were female while 70 percent were male. Likewise, 64 percent of the degree recipients were of non-U.S. origin (mostly from developing countries), while 36 percent were from the United States. The different CRSPs had very different proportions of female trainees. Bean/cowpea was the highest at 44 percent; small ruminants was 35 percent; peanut was 28 percent; pond dynamics and aquaculture was 26 percent; sorghum/millet and fisheries stock assessment were 25 percent each and, soil management was 12 percent. On average, training resources were twice as likely to be used to support males trainees for long-term formal degree training as to be used to support females.

Specifically, what counted was CRSP support, and this differed, often substantially, from case to case. Some trainees had full scholarships for an overseas Ph.D. degree at a U.S. university, while others received small amounts of support for thesis-research 1

Table 1. CRSP university degree training

CRSP	Ph.D. U.S.	Ph.D. Non-U.S.	M.S. U.S.	M.S. Non-U.S.	B.S. U.S.	B.S. Non-U.S.	Totals U.S.	Totals Non-U.S.
Small ruminant[a]	33	73	41	171	1	62	75	306
Sorguhm/millet	99	221	96	198	15	22	210	441
Bean/cowpea	21	53	36	107	6	95	63	255
Soil managem't[b]	29	56	25	24	n/a	n/a	54	80
Peanut	19	21	16	84	-	5	35	110
Pond dynamics and aquaculture	2	13	10	38	-	58	12	109
Fisheries stock assessment	9	8	17	22	-	-	26	30
Totals	212	445	241	644	22	242	475	1,331

a. Based on percentage of non-U.S. students from the total number of students who completed degree training.
b. Based on M.S. and Ph.D.s conferred to students. No information on gender of B.S. degree recipients available.

Table 2. CRSP university degree training by gender

CRSP	Ph.D. M	Ph.D. F	M.S. M	M.S. F	B.S. M	B.S. F	Totals M	Totals F
Small ruminant[a]	84	22	146	66	42	21	272	109
Sorghum/millet	258	62	204	90	23	14	485	166
Bean/cowpea	41	33	77	66	60	41	178	140
Soil managem't[b]	68	16	44	6	n/a	n/a	112	22
Peanut	29	11	72	28	4	1	105	40
Pond dynamics and aquaculture	11	4	40	8	38	20	89	32
Fisheries stock assessment[c]	7	2	13	4	22	8	42	14
Totals	498	150	596	268	189	105	1,283	523

a. Numbers based on percentage of total muber of academic degrees awarded. Note: SR-BA and B.V.M./D.V.M. degrees were also conferred.
b. Totals calculated from Ph.D. and M.S. degrees conferred. Gender for individuals receiving B.S. degrees unknown.
c. Based on a total of 42 students for whom gender data were available.

expenses or for travel to conduct research. It would be incorrect to attribute all the related human resource development to the CRSPs, but the evaluation team recognizes that the training activities of the CRSPs were extremely useful to the programs and institutions they were intended to support. The formal training of personnel from participating the national agricultural research systems and other host-country institutions was an extremely important contribution to the soil management CRSP, which owes a measure of its impact and sustainability to the graduate students trained with CRSP support, some of whom now occupy leadership positions in their respective institutions.

Although the CRSPs have not, in general, collected or analyzed this type of information, many CRSPs have reported that a significant number of trainees in the developing countries have achieved key positions within host-country institutions. The exceptions to this rule were the small ruminant CRSP (annex B) and the impact study on the humid tropics, sponsored by the soil management CRSP (annex E), in which trainees' subsequent activities were reported.

3.2.3. Informal training

Another important aspect of CRSP training was the use of workshops, seminars, symposia, and short courses to extend the results of research to scientists, managers, producers, and other key participants despite the reports from various CRSPs that training activities were curtailed because of management decisions or budget restrictions or both. Many CRSPs undertook technical training that ranged from informal training sessions to formal workshops lasting several days. Participants at these sessions included farmers, technicians, extension workers, project personnel, and host government administrators. For example, in the past 15 years, approximately 2,000 host-country participants attended over 100 sessions supported or sponsored by the small ruminant CRSP. The bean/cowpea CRSP, too, sponsored a large number of short courses both in the United States and in developing countries. The pond dynamics and aquaculture CRSP also reported a large number of training activities in developing countries involving farmers and extension personnel. None of the CRSPs provided the evaluation team with information on the overall gender breakdown of informal training.

3.2.4. Training

Development of "human capital" has been a major output of the program, and over time will likely have a major impact in developing countries as these trained people move into positions of greater responsibility in their countries. An exception to this rule is the pond dynamics and aquaculture CRSP. Although the pond dynamics and aquaculture CRSP recognized that human resources development was critical to sustainable development in aquaculture, nevertheless the first external evaluation panel's (EEP) triennial review in 1985 recommended that training be restricted to prevent deviations from the central research objectives of the program. Training, especially formal degree training, was never emphasized by this CRSP.

The vast majority of the formal trainees are men. This means that the CRSPs training

programs probably did little to change opportunities for women and may have served mostly to reinforce the gender biases in the institutions from which they came.

3.3. Linkages

3.3.1. The CRSPs and the international agricultural research centers

CRSPs share responsibilities with the international agricultural research centers for research on basic food crops of the developing world. The relationships are shown in table 3. In addition, the international agricultural research centers (in particular International Support to National Agricultural Research [ISNAR]) are involved in strengthening national agricultural research systems in the developing countries by means that include short-term training, skill replenishment, and the provision of opportunities for post-graduate education. The International Food Policy Research Institute (IFPRI) shares some responsibilities with the CRSPs for socioeconomic research and the International Plant Genetics Research Institute (IPGRI, previously called the International Board of Plant Genetic Resources) for conservation of plant germ plasm. With the exceptions of the International Board for Soil Resources Management (IBSRAM) and the International Fertilizer Development Center (IFDC), all of the international agricultural research centers cooperating with the CRSPs are members of the Consultative Group for International Agricultural Research (GIAR) and all receive funding support from USAID.

There is a good record of cooperation between the CRSPs and the centers, particularly with regard to the crop commodities. Cooperation takes many forms. Scientists from the CRSPs and the centers work together on common problems (e.g., peanut viruses) and exchange plant germ plasm. The CRSP and international agricultural research center scientists are often graduates of the same universities, where they frequently were classmates. The international agricultural research center scientists have served on CRSP external evaluation panels, boards, and technical committees. The CRSP scientists have served on evaluation teams and as scientific liaison officers with international agricultural research center program committees and boards. There is some evidence of competition among CRSP and center scientists in the production of new crop varieties, but no more so than is found between scientists from different universities working within the same CRSP.

Table 3. Relationships between international agricultural research centers (IARCs) and CRSPs

IARC[a]	Small ruminant	Sorghum/ millet	Bean/ cowpea	Soil management	Peanut	Pond dynamics and aquaculture	Fisheries stock assessment
CIAT		C	C	C			
CIMMYT		R		C			
CIP				R			
IBSRAM				C			
ICARDA	R			R			
ICLARM						C	C
ICRAF	R			C			
ICRISAT		C		C	C		
IFDC				C			
IFPRI	R	R					
IITA			C	C	R		
ILCA	C						
ILRAD	C						
IPGRI		R	R		R		
IRRI				C	R		
ISNAR	R	R	R	R	R		

C = Active cooperation with CRSP.
R = Conducting activities related to some CRSP objectives.

a. See p. vi for list of acronyms.

The CRSPs and the centers complement one another's activities. The CRSP scientists, particularly within U.S. universities, are often more involved in basic research than scientists in the centers. The most noticeable difference, however, is the heavy emphasis that most of the CRSPs give to postgraduate education. Many scientists have received M.S. and Ph.D. degrees, wholly or partly with CRSP support. The centers have offered far fewer such opportunities, and they themselves are not degree-granting institutions. This difference is exemplified by the agreement between the sorghum/millet CRSP and the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) in southern Africa by which ICRISAT donors provided funds for postgraduate training, the national agricultural research system, ICRISAT, and the sorghum/millet CRSP jointly developed a regional training program with the Southern African Center for Agriculture Research, and the sorghum/millet CRSP was responsible for placing the students in appropriate advanced degree programs in the United States and elsewhere.

Both the CRSPs and the centers are involved in plant and animal breeding and in plant protection, but no center is doing research on the health of small ruminants. The

centers, more than the CRSPs, are involved in physiolgoical and agronomic research. The crop commodity CRSPs are much more involved in food processing, storage, and utilization research than the centers that work on these crops.

The centers have more integrated and focused socioeconomic programs than the CRSPs and have conducted more thorough studies of the impact of center research. In 1984, for example, the CGIAR undertook an in-depth study of the centers' total impact. Individually the centers have published independent studies relating to assessment of the value of benefits derived from their research and training activities.

As table 3 indicates, several of the centers are engaged in research on soil management. Although no figures are readily at hand, the total of the centers' research in this area substantially exceeds the investment in soil management by the CRSPs. The international agricultural research centers have responded more quickly and completely than the CRSPs to the concern for research on sustainable agriculture. Several centers (CIAT, ICARDA, and IITA) have redirected their programs substantially toward sustainable agriculture and farming systems by involving physical, biological, and social scientists in well-integrated programs of research, including long-term studies on watersheds.

3.3.2. Networking

Although the CRSPs have forged many collaborative linkages among researchers in the United States and overseas, they have not provided much in direct financial support to formal networks for research and information in the developing countries. The small ruminant CRSP was instrumental in forming the Indonesian Small Ruminant Network (ISRN) and the Small Ruminant Network for Asia (SRUPNA), which is now supported by the International Development Research Centre (IDRC). The Latin American Small Ruminant Network (RERUMEN) was originally located in Peru, but it was moved to Bolivia in 1993 after the murders of CRSP researchers by local terrorists. Cessation of CRSP activities in Peru had a detrimental effect on the network. It is just now becoming fully functional again. Its electronic bulletin board is accessed through the Internet. The small ruminant CRSP in Africa has collaborated with the African Small Ruminant Research Network, supported by the International Livestock Center for Africa, but this network has not been very effective.

The sorghum/millet CRSP has participated in sorghum and millet networks in Africa but has not been their major contributor. In western Africa, the USAID Semi-arid Food Grains Research and Development project supported a network during the project's lifetime. That network, now called POLSORGHUM (French acronym), functions under the guidance of the *Institut d'Economie Rural* in Mali with funding from the African Development Bank. The pearl millet network, ROCAFEMI (French acronym), based at the ICRISAT Sahelian Center in Niger and supported by the Swiss Government, includes active participation by the sorghum/millet CRSP country coordinators. In southern Africa, country coordinators participate in the Southern African Centre for Cooperation in Agricultural Research sorghum network based in Zimbabwe. In Latin America, the sorghum/millet CRSP has been an active participant in such established regional

networks as the Programa Cooperative Centroamericano para le Mejoramiento de Cultivos Alimenticios and Consejo Latinoamericana de Investigadores en Songho. The CRSP assisted ICRISAT in servicing and encouraging the Latin America Sorghum Improvement Program until funding constraints led to its collapse.

The bean/cowpea CRSP participated in the Semi-arid Food Grains Research and Development project cowpea network in west Africa, while it existed, and continues to be involved in Southern African Centre for Cooperation in Agricultural Research's regional activities in beans and cowpeas in southern Africa. It participates actively in the scientific exchange activities of the U.S. Bean Improvement Cooperative.

Together with national institutions in Latin America, the soil management CRSP established and supported the *Red de Investigación de Suelos Tropicales* (RISTROP) in 1986. The network is now self-sustaining.

The peanut CRSP is an active supporter of regional research on peanuts in west Africa and has provided critical support to an informal network on rosette virus. It conducts much of the regional research on insect pests and co-hosts meetings of group scientists. Peanut scientists in the region have voiced their concern that the research network may not be able to continue without CRSP support. In the United States, the American Peanut Research and Education Society is a powerful integrating force in peanut research. Its annual meetings, regularly attended by CRSP peanut researchers from many countries, provide both a forum to discuss the latest advances and an opportunity to lay plans for cooperation and collaborative activities. The CRSP has provided critical support to an informal network on rosette virus.

Regional aquaculture research planning in Asia and the Pacific occurs through the Network of Aquaculture Centers in the Asia–Pacific (NACA) and the Southeast Asian Fisheries Development Center (SEAFDEC), with both of which the pond dynamics and aquaculture CRSP is associated. The United National Development Programme and the Food and Agriculture Organization of the United Nations support an aquaculture research program in Zimbabwe called "Aquaculture for Local Community Development." One promising linkage facilitated by the pond dynamics and aquaculture CRSP is between the Asian Institute of Technology and Auburn University's International Center for Aquaculture and Aquatic Environment. It seeks to develop collaborative strategies for aquaculture development in Indochina.

The fisheries stock assessment CRSP participates in the Coastal Living Resources project, supported jointly by ASEAN and the Australian Government.

3.4. Management structure

3.4.1. Management entities and program offices

Each CRSP has a designated management entity chosen by and from the participating U.S. universities and hosted by one of them. The management entity is accountable

programmatically and fiscally to USAID. Operating funds for the management entity are provided through the CRSP grant. The universities may choose to change the management entity according to CRSP and BIFAD guidelines and changes have been proposed for two CRSPs.

The lead institution, usually with the advice and consent of the participating U.S. universities, appoints a program director and such staff as are deemed necessary for adequate implementation of the CRSP. With few exceptions, the program directors of all the CRSPs are employed full-time. Several of the CRSPs have full- or part-time associate or assistant directors as well as administrative and secretarial support (table 4).

In four CRSPs, the program director reports to the dean of International Agricultural Programs located within the College of Agriculture or its equivalent. The program director of the peanut CRSP reports to the director of Agricultural Experiment Stations. The program's Management Office and the program director are not located within the university's agricultural administration in only two CRSPs, the small ruminant CRSP, where the program director reports to the vice-chancellor of research, and the pond dynamics and aquaculture CRSP, where the program director reports to the dean of International Research and Development.

Although USAID grant documents specify that management costs for each CRSP should not average more than 20 percent of the total USAID funds during the life of the grant, all CRSPs have boards, technical committees, and external evaluation panels; and their management responsibilities to the grantor are about the same. The smaller CRSPs believe that their management costs are underfunded. Evidence suggests that the use of buy-in funds has proved necessary in one case to supplement the office staff to enable management functions to be effectively discharged.

3.4.2. Boards of Directors

Each CRSP is required to have a Board of Directors. The numbers of members and the manner in which they are selected are left to the individual CRSP (table 5). The boards of all CRSPs are largely composed of senior-level administrators from the participating U.S. universities and, for the sorghum/millet, pond dynamics and aquaculture, and fisheries stock assessment CRSPs, these are the only members except for the program director and the USAID project manager, who serve ex officio. Where the numbers of universities participating in a CRSP are fairly large, they are represented on the board by the management entity plus other universities serving on a rotating basis. Initially the board of the soil management CRSP was composed of representatives of the participating universities plus the two ex-officio members.

The Guidelines allow the CRSPs to appoint administrative councils comprising management representatives from all participating U.S. universities where the board is not able to accommodate them. The small ruminant CRSP created a council, which is no longer functioning because of budgetary constraints. This council included representatives from all U.S. participating universities and two host countries.

3.4.3. Technical committees

A technical committee was established for each CRSP with membership drawn from the principal investigators, except for the sorghum/millet CRSP technical committee, which differs in that it has an appointed committee of scientists representing different disciplines. The CRSP project director and the USAID project manager serve as ex-officio members of a technical committee, which meets to develop work plans and budgets, review the technical progress of the total research program or components thereof, propose

Table 4. Locations and Staffing of the CRSP Management Entities

CRSP	Management entity	Program director	Assoc./asst. program director	Additional staffing	Reporting	Location
Small ruminants	UCD	Part-time (80%)	Full-time	1	V.-C. Research	Univ. Admin.
Sorghum/millet	UN-L	Part-time (49%)	Full-time	3	OIAP	Inst. Ag. & N.R.
Bean/cowpea	Mich. St. U.	Part-time (75%)	Full-time	2	IIA	Coll. Ag. & N.R.
Soil management	NCSU	Full-time	None	2	OIAP	Coll. Ag. & Life Sciences
Peanut	U. Ga	Full-time	Full-time	1.4	Dir. Expt. Stat.	Coll. Ag.
Pond dynamics and aquaculture	Oregon St. U.	Full-time	Part-time (50%)	0.5	Off. Int. R&D	Univ. Admin.
Fisheries stock assessment	UM-CP	Part-time (50%)		0.5	OIAP	Coll. Ag.

modifications in the technical approach, and recommend allocations of funds. The technical committee reports its findings to the management entity, which normally shares them with the Board.

The sorghum/millet CRSP has a unique committee named the Ecogeographic Zone Council. It is responsible for planning and implementing collaborative sorghum/millet activities in research, training, and networking. Membership consists of one principal investigator from each of the ecogeographic zones plus one at-large member recommended by the management entity. Membership in the council is determined by the Board of Directors. Composition of the council is reviewed annually.

3.4.4. External evaluation panels

For each CRSP, there is an external evaluation panel to evaluate the status, funding, progress, and plans of the CRSP. The CRSP Guidelines suggest that the external evaluation panel be large enough to cover all the scientific disciplines involved in the CRSP, normally up to five members. The term of each member of the external evaluation panel is normally five years. Where all disciplines cannot be covered by the limited number of members, membership should rotate among disciplines.

Candidates for external evaluation panel membership are appointed by the management entity after a process of consultation with the board, the USAID project manager, and BIFADEC. According to the CRSP Guidelines, the management entity submits nominations for external evaluation panel membership through the USAID project manager to BIFADEC for concurrence, which makes its recommendations to USAID for final acceptance. The appointments are made by the management entity. Nevertheless, there is some perception within USAID and elsewhere that the external evaluation panel is not sufficiently independent.

The external evaluation panels are required to make annual reviews of varying depth of a CRSP's activities and to report their findings and recommendations to the management entity and the Board, with a copy to BIFADEC and USAID. An in-depth review, including visits to host-country sites, is required from time to time on an approximate three-year cycle or immediately prior to preparation of any continuing grant proposal, or both. These in-depth reviews were expected to coincide with the USAID administrative and management review, but these reviews have not always occurred simultaneously.

The external evaluation panel was expected to evaluate annually the performance and productivity not only of the CRSP as a whole but of each project and participating institution. The external evaluation panels were designed to be counterbalancing forces to institutional biases and other centripetal forces within CRSPs. For these reasons, an external evaluation panel's report was presented formally to the CRSP management entity and to its Board of Directors, with copies to BIFAD and JCARD through the project officer for use in the triennial review. The management entity is expected to prepare constructive response to the evaluation panel's findings and recommendations was expected. In practice, the external evaluation panels have been unable to review each

project annually (the soil management CRSP alone has about 100 research projects), but they have reviewed all projects over time and particularly during in-depth reviews.

The number of members of an external evaluation panel ranges from two to six, with the lower numbers associated with the smaller CRSPs. Many renowned scientists and administrators from both the public and private sector and from domestic and international organizations serve on external evaluation panels. Some former project directors have served on the external evaluation panels of other CRSPs, and a few people have served on the external evaluation panel of more than one CRSP. Through this mechanism there has been some cross-linking between CRSPs. For in-depth reviews, where the number of members is less than five, membership is supplemented. Because of funding constraints, the peanut CRSP has reduced the frequency of external evaulation panel's reviews to every other year.

Table 5. Memberships of boards, technical committees, and external evaluation panels of the CRSPs

CRSP administrative body	Board members	Admin. council	Technical committee	Ecogeographic zone council	External evaluation panel
Small ruminant	7	12	13		5
Sorghum/millet	5		6	7	5
Bean/cowpea	5		8		4
Soil management	6		8		3[a]
Peanut	5		6[a]		7[a]
Pond dynamics and aquaculture	3		9		3[a]
Fisheries stock assessment	3		5		2[a]

a. Panels and committees may have more than the number of members indicated.

3.4.5. CRSP financial situation

Table 6 presents the latest information reported by the CRSP and USAID on the financial status of the individual CRSPs. As reported to the evaluation team, the individual CRSPs have received actual USAID spending authorizations totaling $209,549,962. This means that the present gap between the initial funding of $229,325,088 appropriated by USAID and what has actually been authorized for CRSP research is $19,775,126 to date. The CRSPs have already dispersed $198,121,324 of the authorized funds. This means that the six continuing CRSPs (the fisheries stock assessment CRSP has been completed) currently have at their disposal a total of $11,428,638 in USAID funds to discharge all their research and management obligations. Of these six continuing CRSPs, the small

Table 6. Summary of CRSP Financial Management Indicators

CRSP	Total USAID appropriations	Actual USAID authorizations	Actual USAID funds disbursed	Reported university cost sharing	Reported host country cost sharing	Reported total buy-ins	Reported other levereged funds
Soil management	$ 38,946,000	$ 34,003,000	$ 31,607,000	$ 5,564,250	$ 13,309,750	$ 5,500,000	$1,654,480
Sorghum/millet	47,232,202	46,720,002	46,720,002	11,779,754[a]	3,886,916[a]	20,639,232[a]	n.r.[b]
Bean/cowpea	48,007,927	41,458,000	38,212,409	8,287,679	6,353,982	1,222,765	767,000[c]
Fisheries stock assessment	6,000,000	5,614,000	4,581,320[d]	1,286,889	n.r.[b]	0	0
Pond dynamics and aquaculture	12,200,000	12,119,000	10,925,373	2,960,706	3,828,581	1,855,001[e]	n.r.[b]
Peanut	23,456,961	20,455,929	18,232,029	4,033,114	n.r.[b]	1,457,800	3,800,000[f]
Small ruminant	53,366,000	48,777,031	47,843,182	15,845,149	31,860,743[g]	1,670,000	934,287
Totals CRSP	$229,209,090	$209,146,962	$198,121,315	$48,470,652	$59,239,972	$32,344,798	$7,155,767

Sources: Information compiled from financial documentation supplied by the individual CRSPs in July and August 1994 and the information contained in the Evaluation Team's Scope of Work.

a. University cost share, host-country cost share, and buyins reporting only for current grant, 1990–95.
b. Not reported.
c. The sum of $767,000 in 1993 only, plus $109,697 from the 1980–86 grant budgeted for doing host-country audits.
d. Research costs only reported; figure does not include management entity costs.
e. Figure for project years 1989 to 1994 only.
f. Federal and state contributions to the University of Georgia research funds for peanuts.
g. Figure for project years 6 to 14 only.

Table 7. Summary of CRSP Management Costs

CRSP	Direct management costs	Percent of actual disbursements	Indirect management costs	Percent of actual disbursements	Total management costs	Percent of actual disbursements
Soil management	$ 2,190,000	6.93	$ 1,128,000[a]	5.56	$ 3,318,000[a]	10.50
Sorghum/millet	3,754,060[b]	8.04	1,478,184[b]	3.16	5,232,244[b]	11.20
Bean/cowpea	4,708,590[c]	12.32	2,132,289[c]	5.58	6,840,879[c]	17.90
Pond dynamics and aquaculture	1,589,337[d]	14.55	560,763[d]	5.13	2,150,100[d]	19.68
Peanut CRSP	n/a	---	n/a	---	3,263,945[e]	17.90
Small ruminant	n/a	---	n/a	---	7,009,600[f]	14.65

Source: Information repored by the individual CRSPs in July and August 1994.

a. Reported against actual disbursements of $31,607,000.
b. Reported against actual disbursements of $46,720,002.
c. Reported against actual disbursements of $38,212,409.
d. Reported against actual disbursements of $10,925,373.
e. Reported against actual disbursements of $18,232,039.
f. Reported against actual disbursements of $47,843,182.

ruminant, soil management, and peanut CRSPs are scheduled to end before the end of FY 1995. The bean/cowpea, sorghum/millet, and pond dynamics and aquaculture CRSPs are currently scheduled to continue until the end of their respective grants, and each is in the process of developing a continuation proposal. Each of these CRSPs is operating at present with limited USAID funding and unknown prospects for the amounts and timing of additional program authorizations.

3.4.6. University and host-country cost sharing

As shown in table 7 (page 27), the CRSP report an aggregate CRSP cost-sharing contribution of $49,077,442 from the participating U.S. universities. These funds amount to 23.4 percent of *total* USAID CRSP funding provided to date even though the 25 percent cost-sharing requirement only actually applies to that portion of the total USAID funding spent in the United States. All participating universities reported matching at least the required 25 percent minimum cost-sharing contribution, and several stated that they have contributed a higher percentage. One institution, Oregon State University, stated that it routinely reports only the minimum 25 percent contribution for USAID accounting purposes, even though its actual cost-sharing contributions are much higher.

Although the USAID CRSP grant agreements impose no formal cost-sharing requirement on countries hosting CRSP collaborative research activities, four of the CRSPs reported a total of $55,343,306 in cash or kind cost-sharing contributions from the host countries in which they are working. These contributions amount to 26.4 percent of the total USAID CRSP funding actually provided to date.

3.4.6.1. Buy-ins and other leveraging of CRSP funds

The CRSPs report aggregate leveraging of nongrant funding totaling $28,476,535 in buy-ins and $4,676,697 from other sources against total USAID CRSP funding to date of $209,549,962. If the unsolicited cost-sharing contributions from the CRSP host countries are included in funds leveraged by CRSP initiatives, then a total of $88,496,538 has been raised against a total USAID investment of $209,549,962. In other words, leveraging has increased available CRSP funding to 142.2 percent of the total USAID grant contribution to date.

3.4.6.2. Management costs and financial flows

For the six CRSPs reporting in July/August 1994, a total of $27,814,768 in management costs has been expended to administer a total of $189,230,005 in actual CRSP disbursements. This amounts to an overall management cost of 14.7 percent of total CRSP disbursements. The management costs for individual CRSPs range from a low of 11.2 percent to a high of 19.68 percent. There is no clear relationship between the individual CRSP management cost and the total disbursements they have processed.

4. Analysis and conclusions

4.1. Relevance

4.1.1. Global and national needs

Each CRSP came into being through an elaborate planning process involving (BIFAD) USAID, and an independent planning entity chosen using USAID's procurement procedures. The process, described in some detail in the CRSP Guidelines, ensured that work on global problems was identified as the goal of the CRSPs. These goals were subsequently translated into objectives and logical frameworks (annex L).

As the CRSPs have been implemented and have evolved, the objectives and the directions of the research have been subtly modified. Part of the price for ensuring the involvement and commitment of financially strapped host-country institutions and the USAID Missions is that pressing national problems and changing U.S. priorities be accommodated.

The small ruminant CRSP.— The research of the small ruminant CRSP closely followed the original plan, with modifications based on experience. The program was global in the sense that it had projects in the main agroecological zones in which small ruminants were important and was aimed at smallholder problems.

The evaluation team found that current collaboration between U.S. and host-country institutions and scientists is notably effective. But the program was designed without host-country participation, which resulted in several research projects being thrust upon host countries without consideration of their national priorities, examples of which are the fertility work in Indonesia and the simulation modeling in Kenya.

The commodity crop CRSPs.—The bean/cowpea, peanut, and sorghum/millet CRSPs, collectively termed the commodity crop CRSPs, addressed nearly all of the major identifiable biotic and edaphic constraints to increased crop productivity. Disease constraints were high on the list for beans and peanuts, and insect problems for cowpeas. All gave strong emphasis to plant breeding. Although new varieties and hybrids have been produced by the CRSPs, greater emphasis has been given to the production of improved germ plasm which was seen, correctly, as more likely to serve the needs of both the U.S. seed industry and host-country scientists. Basic research was accomplished by the CRSPs on biotechnology, mapping plant genomes, and the nature of pest organisms (their accomplishments are summarized in the annexes to this evaluation).

For these CRSPs, we conclude the existence of a seed industry in the host country has had significant bearing on successful utilization of improved cultivars. This criterion for success has not been considered in all the countries in which the CRSPs have been working. Relevance becomes a moot question if research results cannot be extended to the producer, processor, and consumer.

All three of these CRSPs also made modest investments in food technology. **We conclude, however, that the global importance of this work is questionable, with the conspicuous exception of the work on peanut aflatoxin**, even though it certainly contributed to strengthening departments of food science and technology in U.S. and host-country universities.

The soil management CRSP was originally oriented to the problems of marginal, that is, less productive, lands. This was clearly relevant to the Title XII emphasis on less advantaged farmers, and these lands were considered to be most threatened by unwise use and by population increase. Major investments were made in soil management of deforested lands of the humid tropics, with a smaller investment in the sandy soils of semiarid western Africa, and the smallest investment in the problems of the potentially more productive soils of the subhumid savannas of South America. Not surprisingly, the visible economic impact has been greatest in the last agroecological zone.

More recently, the soil management CRSP has become involved in studies aimed at maintaining arable farming by smallholders on very steep lands in Honduras (p. A-87). Early results seem to show that soil erosion is not a serious problem under farming systems. **We conclude, therefore, that the soil management CRSP should consider investing in research on crops in alternative land management systems and on programs based on perennial crops that will foster reduced farming pressure on these very steep lands.**

The pond dynamics/aquaculture CRSP.—The centerpiece of the pond dynamics and aquaculture CRSP has been its global experiment designed to describe the physical, chemical, and biological principles of tropical pond environments in diverse agroecological zones. It has provided a wealth of information that, when analyzed, will further the scientific understanding of the complexities associated with pond aquaculture systems. There were initial concerns that the experiments were rather elementary. In addition, there were host-country concerns about the feasibility of fish culture, questions about the relevance of a global experiment, and interest expressed in more intensive systems. These concerns were not addressed until the Fourth Workshop Plan, when special topic research was included in the program. Since that time, host-country support has increased dramatically. The research retains a global approach through standardized methods and data reporting. The CRSP has provided critical scientific data for land-use policies involving aquaculture in Rwanda and for shrimp farming regulations in Honduras. **We conclude that it addresses the globally relevant issue of harmonizing aquaculture development with environmental and natural resource conservation.**

The fisheries stock assessment CRSP.—The fisheries stock assessment CRSP researchers imposed limits on their work, both to focus their research and to forestall duplicating the work of other researchers in the field. Thus, in Costa Rica, for instance, work was focused by choice on the artisanal corvina fisheries rather than on the more valuable but industrialized shrimp fishery. The fisheries stock assessment CRSP researchers also avoided duplicating the work of Food and Agriculture Organization of the United Nations, the International Center for Living Aquatic Marine Resources Management (ICLARM), and other non-CRSP researchers who were also working in tropical fish

stock assessment and preparing assessment training courses and associated software. Coral reef studies in the Philippines by the fisheries stock assessment CRSP have shown the specific negative effects of present reef-fishing methods. Solutions, now being pursued by Philippine authorities, have been offered for improving management of coral reef fisheries and for ameliorating the fishery-associated problems.

The long-term relevance of the fisheries stock assessment CRSP lies in its contributions to the process of improving the assessment of the stocks of tropical marine fishes, at both the theoretical and applied levels. Outputs and results from the fisheries stock assessment CRSP speak to and are directed at fishery scientists and researchers. **We conclude that USAID should provide assistance for extension of the fisheries stock assessment CRSP results to fishery managers and policymakers, despite the fact that initial planning for the fisheries stock assessment CRSP did not provide for extension of its research to fishery managers or policy makers.**

4.1.2. USAID priorities

USAID strategies change with time and as new approaches to development find favor. CRSP projects in U.S. universities have not been particularly responsive to these changing priorities. They were established with long-term goals and tend to be orientated toward increasing the stock of scientific knowledge. U.S. producers already have the institutional means to translate research findings into marketable products. CRSP projects in the developing countries are more applied, for obvious reasons, and in several countries they are fully in line with USAID Mission priorities.

In our interviews with USAID Mission personnel, it was evident that most of them did not see their Missions as having any proprietary interest in or "ownership" of CRSP activities in their countries. This perception was prevalent across Missions irrespective of whether individual Mission personnel had maintained good relationships with CRSP scientists and staff over time. Interviewees in general felt that the CRSPs and their in-country research activities were largely the product of negotiations between USAID Washington and participating U.S. universities. With the exceptions of Niger overall, Honduras for the pond dynamics and aquaculture CRSP, and Kenya for the small ruminant CRSP, Mission personnel did not express beliefs that their Missions had ever had substantive roles in planning, implementing, monitoring, or evaluating in-country CRSP activities except for buy-ins. Most respondents saw themselves as having been put in the role of CRSP administrative support, without much real control over CRSP activities in a programmatic sense.

Some CRSPs and USAID Missions have not had good relationships. Some Missions felt that CRSP research did not relate to Mission strategic objectives or host-country priorities, that CRSP scientists did not encourage adequate transfers of information, that the Missions were used only for host-country clearances and other administrative necessities. CRSP scientists, on their part, found some Missions unsympathetic to the global nature of CRSP projects and to the fact that direct beneficiaries of CRSP activities included participating U.S. universities and personnel.

We conclude that there have been a sufficient number of Mission buy-ins to CRSP activities to prove that the CRSPs are capable of responding to changing USAID priorities. Yet success, or the lack of it, often seems to be more related to the preferences of individual Mission directors or ADOs or to disputes between the USAID's Global and Regional Bureaus, all situations that USAID management could resolve if it wished to.

USAID has recently published a new Strategic Plan for Sustainable Development. Its fundamental thrusts include building indigenous capacity. **We conclude that the CRSPs have demonstrated a comparative advantage in building indigenous capacity but they are still learning effective methods for enhancing the use of the participatory approach in their programs.** They could become better aligned with the new USAID priorities if their research were more participatory.

We believe the CRSP model is an effective mechanism, already being used by USAID in collaboration with universities and private voluntary organizations, to address priority areas for environmental protection. The soil management, pond dynamics and aquaculture, and fisheries stock assessment CRSPs have targeted problems of resource degradation and the destruction of coastal ecosystems. The new sustainable agriculture and natural resource management CRSP and integrated pest management CRSP are tackling major environmental concerns.

Finally, the commodity crop CRSPs and the pond dynamics and aquaculture CRSP already serve the USAID goal of fostering economic growth. All have had measurable economic impacts and have contributed to growth in agribusiness and smallholder agriculture.

4.2. Effectiveness

4.2.1. Fulfillment of objectives

As part of its initial grant proposal, each CRSP developed a program goal or a set of objectives. The goals were usually broad in scope, e.g., "to increase grain sorghum and pearl millet production in those countries where they are a principal food crop." Objectives included improving research capabilities in the United States and developing countries; developing and adapting improved technologies and production systems; developing improved cultivars of plants and breeds of animals, and devising methods for reducing losses due to pests and postharvest deterioration of products. Other objectives were to develop new and improved products, to improve the economic position of producers, to expand the body of scientific knowledge, to extend benefits of research and experience to U.S. producers, and to provide training to scientists in developing country.

The evaluation team concludes that to a substantial degree the CRSPs have achieved their original objectives. They have educated many scientists from the United States, host countries, and other developing countries. They have produced a massive quantity of research results and information, bred improved crop cultivars that have been

released for farmer use, and substantial contributions have been made to the body of knowledge on tropical soils, agriculture, and fisheries.

Objectives to develop new methods have also been substantially achieved. New techniques have been developed that should substantially improve the efficiency and accuracy of fishery stock assessments and improve the productivity of pond aquaculture. New methods have been developed to identify and in some cases control a wide variety of pests and diseases of crops and animals. These methods include the use of biological control and integrated pest management to reduce the future use of pesticides. Progress has been made in the detection of dangerous mycotoxins in harvested peanuts. New techniques have been developed in plant and animal breeding utilizing modern techniques of DNA analysis and genetic engineering. Several CRSPs have developed new computer software designed to improve the accuracy and timeliness of management interventions in commodity production.

The CRSPs working with soils, small ruminants, peanuts, and cowpeas have achieved objectives to develop improved production systems involving these commodities and resources, although the sustainability of these systems has yet to be proven through farmer practice and experience.

But we also conclude the CRSP have not accomplished all of their objectives. The commodity crop CRSPs have not been able to develop new food products of significant commercial value. The small ruminant CRSP has not achieved its objective to develop a multivalent vaccine and its breeding program for dual-purpose goats has been much delayed. The pond dynamics and aquaculture CRSP has not completed the analyses of the results of its global experiment. The fisheries stock assessment CRSP has not developed its proposed manual for use by fisheries managers, although it has produced a large book for publication that contains some chapters that might be considered to serve the same purpose. With the exception of NifTAL and SMSS, two long-standing USAID-supported programs that were merged into the CRSP two years ago, the soil management CRSP has not achieved its objective to develop methods of technology transfer, although an "acid soils decision support system" appears to be nearing completion. **We conclude that USAID and the management entities of the CRSPs should determine which of the uncompleted objectives can be met before the grant activity completion dates and that USAID funds should be provided, as necessary, to bring them to fruition.**

It is difficult to determine when broad goals and nonspecific objectives have been adequately met. Even long-term programs need specific short-term objectives, particularly since normal USAID design guidelines call for articulation of an overall goal, purpose statements, statements of specific objectives, and a logical framework statement. **In the interest of good management and accountability, we conclude that more specific and preferably more modest objectives should be established for CRSPs in the future.**

4.2.2. Effectiveness of the CRSP mechanism

The basic concept of the CRSP mechanism envisioned a community of U.S. and host-country institutions sharing the task of resolving major constraints to the production and

use of selected commodities and the management of natural resources. The effectiveness of the management entities, therefore, must be judged not only by the extent to which they enabled CRSPs to reach agreed upon objectives but also the extent to which they encouraged the sharing of responsibilities. **We conclude that four of the management entities, i.e., those for the sorghum/millet, bean/cowpea, peanut, and fisheries stock assessment CRSPs, were highly successful in this regard.** The peanut CRSP achieved a quality of sharing and cooperation that embraced not only participating U.S. and host-country institutions but also ICRISAT and other institutions in developing and developed countries as well.

The question arose in the boards of changing the management entity of both the small ruminants and soil management CRSP. This suggests that the participants were not entirely happy with the leadership they were offered. In both CRSPs there were on occasions poor personal relations between university administrators and project directors. In the small ruminant CRSP, there was the perception that the host university was not adequately committed to the role of management entity, and in the soil management CRSP that the host university exerted too much influence. The pond dynamics and aquaculture management entity had problems with perceptions of imbalance relating to one of the participating universities and between biological and social scientists.

External reviews acknowledge that the boards operate in accordance with CRSP Guidelines, but the styles and effectiveness of the boards differ markedly. In general, the boards provide adequate policy directives to the CRSPs and perform their duties well in commenting annually to the management entity on the performance of the project director and management office. However, they seldom comment upon the quality or usefulness of the research undertaken or provide direction to the technical committees, and those boards composed solely of institutional members display some tendencies to vote along institutional lines..

The major management issue concerning the boards is their relation to the management entity. Legally the management entity is responsible for the CRSP. It is held accountable by USAID for the expenditure of grant funds and the execution of agreed CRSP objectives. The board is, in effect, advisory to the management entity in spite of the fact that the participating U.S. and host-country universities and research agencies are as much, and, in a few cases, even more involved in the work of the CRSPs than are the management entities. The management entities of the sorghum/millet, bean/cowpea, and peanut CRSPs state that they have never overruled their boards, but the boards' advice has been ignored on occasions by the management entities of the small ruminant and soil management CRSP. There have also been differences between the board and the management entity of the pond dynamics and aquaculture CRSP. The management skills of project directors, employed by management entities but evaluated by the boards, have not always been equal to the circumstances.

We conclude that the boards have generally been effective in meeting the requirements of the CRSP Guidelines and that they have on occasion taken quite decisive action to deal with persistent problems. A good example is the decision of the small ruminant CRSP board to terminate the program in Bolivia.

The technical committeess have generally performed two tasks in the CRSPs. The first is to review research project formulation, implementation, and achievements; the second is to review project budgetary allocations and recommend future project budgets. The two are of course closely linked. In general, the technical committees appear to have performed the task of scientific evaluation well, but several of them have run into difficulties in making budgetary decisions, particularly decisions to terminate their own projects and recommend support to the new projects of other scientists. For example, social and computer scientists complained the technical committee of the pond dynamics and aquaculture CRSP, dominated by biologists, made it difficult to integrate their disciplines into the program, and where decisions were made by taking a vote, the votes tended to follow institutional lines. In the sorghum/millet CRSP, the creation of the Ecogeographic Zone Council (an alternative technical committee) was perceived as necessary by several U.S. university and host-country participants.

Several of the technical committees were perceived to be "closed shops" by the external evaluation panels and USAID. They were warned that they were endangering the continuation of their CRSPs by resisting requests to open CRSP projects to competitive bidding. USAID insisted that the small ruminant CRSP open its doors to competitive bidding in preparing a new proposal for fiscal years 1996 to 2000. Several principal investigators did not submit projects for consideration. Of those who did, only one was accepted.

We conclude that the minimum structure of management entity, Board of Directors, and technical committee is necessary for the proper management and governance of a CRSP. We believe that some of the management entities could manage larger programs than they have, and that Boards benefit from the inclusion of external members. The tendencies for the technical committees to establish "closed shops" may be handled through external peer-review input, the establishment of a balancing committee such as the sorghum/millet CRSP's Ecogeographic Zone Council, or by regular election of members to represent the necessary range of scientific disciplines.

Like the boards, the external evaluation panels have generally carried out the duties outlined in the CRSP Guidelines. They have conscientiously reviewed the research programs and projects of the CRSPs and made comments on management. Every external evaluation panel report contains recommendations for improvements in research performance and quality. On the other hand, the evaluation team was told several times that the external evaluation panels were not sufficiently independent of the CRSPs, and there appears to be some truth in this assertion. Sometimes people have been selected who were too closely associated with the CRSP. Because of the high frequency of reviews, some members developed too high a stake in the CRSP and some USAID program managers encouraged external evaluation panel members to adopt a mentoring rather than evaluating attitude. On at least one occasion, a management entity tried, inappropriately, to influence an external evaluation panel's judgment. Nevertheless, the CRSPs generally respected the role of the external evaluation panels and tried to find people who would do the job well. It is to be noted that USAID has not written up any complaints or voiced any major concerns about the performance of the external evaluation panels or the quality of their reports. There have been external evaluation panel

members who have not performed very well, but no external evaluation panel member has ever been removed for cause before the end of his or her term.

The evaluation team was impressed by the quality of the reports of the external evaluation panel for the sorghum/millet CRSP. Prepared under the leadership of a senior officer of a major U.S. seed company, the reports contained strategic vision and useful comments to the CRSP on opening its doors to new ideas and participants. The external evaluation panel of the bean/cowpea CRSP was also conscientious and critical, but the rather rigid structure for its reporting format gave a routine quality to its evaluation and the impression of too much detail. The two external evaluation panel reviews of the fisheries stock assessment CRSP made clear recommendations. It should be noted that the less frequent schedule of reviews for this CRSP improved the detachment and vision of the external evaluation panel members.

We conclude that a well-functioning external evaluation panel is critical to the smooth running and success of a CRSP. External evaluation panels should be allowed greater opportunities to review a CRSP as a whole and more time to discuss and prepare their reports. It is instructive to note that in this regard the staff of the NifTAL project, having experienced an independent in-depth review organized by USAID before it became a part of the soil management CRSP and therefore subject to the external evaluation panel review process, is clearly of the opinion that the in-depth review was of greater value. **The evaluation team concludes that the external evaluation panel should be retained, that its guidelines should be revised along the lines indicated, that more members be drawn from the private sector, that the frequency of reviews be reduced, and that the scope of each review should be enlarged.**

Suitably qualified scientists are now available in almost all developing countries. Directors of African national agricultural research systems have expressed strong opposition to having expatriates as country coordinators although they said they still appreciated regular short-term visits from CRSP scientists from U.S. universities. Respondents from USAID Missions and host-country principal investigators who answered the questionnaires on CRSP Planning and Performance (Annex K) were generally not convinced of the value of expatriate scientists.

The evaluation team concludes that expatriate country coordinators and even expatriate scientists are now seldom necessary or advisable. Where they still exist, a time-bound training program should be instituted for their replacement.

4.2.3. Effectiveness in transferring results

Although the CRSPs were discouraged from involving themselves in extension work,, they had operational objectives relating to the transfer of technology. They were specifically permitted to expend funds on pilot projects to test the validity of new or improved technologies, and they were expected to become integrated into USAID's country strategies.

The small ruminant, soil management, pond dynamics and aquaculture, and fisheries

stock assessment CRSPs undertook pilot-scale projects with significant demonstration value. Examples are the distribution of dual-purpose goats with appropriate feed packages to farmers, particularly women farmers, in Kenya; improved soil management packages for the humid tropics at Yurimaguas in Peru; the water quality laboratory established in Choluteca, Honduras; the efforts by shrimp farmers to maintain water quality in the Gulf of Fonseca; and the demonstration by the fisheries stock assessment CRSP program of the use of alternative fisheries such as cultivated clams and sea grass to allow restocking of fish in the reef areas of the Philippines.

The three crop CRSPs have been involved in pilot seed-production projects or trials of new and improved seeds on farmers' fields. The soil management, pond dynamics and aquaculture, and fisheries stock assessment CRSPs have created simulation or mathematical models for decision support systems in technology adoption. Among these systems are the acid soils decision support system, PONDCLASS, and catch-at-size analysis programs.

To ensure that pilot- and operational-scale research linking outputs to impact will be successful, we conclude that pilot projects should be formulated in consultation with the end-users, the participating host-country institution, and the USAID Mission. Furthermore, they should only be implemented with the active participation of host-country institutions.

If adaptive work of this nature did not involve the expenditure of a particularly large portion of the CRSP resources (and some of this work has been financed through buy-ins by the USAID Missions and even by the producers), it was because the CRSPs were constantly reminded by USAID Washington of the need to emphasize research of global importance and by their peers of the importance of quality in scientific output, usually judged by the number of publications in refereed scientific journals. Given these circumstances, the evaluation team judges that the output from this type of activity has been satisfactory. More could be done.

There are other technological packages already developed by the CRSPs that should be carefully examined for their potential utility. Examples are given in section 3.1.1 and the technical annexes. The crop commodity CRSPs have several improved hybrids and varieties with improved characteristics that they hope will be used by producers in the United States or developing countries. The existence of a viable and interested seed industry will be critical to any significant utilization of them in the next three to five years. Where seed companies have already requested foundation seed (for example, Sorghica Real 40 and 60 in Colombia) the likelihood of impact is high. In contrast, a new, much improved peanut variety, Fleur 11, ahs been released for farmer use in Senegal, but its utilization, according to the CRSP, depends on whether "successful seed multiplication programs can be mounted." The small ruminant CRSP has demonstrated that high proflicacy genes can be incorporated into local Moroccan sheep, but the practicability of the genetic improvements have yet to be proven.

The CRSPs cite several examples of manuals and books written to enhance the impact of CRSP-developed technology. The bean/cowpea CRSP has produced a manual on

cowpeas for use by U.S. food processors. The pond dynamics and aquaculture CRSP is producing a safety manual for developing country farmers who use masculinity-inducing drugs in aquaculture. It is collaborating with the American Tilapia Association in generating data required for final Food and Drug Administration approval of the use of an androgen hormone in the United States. Research under the fisheries stock assessment CRSP has led to the publication of a book that is expected to help revive coastal reef fisheries in the Philippines.

The soil management and small ruminant CRSPs have developed several technological packages that have had extensive testing on research stations and in farmers' situations. The dissemination of these innovations, in whole or in part, in developing countries is likely to be slow without a concerted extension effort including validation in farmer-managed trials, participation of users' groups, policymakers, and nongovernmental organizations, and involvement of interested USAID Missions.

USAID is a development agency that has invested substantial amounts of public funds in bringing these outputs to their persent states. **We conclude that USAID should seriously consider assisting in a follow-up, utilization phase of activities beyond the CRSPs to ensure the future utilization in developing countries of the most promising technological imrpovements and innovations.**

4.3. Efficiency

4.3.1. Financial efficiency

In commenting on the financial management of the CRSPs, the evaluation team wishes to make clear that its analyses should in no way be interpreted as in-depth financial/management audits. The evaluation team had neither the time nor the professional skills to conduct such investigations. Its primary objective was to identify with CRSP participants what problems in the CRSP financial management mechanism had had the greatest impacts on the successful conduct of planned research activities—that is, the problems that constrained the efficiency of CRSP planning and implementation.

4.3.1.1. General financial management

The major conclusion of the evaluation team with respect to financial management is that the management entities and the university/institute budgeting and accounting units charged with supporting CRSP research activities have discharged their responsibilities quite professionally. We have seen no evidence that USAID funds were mismanaged or misallocated by these units. To the contrary, we believe they should be commended for their collective ability to track and manage CRSP funding contributions from several different sources and effect their allocation to meaningful research activities. This performance is particularly impressive given the significant stresses incurred by USAID, the management entities, the participating universities, and the host-country agricultural research systems in an era of rapidly shrinking development resources.

In this regard, the major problem cited by the CRSP management entities was

USAID's inability to honor, in full and on time, its financial commitments to the CRSPs. The management entities point to the gap of approximately $20 million to date between the original grant and actual grant obligations. **We conclude that, over time, the difficulties in accommodating budget cuts that this inability created for the CRSPs were substantial.** Funding cuts led directly to CRSP management entities and participating universities having to make extremely difficult decisions. These decisions resulted in actions being taken to discontinue specific research activities, close operations in host countries, prematurely discharge CRSP scientists and staff, and effectively eliminate entire CRSP components, particularly socioeconomic inputs into multidisciplinary work. Coupled with this problem, most of the management entities voiced strong concerns about the persistent and inexplicable delays they had encountered in receiving their notifications of annual funding authorizations from USAID. **We conclude that these delays introduced a second element of instability into CRSP research planning and implementation.**

The reasons for the persistence of this particular problem are still not clear to the evaluation team, but its effects on the operations and morale of the management entities and the universities were clearly evident during the team's campus visits. Despite being eight months into the fiscal year at the time, several CRSP managers stated that they had not yet received final notifications of FY 1994 funding and were in danger of running out of previously obligated USAID funds. In some instances, management personnel claimed they were within a few days of having to notify their participating universities and field operations to shut down their research activities until the required USAID notifications were received.

We believe this problem is solvable, most likely by the addition of larger numbers of competent financial managers within USAID or by streamlining the agency's financial procedures, or both, and that USAID's senior management owes it to the agency to speedily eliminate the blockages in the existing system.

At the level of individual CRSPs, management personnel at the management entities, universities, and field posts indicated that there were problems with slow and incomplete vouchering of field expenses from field research sites and host-country agencies and, consequently, slow replenishments of field operational funds. In some instances these problems were reported to have left CRSP field posts strapped for operating funds for significant periods or necessitated field staff financing of CRSP research operations from their personal funds or both. **We conclude that more attention is needed to streamline replenishment procedures where possible and to eliminate any unnecessary layers of CRSP or university bureaucracy in the vouchering process.**

At the program level, all CRSPs to varying degrees enunciated their belief in multidisciplinary approaches to the planning and implementation of research projects and to the development and dissemination of appropriate and tested research results. Yet when budget cuts were imposed by USAID during the course of CRSP implementation, some CRSPs decided to allocate the funding cuts disproportionately across academic disciplines and participating universities. Funding limitations more often than not meant that resources for the social science and economic components of an individual CRSP, which

were often meager to begin with, were the first to be cut. In some cases, entire university support programs in the social sciences were cut back severely or dropped.

When questioned about these apparently disproportionate cuts, personnel at several management entities and universities said they had supported the cuts on the advice of BIFADEC officials and because USAID project managers had never seriously and consistently pressed the CRSPs to monitor, evaluate, and document the impacts their research activities were generating in the United States and in the developing world. The result in several instances was that, in the first few years after CRSP implementation, the capacities of some CRSPs to conduct genuinely multidisciplinary research efforts inclusive of the social sciences and to monitor, analyze, and report consistently on project impacts were either nonexistent (as for the fisheries stock assessment CRSP) or severely reduced (as for the pond dynamics and aquaculture, the soil management, and peanut CRSP).

4.3.1.2. Management costs and financial flows

The evaluation team concludes that CRSP management costs, when compared to actual disbursements, are modest. The spread between the highest and lowest management cost rate is less than 10 percent, and there appears to be no clear pattern of management cost rates when compared to actual disbursements; in terms of financial flows, the largest CRSPs do not consistently have the lowest management cost rates or vice versa.

4.3.1.3. University and host-country cost sharing

According to the available records, all management entities and affiliated universities have met at least their minimum cost-sharing obligations as stipulated in the various grant agreements. Most CRSP institutions have contributed significantly more support to their CRSP activities than was required. **The evaluation team concludes that these university contributions to support the CRSPs are very positive indications of the universities' strong commitment to the CRSPs. We also believe that the contributions have been effectively used to meet well-defined CRSP objectives.**

The reported cost-share contributions to the CRSP necessarily under-report actual contributions because they do not, and probably cannot, actually enumerate the financial value of the numerous informal interactions of CRSP and non-CRSP faculty and staff at the land grant universities and in the host countries. These informal interactions have facilitated the successful design, implementation, and analysis of discrete research activities, the informal sharing of laboratory and other facilities, and other similar contributions.

With regard to alternative methods to increase cost sharing for CRSP-like activities

in the future, two possibilities merit further evaluation. First, given that host countries have already made substantial contributions in cash and in-kind support the CRSP on a voluntary basis, it would perhaps be appropriate for USAID to recognize such contributions formally by requiring some minimal level of host-country accounting for cost sharing in the future. If a cost-sharing requirement is considered desirable, however, the percentage contribution should apply only to the portion of USAID CRSP funding that is actually spent in the host country for local research or local research scientists or both. Second, formal research agreements for projects should be encouraged between participating U.S. universities, host-country universities, and appropriate international agricultural research centers. Under such tripartite agreements, the parties could be required to make cost-sharing contributions to the cost of specific CRSP research projects.

4.3.1.4. Buy-ins and other leveraging of CRSP funds

The major conclusion of the evaluation team is that in the aggregate the CRSPs have been very successful in leveraging grant funds secured from USAID with funding from other sources. As seen in table 6 above, partially reported contributions to CRSP activities from the countries hosting CRSP research activities have amounted to $55,343,306 in cash and kind. In addition, buy-ins and other leveraged funds from USAID Missions, the international agricultural research centers, private-sector producer associations and firms, state governments, and other sources total $33,153,232 to date. The combined leveraged contribution to CRSP research totals $88,496,538, or 42.2 percent of USAID funds actually provided to the CRSPs to date.

The leveraged funds have been of great importance to several CRSPs both in initiating and/or expanding research activities (PL 480 proceeds assistance to research activities in Honduras or buy-ins in Egypt) and in supporting CRSP program administration (the pond dynamics and aquaculture CRSP operations with the USAID Mission buy-in in Egypt). However, it should be noted that some CRSP experiences with Mission buy-ins have not been altogether satisfactory for the concerned parties either because they were too demanding administratively or because the work required under the buy-in, while addressing the short-term needs of the USAID Mission, was not entirely compatible with the longer-term, globally mandated research objectives of the CRSPs.

The evaluation team concludes that CRSP-like activities in the future should be supported by USAID Missions and other types of buy-ins only where there is appropriate and mutual interest in a defined research activity. Buy-ins should not be allowed in instances where a Mission is simply trying to use the buy-in mechanism to supply routine, short-term, consulting services through noncompetitive procurement.

We believe that the opportunity and mechanism for buy-in support should be provided from the start of any future CRSP-like research program. We suggest that one model for such collaboration, USAID's Irrigation Support Project for Asia and the Near East (ISPAN), should be evaluated in this regard. Under this project, *one central administrative/financial unit* represented a consortium of participating universities and private firms in negotiating, signing, and facilitating the implementation of a large number of Mission

buy-ins. The preliminary planning work for a buy-in was generally done with the collaboration of one or more of the agencies participating in the consortium; implementation was always done with their participation. The final evaluation of this project in 1993 concluded that the buy-in mechanism had worked well and had been particularly instrumental in fostering solid and mutually reinforcing relationships between the regional project and individual USAID Missions. The ISPAN personnel felt that they were addressing development problems identified by their USAID and host-country clients, and USAID Mission personnel felt that the project was listening to and addressing their problems and needs.

4.3.1.5. Financial management and institutionalization of interventions

Institutionalization of good financial management practices within agricultural research systems in the developing world is critical to their long-term sustainability. In an era of declining development resources, institutions that have demonstrated their ability to properly manage government and donor support with transparency and probity are much more likely to be listened to seriously when applying for new funding. In this sense, the association of financial management personnel from the CRSP universities with the national agricultural research systems has been highly beneficial. The systems, with university assistance, have a much better appreciation of the financial management procedures and accounting requirements involved in USAID-sponsored research projects. And exercises in the collaborative planning and implementation of CRSP research projects, particularly under the stress of budget reductions, have been very valuable learning experiences for host-country participants in formulating and executing their own national and disciplinary research agendas.

At the operational level, host-country researchers and support staff are undoubtedly more prepared to deal with the financial management of their programs. They may also be better placed to solicit research funds from donor agencies. What unfortunately has not changed significantly over the period of CRSP implementation is the host governments' abilities to provide greater recurrent-cost funding for agricultural research.

Research program directors in every country visited by the evaluation team stressed the importance of continued CRSP funding in sustaining their activities. Most told of deteriorations in the capacities of their own governments to provide research funding much beyond that necessary to pay the salary and benefit costs for existing researchers. In many countries, such payments absorb over 90 percent of available research allocations. **We conclude that, while CRSP funding ameliorated these situations for certain disciplinary work on a temporary basis, the CRSPs to date have not been successful in fostering greater host-country government recurrent-cost support for local research institutions.**

4.3.2. Organizational efficiency

In response to the 1985 midterm evaluation of the CRSP concept by Hogan et al., a workshop for USAID convened in 1987 to prepare for the second decade of CRSP re-

search activities. At that workshop, one participant reported the following statement from his small-group discussions:

> By far the most important action AID could take to improve CRSP performance is to provide some degree of long-term stability in commitment to and budgetary support for research in general and the CRSP in particular. Uncertainty about month-to-month funding and downward appropriation tends [to] destroy morale, cause good people to go elsewhere and make long-term planning impossible. In short, these conditions run counter to many well-known conditions for carrying out an effective research program and, if continued, will result in reduced payoff from the taxpayer's dollar.
>
> Notwithstanding the many uncertainties the Agency faces with respect to appropriations and the numerous competing demands, earmarks and mortgages, it is clearly in the interest of U.S. taxpayers and developing countries for AID to reaffirm the role and importance of research in development assistance and to establish a long-term strategy for supporting agricultural research.
>
> A plan for strengthening agricultural research for developing countries should be developed in cooperation with the CRSP, IARCs, and other components of the international science system. The plan should include budget targets, and should identify major actors, including CRSPs, and their mandates.
>
> The existence of such an indicative plan, which was embraced by the top AID management, would go a very long way in articulating AID's intentions and providing CRSPs and other research performers with some degree of stability in the form of planned budget support. (*Proceedings of the CRSP Directors and Program Managers, Workshop Decade Two Preparation Final Report*, 1987, p. 21.)

The evaluation team concludes that this statement is as apt today as when it was originally drafted. This is so despite the fact that the organizational structures within the existing CRSPs have functioned reasonably well. Excellent research has been conducted, many research outputs have generated the impacts anticipated, and program management costs have been modest when compared to the total financial flows.

The essential deficiencies in and constraints upon CRSP operational efficiency have, if anything, become more destructive of the initial Title XII legislation's intent to generate a collaborative, long-term relationship between USAID and the land grant universities. In an era of increasing program stress and uncertainty, the overall relationship between USAID and the CRSP-participating institutions is now even more tense and unstable than it was at the time of the report. In an effort to be prepared for further declines in CRSP funding and research plan modifications for the future, USAID project managers have required more frequent reporting from the management entities and have played an increasingly direct role in management of the CRSP grant agreements. These constant demands have clearly affected relationships between USAID and the management entities. This is ironic considering that grant agreements were specifically selected as the preferred implementation mechanism for the CRSPs because they were intended

to place maximum management responsibilities with the management entities and participating universities and to relieve USAID officials of day-to-day CRSP program and administrative tasks.

Given the stresses at present, it is not surprising that a defensive mentality is evident among many CRSP implementors at USAID, the management entities, and the universities. Given this situation, we believe that creativity and optimism with respect to the future of the CRSP have been replaced, in many cases, by attempts to salvage as much good research output as possible in the face of rumors of further cuts in resources or, for at least three CRSPs, outright termination of activities in the near term.

At the level of USAID, tensions are evident between the CRSP project managers and more senior USAID administrators. The evaluation team received many comments from project managers to the effect that they felt "outside the loop" when major decisions made within USAID directly affected their CRSP portfolios. One consequence of this situation has been to put most USAID and CRSP program managers in a polarized and defensive mode with respect to "outsiders." Critical discussions of CRSP organization, operations, outputs, and impacts are difficult when discussants are evaluated first and foremost as defenders or opponents of CRSP continuation. Another consequence is that attempts to defend CRSP accomplishments, even where those accomplishments are self-evident, have on occasion lapsed into unnecessary exaggeration of actual outputs. A third is that project managers have been forced by the deteriorating situation to be proactive in fending off potential threats to CRSP continuation and thus find less and less time to discharge their primary leadership roles of fostering creative and forward-looking research programs.

In sum, the evaluation team concludes that CRSP operational efficiency has been seriously eroded by the instabilities inherent in USAID's overall program. Those instabilities have not diminished since the 1985 Hogan report; if anything they have increased in number and amplitude. Until they are dealt with definitively by senior USAID management, the surviving CRSPs will be forced to operate under a set of severe programmatic and financial constraints that will obviously reduce overall operational efficiency.

4.4. Impacts

4.4.1. Economic impacts of CRSP activities

The rigorous evaluation of the economic impact of any research and development activity in the United States or in the developing world is a difficult and time-consuming task. *Effective impact evaluation requires planning, beginning with the initiation of a project's design, through its implementation, and, ideally, for a period after its conclusion.* To have maximum effect, such evaluations should be planned by and executed under the supervision of a multidisciplinary planning unit within the project. To be adequately comprehensive, such an exercise requires the active participation over its life of both tech-

nical and social scientists because no single discipline has a monopoly on the identification, quantification, and interpretation of impact data during and after project implementation.

In conducting this evaluation, one of the first problems encountered was that in activity planning and implementation most CRSP participants and USAID managers had not made a clear distinction between CRSP project *outputs* and project *impacts*. There was a strong tendency in most of the CRSPs to lump all activity results under a generic category of project "accomplishments" and, when pressed, to discuss all "accomplishments" as impacts.

The evaluation team realized early on that such a generic lumping of "accomplishments" was not compatible with the execution of its Scope of Work. Team members, therefore, in their conversations with CRSP participants and managers and in writing their individual contributions to this evaluation report have been careful to distinguish between project outputs and project impacts. We also have worked under a somewhat broader definition of project impacts than is contained in the team's Scope of Work. To the extent possible based on the existing documentation and our field visits, we have tried to assess CRSP impacts in financial, economic, social, and institutional terms at the macro- and microeconomic levels.

For purposes of this evaluation, therefore, project outputs — the results that can be attributed to direct and planned applications of total CRSP project resources — are discussed separately from project impacts. Whereas impacts are the subject of this section, project outputs are dealt with both in this main report and, in greater detail, in the technical annexes. Therefore, by our definition, CRSP outputs are accomplishments such as the development and release of new sorghum, peanut, cowpea, and dry bean cultivars by host-country research systems in collaboration with CRSP scientists; the development in Kenya of dual-purpose goats of higher genetic potential; new aquaculture technologies that have increased the productivity and lowered the costs of shrimp farming and/or tilapia rearing; new processing systems designed to produce marketable food products from cowpeas, sorghum, and peanuts; production of well-trained M.S. and Ph.D. students at CRSP universities; and the expansion of the scientific knowledge base in many fields through the publication of technical books, research papers, and other articles in the United States and elsewhere.

CRSP impacts, on the other hand, are the incremental net gains in efficiency or equity accruing to *third parties*—individuals, enterprises, institutions, and/or the largerciety — from their *adoption and use* of technologies and management techniques developed with the participation of CRSP scientists or the use of CRSP resources or both. As discussed below, some of the quantifiable CRSP impacts have included the financial gains to shrimp producers in Honduras from their adoption of lower-cost feeding techniques; the financial gains to Texas and Oklahoma sorghum growers and the economic gains to American consumers from adoption of CRSP-developed sorghum varieties with greenbug resistance; the financial gains to smallholder farm families in Kenya who have obtained dual-purpose goats bred through CRSP activities; the financial gains to dry bean producers and the economic gains to societies in the United States, Mexico, Honduras, the

Dominican Republic, and other countries where new bean cultivars have been adopted, thereby improving domestic food security or exploiting new export markets.

Other equally important but less well-documented impacts have accrued from CRSP and host-country institutional interactions around the world. Examples include the influence CRSP-trained scientists have had on the development of better agriculture-sector policies in their individual countries since they left graduate school and assumed their current positions; the improvements in institutional management and research priority-setting resulting from the interactions that host-country research program managers have had with their CRSP counterparts; and the new attitudes, perspectives, and approaches conveyed by CRSP-trained scientists and managers in daily interactions with their colleagues and students.

It should not be assumed from these statements, however, that project impacts have been of equal magnitude on a per dollar basis across all CRSPs. **The evaluation team concludes that at present the pond dynamics and aquaculture, small ruminant, and bean/cowpea CRSPs have had the most impact per dollar spent in the developing countries and the sorghum/millet, peanut, and bean/cowpea CRSPs have had the most impact per dollar spent within the United States.**

Just as important for this evaluation, the impacts that did occur have not been equally documented across the CRSPs. The high variability among the CRSPs with respect to reported impacts is inherent in both the differing objectives of the individual CRSPs and in the nature of the technologies they were attempting to generate over time. For example, the fisheries stock assessment CRSP was specifically designed to produce a manual on how to do stock assessments of marine fish populations. The entire implementation of this fisheries stock assessment CRSP was oriented toward that objective with the result that, when the manual as a technical book was in the final stages of development in mid-1994, the scientists involved had no time and no resources left under the fisheries stock assessment CRSP to take the next logical step of applying the new assessment methodologies to actual situations.

In the case of the soil management CRSP, it appears to the evaluation team that the overall lack of impacts from the work to date on soil management (as compared to the production and utilization of rhizobium inoculant to promote nitrogen fixation by legumes) is at least in part due to the long gestation period needed to develop and test technically sound and financially attractive soil management technologies under tropical conditions, even in situations where research activities are well planned and implemented. By contrast, scientists working under the pond dynamics and aquaculture CRSP determined after a few months of applied research that technically sound and financially attractive cost-savings measure could be applied by the Honduran shrimp industry if participating enterprises would make simple changes in the feeding regimes they used in their growing-out ponds. Similar instances of relatively rapid progress from initiation of research activities to broader dissemination of new products or technologies are cited below for each of the commodity-oriented CRSPs.

In assessing the documentation of project impacts by the CRSPs, the evaluation team

was impressed by the wide variability in attitudes toward and methodologies and processes used for evaluating project impacts. Although the need for rigorous, long-term economic impact analysis was implicit in the logical framework methodology used in the design of most of the early CRSPs, in practice each CRSP management entity was left to design and implement its own socioeconomic component and procedures to document impacts.

Managers of the bean/cowpea, sorghum/millet, and small ruminant CRSPs chose to involve social scientists on a reasonably consistent basis in CRSP planning, implementation, and evaluation activities. They actively promoted interdisciplinary approaches to research and initiated fairly comprehensive efforts to establish baseline conditions in their geographical areas of concentration to document both potential and actual project impacts and to identify the local factors that would encourage or constrain adoption of new CRSP technologies by potential beneficiary populations. With these objectives in mind, they actively urged USAID to provide sufficient and specific support funds for socioeconomic analyses in a period of shrinking CRSP resource allocations. USAID project managers reacted by claiming that the decision to support socioeconomic activities or not was a CRSP decision based on its own budget problems.

At the other end of the CRSP spectrum, the soil management and fisheries stock assessment CRSPs appear to have chosen to have limited or no effective participation by social scientists in their activities, with serious consequences for their abilities to demonstrate any significant impacts.

With respect to impact analysis, the peanut and pond dynamics and aquaculture CRSPs appear to be intermediate cases. The managers of the peanut CRSP generally did a good job of postulating a number of potentially significant impacts of their work. Their presentations, however, were mostly anecdotal in nature, which led to some difficulties when they had to produce the supporting quantitative data required to move much beyond a superficial level of analysis. In the case of the pond dynamics and aquaculture CRSP, the main problem seemed to be the reluctance of the technical scientists in the field to clearly present their evidence for impacts, even though it appeared evident to the evaluation team that substantial progress was being made in several countries in moving viable new technologies from the research stations to the intended beneficiaries. As a result of this excessive modesty on the part of the technical scientists and the lack of a consulting economist, the existing enumeration of impacts from this CRSP's activities probably significantly understates the actual results to date.

In these cases, the CRSPs have probably done themselves a considerable disservice by inadequately documenting their actual impacts, particularly when those impacts are judged against the relatively modest resources expended in the United States and at overseas sites to accomplish them.

The other major consequence of the absence of the well-planned and uniform approach to impact evaluation across all CRSPs was that most social scientists who were actually involved in CRSP activities were given de facto liberty to choose both what they wanted to study and the methodologies they would use in their research. This has led

directly to wide variations in the rigor of the impact analyses conducted to date and to the production of noncomparable analytical results. **We conclude that it is impossible logically to aggregate the results of all CRSPs to assess the total economic benefits against total research and extension costs because the available analyses vary widely in methodologies used.** Some include qualitative statements, some partially budget single technologies; some use whole farm and other analyses using linear programming; and some include a limited number of more sophisticated studies using economic surplus models or econometric techniques or both and varied in their degree of quantification.

4.4.1.1. Specific economic impacts reported from the CRSP activities

This section presents the evaluation team's response to the key impact question in our Scope of Work: "What have been the CRSPs' contributions and direct impacts, in dollar terms and in terms of other changes that may be unquantifiable, on agricultural development and production in the collaborating countries, in other developing countries, and in the United States?" For the reasons of variability among the analyses stated in the previous paragraph, the specific economic impacts reported are listed by individual CRSPs.

4.4.1.1.1. The peanut CRSP: impacts

International impacts

- In Jamaica, it is reported that 10 percent of peanut farmers are now using a new peanut cultivar, CARDI-Payne, developed by CRSP researchers. This cultivar is estimated to yield 42 percent more than the traditional peanut variety and is acceptable to consumers, especially for peanut butter production. It is presently grown on about 10 percent of the total peanut area of 5,000 acres. If this cultivar should be adopted on the entire peanut area, it has the potential to add $600,000 annually in additional revenues for producers. This would be a tenfold return on the research investment made to develop it.

- In 1992, as a result of collaboration with the peanut CRSP, the Bureau of Food and Drugs of the Ministry of Health in the Philippines set allowable levels for aflatoxin in food at 20 parts per billion. This action was taken because of evidence linking the accumulation of aflatoxin in the body to liver cancer. Subsequent government testing for aflatoxin levels in domestic food products at nine processing firms led to the condemnation of existing stocks of their peanut products. The firms in question were also suspended from marketing their products until they met the required standards and until the firms submitted detailed descriptions of their quality control procedures, sanitation processes, raw material acceptance and rejection systems, recall systems, and written commitments to maintain quality standards and voluntarily recall products in the case of defects.

Domestic Impacts

- CRSP researchers in North Carolina developed a pest management strategy to control the southern corn rootworm, which can cause extensive damage to peanuts in North

Carolina and Virginia. This area represents 15 percent of the 1.7 million acres planted to peanuts in the United States. The strategy has eliminated the need to use an estimated 42,000 tons of chemicals on the area's peanut crop. Under current production costs, the financial savings from CRSP technology in North Carolina and Virginia are expected to total $1.5 million annually.

- In North Carolina, CRSP research led to the release of a new peanut cultivar, NC10c, which is the only *Cylindrocladium* black rot–resistant cultivar available to local farmers. In 1992 and 1993 this cultivar occupied about 20 percent of the North Carolina peanut acreage, and it is estimated that the net value of the crop losses prevented was approximately $4.5 million.

- In Texas, a new peanut cultivar, Tamspan 90, was released. It yields 11 percent more than Starr, the previously most popular cultivar. It has partial resistance to important soil-borne diseases, including *Sclerotinia* blight and *Pythium* pod rot. Tamspan 90 was grown on about 28 percent of the total peanut area in Texas and Oklahoma in 1992 and 1993. This area produced peanuts with an annual gross value of about $25 million.

- CRSP researchers developed procedures to control a highly contagious and lethal seed-borne peanut stripe virus, which had been inadvertently introduced into the United States from China. These procedures prevented a potential epidemic linked to the propagation and spread of infected peanut seed throughout the southern peanut growing states. According to CRSP scientists, had the infected seed spread to all peanut production areas, crop losses could have amounted to several hundred million dollars. The avoidance of restrictions on interstate movements of peanut seed alone generated a savings of about $100,000 annually.

- A new integrated pest management technique developed by CRSP researchers in North Carolina uses pheromone traps to monitor populations of southern corn rootworm in peanuts. By applying pesticides only when pest populations reach economic damage thresholds, growers can now reduce their pesticide use by an estimated 42 tons per year. When this management technique is in widespread use, it is estimated that it will reduce peanut production costs in Virginia and North Carolina by approximately $840,000 annually and have the subsidiary environmental benefits of reduced pesticide use.

4.4.1.1.2. The bean/cowpea CRSP: impacts

International impacts

- Since its release in the mid-1980s, PC-50 has become the most widely grown bean in the Dominican Republic. Based on analysis of a 1992 national farmer survey, an estimated 33 percent of the country's bean farmers were planting the new variety on 48 percent of the total bean area. Among surveyed growers, the mean yield from PC-50 was 987 kilograms per hectare, while the mean yield for the country over the last

ten years was 505 kilograms per hectare. In 1993, 3,465 metric tons of PC-50 seed were sold to farmers throughout the country. Total revenues derived from using PC-50 have been estimated by the CRSP at over $5 million.

- In the late 1980s, when bean golden mosaic virus became an increasingly important constraint to bean production in the Dominican Republic and throughout Latin America, CRSP scientists developed a transgenic dry bean line with resistance to golden mosaic. This new bean line is being incorporated into bean breeding programs worldwide and is saving years of research time when compared to traditional plant breeding work. In addition, based upon CRSP-sponsored research in 1989, a single bean-planting season was introduced in the main bean growing region of the country. When adopted in the San Juan Valley, this technology not only reduced the incidence of bean golden mosaic virus but also enabled farmers to protect their crop while applying less insecticides.

  CRSP contributions to and direct impacts upon the bean industry in the Dominican Republic are at least partly responsible for the fact that the country is now essentially self-sufficient in dry bean production and will be saving an estimated $5.7 million annually with cessation of the bean imports previously needed to satisfy domestic demand.

- With an estimated one million people threatened by drought in 1985, the European Economic Community, USAID, and the Government of Senegal purchased 700 tons of California Blackeye #5 cowpea seed for emergency distribution in the country. CRSP scientists made the determination that this particular cowpea cultivar could be effective in the driest parts of northern Senegal and provided advice on the most effective methods for growing the crop. With a major contribution from Blackeye #5 seed, augmented by local cowpea landraces, cowpea production in Senegal increased from 16,000 metric tons in 1984 to about 80,000 metric tons in 1985. An internal rate of return analysis of the emergency operation indicated a return of 63 percent.

- New cowpea storage technologies involving a solar heater, triple bagging, and improved ash storage have been extended to over 6,000 men and women in northern Cameroon by the Ministry of Agriculture, the cotton parastatal organization called SODECOTON, and several USAID projects. Local acceptance of these technologies is reported to be up to 90 percent, and several potential entrepreneurs have expressed interest in setting up village-level solar heaters for farmers with cowpea amounts too small to warrant their own investment in this technology and in cowpea milling operations. In western Africa alone, cowpea weevils cause an estimated loss in stored cowpeas of over $50 million. If the solar heating technology were to be adopted throughout the area, a large percentage of these losses could be eliminated.

  Sterns and Bernsten (1992) assessed the impact of the joint cowpea research and extension program in northern Cameroon jointly sponsored by the *Institut de Recherche Agronomique* (IRA) and USAID. The latter's projects were the CRSP, the Semi-arid Food Grains Research and Development project, and the National Cereals Research and Extension project. They estimated that the internal rate of return from the development and extension of the improved technological package for cowpeas was 15 percent for the base run assumptions. With sensitivity analyses based on eight

key variables, the internal rates of return varied by less than plus or minus 30 percent, implying an internal rate of return for the total program in the range of 10 to 20 percent. When cowpea market price and cowpea grain yield for the package extended to farmers were increased by 25 percent, the internal rates of return became 22.2 and 24.8 percent, respectively. When these variables were decreased by 25 percent, the internal rates of return became 3.5 percent and negative, respectively.

- As a result of the work by CRSP scientists, village mills in Ogbodu-Aba and Isiala-Ngaw in Nigeria are producing cowpea meal for the production of *akara* and *moin-moin* by village women and vendors. Weaning foods based upon cowpea/cereal blends are also being manufactured at each location. An impact assessment survey shows that cowpea consumption has increased up to 150 percent from 1982 to 1991. The survey also indicates that weekly expenditures per household for cowpeas increased from a minimum of Naira 1.5 in 1982 to a maximum of Naira 22.5 in 1991. Such an increase implies an improvement in the image of cowpeas from a "food for the poor" to something of a status food. This is supported by the fact that consumption is now greater among higher income than lower income families. Concomitant with increased cowpea consumption has been a reduction of severe malnutrition in children by 70 to 100 percent in the areas surveyed, although it is not possible to attribute the change solely to cowpea consumption or the CRSP interventions.

- In Mexico the CRSP has developed and released four new drought-tolerant cultivars in four market classes—pinto, black, tan, and small-seeded pink beans—for production in the semi-arid highlands. Yield estimates from growers' fields over three years indicated that the new varieties out-yielded local cultivars by 56 percent. In cooperation with the Ministry of Agriculture, 33,000 hectares of the new cultivars were planted for seed production by newly formed grower associations, which will market the new seeds.

- In 1993 in Honduras, Dorado and Don Silvio, two new CRSP dry bean varieties with resistance to bean golden mosaic virus were released. The project turned over 2,000 pounds of foundation seed to the National Bean Program and artisan seed producers who, in turn, used it to generate 30,000 pounds of certified seed, which they sold to farmers. An additional 80,000 pounds of certified seed were produced the following season. Unfortunately, bean production in Honduras was seriously affected by a severe drought during the second planting season of 1992 and excessive rains during both the first and second planting seasons of 1993. Consequently, the impact of the new releases has been difficult to document. However, in bean production zones where the use of Dorado is widespread, yield increases of 15 to 20 percent have been reported.

Domestic impacts

- CRSP plant breeders have developed new dry bean varieties more appropriate to the needs of export markets. In Michigan, new bean cultivars developed by the CRSP are being planted annually on over 80,000 acres. These new cultivars are capable of increasing bean yields by 20 to 25 percent. In a normal year, this yield increase would

mean over $3.7 million in increased receipts for Michigan bean growers. In New York state a new red kidney bean cultivar was developed. It has a yield advantage of 30 percent over former cultivars and has shown superior canning qualities. Planted on 2,000 acres with an increased yield of 300 pounds per acre, this cultivar can mean an additional income of $150,000 per year for New York state bean growers.

- In Nebraska CRSP researchers have released Starlight, a Great Northern bean that is larger and a brighter white than any other bean currently grown. It is expected that Starlight will give Nebraska bean growers a competitive edge in European markets where these qualities are important. Starlight also provides resistance to such bacterial diseases as halo and common blight and to fungal diseases including white mold and rust.

- Also in Nebraska, a new rust resistant Pinto bean cultivar, Chase, was released in 1993. The yields of this cultivar were superior to the standard varieties used in Nebraska and Colorado under severe rust conditions and were equal or better under non-disease conditions. Chase also had moderate resistance to several molds and bacterial blights. Registered seed of Chase has been produced by two companies in California and foundation seed has been grown in Wyoming, Idaho, and Nebraska.

- In Wisconsin CRSP researchers have released two snap bean lines with enhanced capacity to fix biological nitrogen. This capacity reduces the need for high nitrogen application levels, thus reducing groundwater nitrate pollution from runoff. Production costs for Wisconsin farmers are expected to be decreased by $15 to $20 per acre by the reduced requirement for chemical fertilizer.

4.4.1.1.3. The sorghum/millet CRSP: impacts

International impacts

- CRSP scientists at Texas A&M University developed the sorghum breeding lines subsequently used by Dr. Gebisa Ejeta, an ICRISAT plant breeder, and colleagues at the Sudan Agriculture Research Corporation to develop and release Hageen Dura 1, a new hybrid sorghum for farmers in the Sudan in 1983. Hageen Dura 1 produces high-quality food. It is now being grown under irrigated conditions in the Gezira Irrigation Project on 35,229 hectares of its land or 12 percent of the total Gezira crop area in the 1991/92 crop year. With appropriate fertilization, Hageen Dura 1 can produce up to 150 percent more than local sorghum varieties grown under traditional systems with no fertilizers. One economic impact study estimated social benefits from this research of 157 million 1990 Sudanese Pounds, approximately $7.85 million at the market exchange rate. Internal rates of return to research on this hybrid were estimated at 22 and 31 percent for low and high levels of fertilization, respectively.

- Collaborating CRSP scientists at Texas A&M and in Honduras developed several new sorghum cultivars, including Sureño and Catracho. With fertilization and a package of soil conservation techniques, the new cultivars compared with traditional seed have increased yields by over 100 percent on steep hillsides in southern Honduras. By 1989

Sureño was being planted on approximately 12 percent of the total Honduran sorghum area. Recent economic analysis (Lopez-Pereira et al., 1992) has estimated the net present value of the Sureño cultivar at $4.6 million in 1989 dollars. It was further estimated that, if diffusion continued at the same rate through 2012, estimated benefits would increase to between $11 and 14 million. Finally, researchers estimated that use of the improved cultivars when combined with recommended soil conservation techniques and seed treatments at low levels of fertilizer applications had an internal rate of return of 32 percent.

Domestic impacts

- CRSP scientists developed greenbug (Type E) resistant sorghum hybrids for use in the United States and Latin America. Total USAID investment in this research over a ten-year period amounted to less than $5 million. Economic gains from development of these hybrids in the United States in 1989 were estimated with and without the conditions of the 1989 farm program. Under the program, gains were projected to total $389 million, $273 million in net benefits to sorghum producers and $116 million in net gains to consumers, which represented an estimated internal rate of return on research investment of 48.2 percent. Without the farm program, net U.S. benefits were estimated at $113 million, with an internal rate of return of 33.4 percent (Eddleman, et al. 1991). If sorghum producers in the Great Plains were still completely dependent on sorghum varieties with no resistance to greenbug (that is, using 1974–76 vintage seed varieties), it has been estimated that U.S. grain sorghum production would be approximately one-third less than is expected with resistant sorghums, or a potential loss of approximately 560 million bushels of sorghum annually.

- As a consequence of the sorghum/millet CRSP's procedures or programs or both, an estimated 75 percent of commercial sorghum hybrids currently planted in the United States contain some germ plasm from Africa and India. The net benefit to the economy from production of food quality sorghums has been estimated at $183 million under conditions of the 1989 farm program and $91 million without the program. The internal rates of return on USAID research investment with and without the 1989 farm program are 41.7 and 33.5 percent, respectively. In addition, development and production of lighter colored food sorghums has enhanced the potential for increasing American export of food sorghums, specifically for tortilla markets in Mexico and to the Japanese sorghum market.

4.4.1.1.4. The small ruminant CRSP: impacts

International impacts

- In Kenya, the introduction of dual-purpose meat and milk goats and improved forage production practices has been estimated to result in a 66 percent increase in food yields from goats for smallholder families. Expressed on a per hectare basis, each dual-purpose goat generates $52 in additional income for smallholder goat producers. To date, however, less than 500 smallholder farm families have actually received dual-purpose goats produced by the small ruminant CRSP/KARI project.

- In the region in western Kenya most impacted by goat distributions to date, Semenye and Getz (1993) reported that protein production increased. Meat yield has increased by 60 percent. Milk has become available for families with lactating does, and in a 60 day period, farmers can obtain up to 30 liters of goat milk per doe.

  On average, 90 liters of milk can be obtained from local cows per year if the farmer had access to sufficient land to maintain a cow. The same amount of milk can be produced by three dual-purpose does at only 60 percent of the maintenance cost needed for a cow. Goat technological packages have generated proteins (meat and milk), forages, increased crop production (double cobber maize), increased crop yields with manure application, and increased cash income for household needs. In western Kenya, the identification of sweet potato vines as a suitable early weaning feed for kids allows farmers to obtain an additional 87 liters of goat milk for family consumption and local sale.

  More recent studies in newer clusters of farm families receiving the new goats document that these are producing on average 63 kilograms of milk per 90-day lactation, yearling kid weights of 20 kilograms, and 182 kilograms of manure. Farmers are receiving a return of $44.88 against variable costs of $22.90. The gross margin per doe-kid is $16.98.

- A new vaccine against contagious caprine pleuropneumonia (CCPP) was developed and shown to be efficacious in on-farm trials in Kenya. The disease affects at least 48 million goats in Africa and Asia and, if untreated, has a mortality rate greater than 80 percent. The new vaccine has an extended shelf life and, when properly used following the recommended regimen, is highly effective. If the vaccine were widely available, it could prevent an average of 82 annual local outbreaks involving an estimated 300,000 goats in Kenya. Before vaccine production was fully transferred to the Kenya Veterinarian Vaccine Production Institute, one million doses of the new CCPP vaccine were produced. Since the transfer of responsibilities, the production of the new CCPP vaccine has been given low priority by government officials and actual vaccine output has declined significantly.

- On-farm testing in Indonesia of the CRSP sheep technological package through the Outreach Pilot Project (OPP) demonstrated the potential for increasing yields by 50 percent over the traditional system. An economic surplus model was then used to evaluate the OPP/CRSP effort in West Java. All costs of the program were considered and discounted against the net benefits of the OPP technological package. Assuming an adoption rate of 20 percent peak adoption achieved in twelve years, preliminary results yielded an internal rate of return of 19.2 percent. Sensitivity analyses varying the rates of adoption and including spillover adoption effects in neighboring provinces yielded rates of return of 22.9 and 24.8 percent. Given existing market conditions, the distribution of the gains from research was estimated to result in producers capturing 77 percent of the economic surplus generated.

- CRSP researchers in Indonesia have developed grazing systems in which sheep at stocking rates of up to ten animals per hectare are used to control weeds under the trees on rubber plantations. These systems are estimated to reduce plantation labor costs by 18 to 31 percent. The systems are also said to have saved Indonesia an esti-

mated $51 million annually by eliminating the cost of the herbicides previously used on the plantations.

4.4.1.1.5. The soil management CRSP: impacts

International impacts

- The University of Hawaii's Nitrogen Fixation by Tropical Agricultural Legumes (NifTAL) assisted the Government of Zambia to establish legume inoculant production facilities at two different sites. As a result, the area planted with inoculated soybeans rose from 6,550 hectares in 1984 to 22,780 hectares in the 1991/92 crop season. Research data indicate that about 48 percent of the yields of inoculated soybeans can be attributed to the use of those inoculants. In Zambia, commercial farmers who use inoculants have average soybean yields of 1.8 metric tons per hectare, compared with farmers who do not use inoculants and have average soybean yields of only 0.7 metric tons per hectare.

- At the farm level in Zambia, the cost of rhizobial inoculation was estimated at about $3.60 per hectare, with a return on investment to the Zambian farmer of 1:70. In contrast, the return on investment in nitrogen fertilizer is estimated to be only 1:3. The cumulative economic benefit for Zambia due to crop yield increases attributed to inoculation was estimated at $17,880,000 over the period 1984 – 1992. During this period, nitrogen derived from biological nitrogen fixation through inoculation was estimated to be equivalent to nitrogen fertilizers with a replacement cost of more than $5,370,000. The projected ten-year future economic benefit for Zambia attributed to the continued use of inoculants on soybeans was estimated at $134,000,000.

  The initial USAID Zambia investment in NifTAL assistance through the ZAMARE project was $300,000 in 1983. In the eight-year period since project implementation in 1984, the combined economic benefits to Zambia including yield increases and nitrogen fertilizer replacement attributed to seed inoculation technologies were estimated to exceed $23,000,000. Additional benefits include enhanced protein availability and the implementation of a sustainable, environmentally sound, resource management practice.

  In 1990 rhizobial inoculations in the management of soybeans on farmers' demonstration plots in Thailand showed that with application of nitrogen/phosphate fertilizers net returns over variable costs were Baht 6,108 per hectare greater than the control plots, whereas application of rhizobial inoculation without chemical fertilizers increased net returns to Baht 7,685 per hectare. When inoculant was used with chemical fertilizers, net returns were Baht 8,781 over net returns from the control plots.

4.4.1.1.6. The pond dynamics/aquaculture CRSP: impacts

International impacts

- In Honduras, commercial shrimp farming has grown to 11,000 hectares of ponds since 1979 and with a 1992 raw product value of $40.2 million is now the country's fourth most valuable export.

In collaboration with the *Asociación Nacional de Acuicultores de Honduras* and local shrimp producers, CRSP researchers determined in on-farm trials that using 20 percent protein feed in rearing ponds produced weights of marketable shrimp equal to those produced in ponds where 40 percent protein feed was used. This research finding has convinced local producers to use the lower protein feed and has reduced their feed costs by approximately one-third for the same levels of marketable output.

Another study determined that young shrimp do not feed until four weeks after hatching. This single finding saved shrimp farmers one month of feed costs per growing cycle, generating a savings of $975,000 in the first year the delayed feeding strategy was implemented.

Additional savings came from recommendations in a third study to decrease direct feeding of shrimp by using chicken-litter fertilizer (250 kilograms per hectare per week) to enrich the shrimp pond environment and thereby indirectly feed the shrimp. This practice can substitute for processed shrimp feed during the first four to eight weeks of cultivation.

- Over a ten-year period, the pond dynamics and aquaculture CRSP has developed and tested technologies on limited-resource tilapia farms that increased production by more than 100 percent over traditional tilapia raising methods. Partial enterprise budgets have been developed to compare the financial costs and returns for 41 different production technologies. Several indicate profit potential and are being practiced by farmers with limited resources. Net returns to land, labor, and management ranged from $174 to $542 per hectare.

- In experiments since 1983 in Comayagua, Honduras, stocking male Nile tilapia at more than one fish per square meter in organically fertilized ponds resulted in smaller fish but no greater fish yields. Increasing the stocking rate to two fish per square meter resulted in greater yield when organic fertilizer was supplemented with urea. The combination of organic fertilization and supplemental feeds increased feed-use efficiency if feed were combined with low amounts of fertilizer or if no supplemental feed was provided until the third or fourth month of fish grow-out. However, economic returns from ponds that received organic fertilizer combined with supplemental feed were no greater than returns from ponds that received organic fertilizer supplemented with urea. Tilapia yields of 3,500 kilograms per hectare were obtained from natural pond productivity alone. Yields increased to 5,300 kilograms per hectare in 150 days when supplemental feed was used, but high feed cost reduced net returns to less than those for fertilizers alone.

  In the absence of a sales price differential based on individual fish size, semi-intensive tilapia culture was clearly profitable for management systems that rely on enhanced natural pond productivity. Production of large (400 grams) tilapia necessitates the use of supplementary feed, but a higher market price for large tilapia would be required for this management system to be profitable. Large tilapia generally are produced for export markets. Tilapia harvested from semi-intensively managed ponds can supply domestic markets in Central America. Combined use of organic and chemical fertilizers as nutrient inputs for tilapia ponds requires less capital expenditure than if supplemental feeds were used and therefore are more appropriate for small- to medium-scale commercial producers who supply domestic markets.

Finally, in Comayagua there were few fresh fish available in local markets ten years ago. Now the 600 fish farms in the region provide a stable domestic supply. As a result, the demand for tilapia fingerlings has increased by at least 600 percent from 1986. The pond dynamics and aquaculture CRSP activities in Honduras have also provided the scientific foundation and training that has resulted in the development of large-scale commercial tilapia farms producing export products for markets in the United States and Europe. Several large commercial farms are already operating and more are in the planning stage or under construction.

- In Rwanda, pond dynamics and aquaculture CRSP research demonstrated that fish was the best cash-generating crop among the traditional crops studied. In 1983 there were no extension recommendations for Rwandan fish farmers despite the fact that these farmers raise fish for cash income, not home food consumption, and 65 percent of farmed fish are sold in high-demand markets. Research by pond dynamics and aquaculture CRSP has developed appropriate production technologies based local inputs and for fish ponds at various elevations. Within a five-year period, average annual rural pond fish production increased from 260 pounds per acre to more than 1,300 per acre using techniques developed by the CRSP. Some private farms have reached annual production levels of 5,670 pounds per acre. Surveys have indicated that participation in fish farming can increase family incomes by 14 percent or more.

- Scientists from the CRSP in Thailand have developed economically efficient fertilizer strategies using a combination of organic and inorganic fertilizers that can produce up to 18,000 kilograms of tilapia per hectare per year. The new strategies are currently being adopted by 500 small-scale fish pond operators in Udon Thani Province. In Nong Khai Province, adoption of the fertilizer techniques by the 100 small- to medium-sized operations there could result in increased net income of approximately $2,500 per hectare.

  Supported by the pond dynamics and aquaculture CRSP and the Asian Institute of Technology (AIT) Outreach Program in the last five years, the annual production of tilapia in Thailand has increased from 20,000 to 80,000 metric tons. Tilapia is now the largest tonnage freshwater fish produced in Thailand. The demand for private sector-produced, sex-reversed tilapia fingerlings has exceeded the current supply, creating new opportunities for fish hatchery entrepreneurs.

  Ten years ago, fish farming failures caused banks in Thailand to withdraw loans. Recent advances in technology have made fish farming a profitable enterprise and the banks are again lending money for aquaculture. Asian Development Bank loans are also available through Thai institutions, and the Thai government is presently subsidizing the construction of thousands of ponds for water conservation purposes. Many of these ponds have potential for fish production, particularly in northeastern Thailand.

4.4.2. Social impacts and gender issues

4.4.2.1. Introduction

The CRSPs were designed to create new knowledge and technologies adapted to developing country conditions while at the same time providing benefits to American agriculture. They were not specifically designed to deliver programs and services to people in developing countries. As originally envisioned, all of the CRSPs were supposed to have favorable impacts on their beneficiaries. There is an inherent potential contradiction between the global purpose of the research of the CRSP program overall and the attempt to target benefits to groups of people in a particular society. In addition, as with all USAID programs, the CRSPs were to be sensitive to gender issues, including the role of women.

The direct beneficiaries of the CRSPs included:

- the U.S. institutions and their professors, students, and employees;
- host-country institutions and their employees;
- American agricultural interests; and
- host-country pilot project participants.

CRSP expenditures have resulted in the creation of a network of U.S.-trained scientific professionals in developing countries who have personally benefitted from U.S. development assistance. The host-country institutions seem to have been strengthened by the presence of these trainees and by CRSP research activities, with the caveat that dependence on insecure foreign sources for research budgets, especially in the poorer countries, in some cases has made for externally influenced research agendas. The direct beneficiaries of the CRSPs were predominately male. In some countries few, if any, females were identified for long-term foreign training, especially at the Ph.D. level. Most of the United States professors involved in the CRSPs were also male, and the majority of CRSP management positions were held by males. In many of the CRSPs, female trainees were found mostly in the traditionally female-majority disciplines of food science and food technology.

USAID project managers questioned whether this predominance of direct benefits on males is a result of the CRSPs. **The evaluation team concludes that few measures were taken by the CRSPs to address the issue of gender balance. The small ruminant and bean/cowpea CRSPs were exceptions to this rule.**

During this evaluation, no statistical enumeration or structured interviewing of beneficiaries took place. The CRSP management entities and the NARS established a program of meetings and interviews for the evaluation team with individuals whom they deemed relevant and knowledgeable. These included trainees, farmers, administrators, and scientists. The Team's schedule of interviews was, therefore, determined by those who set up the meetings. Most of the people interviewed for this evaluation attributed the disproportionate direct benefit to males to the societal characteristics of the cultures involved, the lack of interest by women in scientific disciplines and agriculture, and the criteria of the host-country institutions for the prerequisites for becoming institutionally sponsored trainees. Few measures to address gender balance were reported. Only one institution, the

Escuela Agricola Panamericana (EAP) in Honduras, reported that it had adopted a program actively to recruit female students. It had obtained initially promising results, increasing its female student population by nearly 15 percent in three years.

The indirect beneficiaries of the CRSPs have included:

- rural residents who used CRSP-developed technologies;
- people trained by CRSP-trained scientists;
- family members and relatives of direct beneficiaries;
- institutions, colleagues, and co-workers of CRSP-trained scientists;
- students, colleagues, and institutions of CRSP-collaborators in the United States and host-country based;
- consumers who had more food as a result of CRSP-developed technologies; and
- beneficiaries of spread effects caused by economic activities resulting from the adoption of CRSP technologies.

Some of the CRSPs had design components aimed at assessing the potential for indirect benefits and spread effects. The small ruminant CRSP devoted substantial resources to describing and predicting constraints and adoption-promoting factors in Kenya, Indonesia, Brazil, and Peru. The bean/cowpea CRSP conducted studies aimed at ensuring that the research conducted would have positive effects on indirect beneficiaries. On the whole, however, the indirect social impacts of the CRSPs were largely inadvertent or incidental to the research activities and went unmeasured. Therefore, this evaluation cannot evaluate them or attribute observed changes to specific factors within or outside the CRSPs.

4.4.2.2. Employment and income

Several of the CRSPs reported increased employment or income at least partially attributable to CRSP activities.

Studies in Rwanda and Thailand revealed that fish farming had grown rapidly in recent years. Prior to the current civil unrest in Rwanda, the pond dynamics and aquaculture CRSP had a large and successful outreach component and more than 25 percent of the fish farmers were women. A study revealed that women who worked in groups had most effectively realized the benefits of fish culture for their families, including children. Land tenure for certain types of land was based on land uses approved by the government. The pond dynamics and aquaculture CRSP results were used to address this issue, and prior to the current disruption of the population and government, fish farming had become an accepted land use practice in the fertile lowlands and *marias* controlled by the govern-

ment. The CRSP had been so successful in encouraging women to adopt fish farming that a research project was conducted to document the program's success and to seek opportunities to structure similar extension programs for women in the region.

In Honduras, the pond dynamics and aquaculture CRSP has conducted baseline water quality studies to assist in regulatory decisions on the expansion of the shrimp industry in the sensitive coastal zone. This industry provides employment opportunities to thousands of people, including a significant number of women, now engaged in 8,000 direct jobs and 20,000 indirect jobs involving 40 percent of the people from depressed economic areas. This industry has helped to reverse the population exodus from the southern region of Honduras into urban areas. How much of this change is attributable to the CRSP is unknown, but the government expressed strong support for this CRSP, citing it as helpful to this key industry, which supplies a substantial proportion of Honduras's foreign exchange.

In the small ruminant CRSP, a nongovernmental organization had integrated the dual-purpose goat breeding and technology packages into an overall program of assisting farm families in western Kenya to improve their earning power and diversify risks. The Kenyan Agricultural Research Institute also was planning to utilize private-sector entrepreneurs to increase the rate at which dual-purpose goats were made available to farmers. This dual-purpose goat is now a registered breed.

4.4.2.3. Nutrition

The small ruminant, bean/cowpea, sorghum/millet, and peanut CRSPs all assume that the technologies they have developed will eventually have positive benefits on the nutritional status and buying power of farmers and poor people in developing countries, although the evaluation team had no means of assessing this social impact. The CRSPs claimed that improved cultivars and livestock breeds developed with CRSP research support have better nutritional qualities and improved yields and digestibilities, therefore have provided improved nutrition at lower prices to target groups. However, the minimal distribution of the genetic materials to date makes this claim difficult to validate. This impact is probably more potential than actual.

4.4.2.4. Trained people: numbers, gender, and impacts

In the small ruminant CRSP, a major human resources impact was the elevation to responsible positions of social scientists and economists in the Kenyan Agricultural Research Institute. This allowed their perspectives to be incorporated into strategic and tactical planning as well as operational research activities.

Women have had key roles in all phases of pond dynamics and aquaculture CRSP activities. These key roles include the pond dynamics and aquaculture CRSP project director, associate and assistant directors, U.S. principal investigators and research assistants, and host-country research assistants and students despite the fact that aquaculture as an academic profession does not attract many women. Numerous women have been attracted to aquaculture, however, through their experiences as Peace Corps volunteers.

The percentage of students who are women are as follows for different pond dynamics and aquaculture CRSP training categories: 34 percent, B.S degree; 20 percent, M.S. degree; 26 percent Ph.D. degree; and 26 percent nondegree training. The bean/cowpea CRSP also has one of the best records in terms of training women, especially in degree training where women constitute 44 percent of the students.

4.4.2.5. Farm household and farming systems

In the CRSPs research activities, few of the scientists have considered or understood the household as the basic socioeconomic unit of production and consumption. Most of the research work conducted was focused on biological, physical, or ecological constraints. Some of the CRSPs, however, were exceptions to this rule.

In Thailand, under the pond dynamics and aquaculture CRSP, the Asian Institute of Technology's Aquaculture Outreach Program concentrated on the identification of the needs of small-scale farmers and the constraints to development of aquaculture as components in farming systems. In its first phase (1988–1992), recommendations for fertilizer use and fry nurseries reached 700 farmers in Northeast Thailand and were included in training materials for 840 people from 18 government agencies and nongovernmental organizations. Of the farmers known to have received the Aquaculture Outreach Program's recommendations, 38 percent adopted recommendations during the first year and 55 percent during the second year. The Aquaculture Outreach Phase II (1993–1997) targeted six districts in three provinces in northeast Thailand. This geographic area includes at least 30,000 farms.

The soil management CRSP in Indonesia appointed a woman anthropologist as its first resident country coordinator. She conducted a detailed baseline study of the area affected by the transmigration program in which the CRSP had agreed to work. This study formed the basis of the subsequent activities of the CRSP until budgetary constraints caused the withdrawal of the CRSP expatriate team from the country.

4.4.2.6. User participation in research and technology transfer

A major weakness in the CRSPs with respect to social impact and benefit incidence is that the beneficiary populations were, with some exceptions, not defined and targeted before research activities were designed. The choice of the research thrusts was frequently made by researchers based on their interests and training, not on the needs of a particular group of people or a society. Social science activities within the CRSPs, when they were undertaken at all, were designed to assist the biological scientists to avoid social and economic pitfalls and not necessarily for selecting the best area for intervention. Some of the social science work was largely descriptive, based on the social scientists' own interests and having little relevance to most of the CRSPs' work. Social scientists were utilized by CRSPs to provide outreach activities and to document impacts. In general, CRSP-sponsored research activities and technology transfer were undertaken without re-

gard to social constraints or potential for impact. Overall, most technologies developed, such as improved seeds, better goats, agronomic practices, were gender neutral.

The evaluation team was given the opportunity to meet and talk to farmers and producers in each developing country visited. However, the Team had little information on why a particular farmer was selected or the extent to which CRSP activities directly impacted that individual. Nevertheless, some of the CRSPs were able to demonstrate that farmers were aware of the technologies CRSPs had developed such as cowpea varieties in Senegal, pond management practices in Thailand, and sheep and goat management practices in Kenya, Indonesia, and Brazil.

The small ruminant CRSP changed policy and research programs at KARI with regard to the analysis of biosocial roles in agropastoralist production systems. These changes included examining labor requirements and constraints and the roles of women and children in household production activities and management decisions, and recognizing implications for future policy interventions. It also resulted in the inclusion of social acceptability of the dual-purpose goat technology package as a research goal.

Unlike some of the other CRSPs, the bean/cowpea CRSP made overt efforts to collect and use knowledge about social systems to target research projects to be carried out under the program. This type of baseline work, when adopted and used by biological scientists in guiding their work, would increase the likelihood of intended social impacts beneficial to target populations. Nevertheless, in order to know whether this is true, studies of social impact among target populations need to be carried out.

The fisheries stock assessment CRSP results clearly identified social factors in need of attention by developing countries related to overfishing, reduced numbers and sizes of fish, inappropriate and dangerous fishing methods (blasting and cyanide poisoning), and a failure to exploit alternative fishery resources. In one case, CRSP work included recommendations for establishing sanctuary areas and for alternative fisheries. Other donors are following up on CRSP research with action projects based on these findings. IDRC in particular has funded a project in the Philippines, which is designed to deal with community-based fisheries resource management, especially social constraints.

Most of the activities in the sorghum/millet CRSP related to plant breeding activities, preservation of land races and varieties, and agronomic practices. In project design little attention was paid to social impacts, although CRSP funded scientists went to some lengths to verify and estimate financial and economic benefits of the program. In Honduras, University of Kentucky social scientists conducted studies of farmers engaged in sorghum production. Their attitudes and practices regarding constraints to sorghum production were collected and analyzed. This information subsequently was used by agronomists and plant breeders to refine the direction of their plant research. One plant breeder felt greatly influenced by these early studies and stated that this information shaped his understanding of what kinds of varietal characteristics would meet producers' needs and consumers' preferences. This social science assessment was dropped prematurely from the sorghum/millet CRSP early in the life of the program due to lack of funds.

The peanut CRSP worked primarily on breeding, which included genetic engineering, entomology, agronomic practices, and food processing research. No studies have been made of social impacts, although outreach activities have been conducted in various locations.

The use of plant breeding as an intervention of choice for mitigation of all kinds of environmental, social, agronomic, pathological, and entomological constraints seems to be excessive in several of the CRSPs' portfolios of projects. The question from the producer's point of view might well be what other agricultural or economic activities, including export or cash crops, off-farm employment, handicraft production, and wage labor, might provide more returns to the family.

4.4.2.7. Recognizing women's roles

The CRSPs undertook some specific activities within their programs that took into account the unique roles of women in the developing countries where they were conducting research activities. These roles included agricultural production, postharvest processing, food preparation, and food marketing. In addition, workshops were held by some CRSPs to target women and to increase awareness of gender issues.

The bean/cowpea CRSP had a strong focus on women's roles in agricultural production and utilization. According to CRSP reports, women are responsible for almost all aspects of bean and cowpea harvest, storage, food preparation, and processing in both Africa and Latin America. This CRSP had a separate Women in Development Program, which in close collaboration with biological scientists successfully brought gender issues into the design of research activities. The awareness of gender roles and constraints is reported to have improved the acceptance of the technologies that the CRSP developed.

A specific attempt was made by the peanut CRSP in Thailand and the Philippines to mount outreach interventions that targeted women, particularly as food processors. These activities were socially successful in that women's cooperatives were convinced to participate, but a subsequent study of costs in Thailand demonstrated that the processing activity was not economically viable.

Among the developing countries visited, the evaluation team noted some differences among the developing countries visited in the roles of women with respect to the same CRSP-prompted technologies. For example, in Kenya in several instances the presence of women serving as goat caretakers and advocates for the technology was in sharp contrast to Brazil, where a goat-production cooperative was all male.

Development projects, especially agricultural research investments, tend to promote the status quo because they work directly with existing government, university, and private-sector organizations and structures. These projects are not usually the appropriate mechanisms to promote such social changes as the equal treatment of ethnic and religious groups or the rights and safety of women and children in patriarchical societies. Furthermore, they tend to further strengthen the power and authority of existing institutions with

existing prejudices. Unfortunately, the lip service paid by development projects to "Women in Development" activities serves to create more cynicism than good will.

USAID project managers have asked whether each CRSP should have a gender specialist or whether CRSP should have more in-depth gender studies. The lack of equity in gender-benefit incidence is due more to a lack of proper planning and targeting of overall programs rather than the inclusion of a particular gender advocate among the implementing personnel of the CRSPs or the conduct of particular studies. There has to be a shared understanding about who is supposed to benefit from a set of activities, and this was never made clear in the selection of the overall CRSP research areas or subprojects or in the year-to-year management and oversight activities of USAID. Respondents from the USAID Missions and the international agricultural research centers to the questionnaires on CRSP Planning and Performance considered that gender issues were not being adequately addressed in the CRSPs (Annex K). **The evaluation team concludes that the goal of gender equity was not clearly articulated from the outset and accountability for it was not demanded by USAID project managers during the life of the program activities.**

4.4.2.8. Social impact summary

As a whole, the CRSPs had the social impact of reinforcing the status quo in agricultural research institutions in the United States and developing countries. The CRSPs were particularly effective as a means of supporting and strengthening U.S. land grant universities and developing country research institutions. The CRSPs' impacts on consumers, processors, producers, and the rural poor in developing countries have probably been minimal, although this conclusion is based on anecdotal and biased information and has not been measured quantitatively. The CRSPs did little to ensure representation of all ethnic and gender groups in the direct benefit incidence of the program activities, such as training and research-grant allocation.

The evaluation team concludes that, if they are to address issues of social impact with any hope of success, future CRSP programs, particularly if they maintain their global focus, must be truly multidisciplinary, involving biological, physical, and social scientists in an integrated, mutually reinforcing way because it is much more difficult to precisely identify and target beneficiary groups on a global scale.

4.4.3. Institutional impact

4.4.3.1 Developing countries

The CRSPs have purchased equipment and vehicles for use by host-country institutions to carry out their responsibilities to the CRSP. These durable items are used in other research projects and most will remain with the institutions after the particular project for which they were primarily purchased is completed. The CRSPs have helped to establish laboratories where none existed before and have trained technicians to work in them.

Most importantly, they have trained hundreds of scientists to the requisite technical level so that they could become true collaborators in planning and implementing CRSP research. They have notably strengthened economics and social sciences in the NARS of Senegal, Kenya, Morocco, Indonesia, the Philippines, and possibly other countries and helped to demonstrate the value of a multidisciplinary approach to planning and conducting applied agricultural research.

Over the years, CRSP-trained scientists have advanced in their careers and many now head up national research laboratories and institutes, university departments, national research planning departments and even national research agencies. Clearly people with growth potential were selected for CRSP-related scholarships and their association with a CRSP confers recognition upon them as scientists within the national scientific community.

We conclude that the CRSPs have helped to create an endowment of scientific personnel, most of whom have returned to their home institutions to continue their contributions to agricultural research, management, and national development policy.

While it is the general conclusion of both CRSP managers and evaluation team members that CRSP-trained scientists may well represent the greatest resource for affecting positive developmental change in their individual countries. The actual impacts of their presence since returning to their countries have not been documented by CRSP managers. **In the opinion of the evaluation team, the absence of such documentation leads directly to a significant underestimation of the actual benefits being derived from the CRSP program.**

The CRSPs have enhanced the institutional capacities of both national agricultural research systems and host-country universities. In Africa the collaboration has mostly been with the national agricultural research systems, but four well-known universities, the University of Ghana/Legon; Amadou Bella University in Nigeria, Sokoine University of Agriculture in Tanzania, and the Institut Agronomique et Veterinaire Hassan II in Morocco, have participated in CRSP projects, and the bean/cowpea CRSP has helped improve research and instruction at Bunda College of Agriculture in Malawi.

In Thailand and the Philippines, the involvement of universities was probably somewhat greater than the involvement of the NARS. The universities included not only several strong national and regional universities but also the Asian Institute of Technology, a regional postgraduate level university, to which the pond dynamics and aquaculture CRSP has significantly strengthened in the field of aquaculture. The University of the Philippines at Los Banos (UPLB) can also claim a regional mandate, not the least because it houses the International Rice Research Institute (IRRI) and the Southeast Asian Research Center Agriculture (SEARCA) on or adjacent to its campus. In Indonesia, the collaboration has been largely with the NARS.

Universities and national agricultural research systems in southeast Asia have considerable strengths in their own right, but they have been enhanced by their associations with

the CRSPs. At Kasetsart University, for example, the peanut CRSP has helped create a regional center of excellence in peanut food science and technology which is likely to outlast its involvement with the CRSP. **We conclude that there is much advantage to be gained from CRSP involvement with developing country universities with strong postgraduate programs, able to train the future scientists who will work on resource management and CRSP commodities. We recommend the CRSPs do more, working to ensure a critical mass of scientists in a range of disciplines, trainedat several universities, and increasingly at the best national and regional ones, with at least the minimum of equipment, facilities, and communication links to be effective.**

In Honduras the CRSPs have been working largely with the EAP, a regional agricultural college. The bean/cowpea and sorghum/millet CRSPs are housed on the campus. The benefits are regarded as mutual. The CRSPs have provided scholarships for postgraduate training to some of the faculty members and provided funds for collaborative research projects. The school, which is rightly renowned for its practical curriculum, provides an agricultural infrastructure that enables improved technology to be translated into farmer practice. For example, the seed unit of EAP has produced several tons of good quality seed of improved varieties of beans and sorghum developed in the CRSP projects.

The pond dynamics and aquaculture CRSP has also enhanced the capacity of a Honduran private association of shrimp enterprises (ANDAH) to undertake its own research and environmental monitoring. The industry is convinced that it can only survive in an environment with minimal resource pollution and sees its cooperation with the CRSP as an assurance of that survival. Equally important is the pond dynamics and aquaculture CRSP research link with the development of Honduran coastal environmental conservation regulations and sustainable shrimp production systems. These related initiatives will determine the sustainable level of expansion appropriate for the Honduran industry. The project activities are also expected to influence commercial development activities in Nicaragua and El Salvador, which also have suitable shrimp farming sites on the Gulf of Fonseca.

In Brazil the CRSPs have cooperated with EMBRAPA, one of the strongest NARS in the developing world. Leaders of national projects on beans and cowpea pest management, national programs on sorghum, soils management, small ruminants, and agricultural environment monitoring, and the director of national research planning have received postgraduate education with CRSP assistance and have been involved in collaborative research programs.

4.4.3.2. U.S. institutions

When the CRSPs were created, it was accepted that the U.S. land grant universities could make substantial contributions to the U.S. foreign technical assistance program and assist in reducing widespread poverty and malnutrition in the developing world. It was recognized that this would take time because tropical agricultural systems were not well understood. The CRSPs have done much to change this situation, and in doing so have helped

the participating universities gain knowledge, experience, and access to improved technologies for what must generally be regarded as minor U.S. crops. U.S. producers of beans, peanuts, sorghum, millet, sheep, goats, shrimp and fish have been the beneficiaries. We now also know a great deal more than we did about tropical soils and reef fisheries at a time when their degradation are matters of much environmental concern.

Many U.S. students, a significant number of whom are ex-Peace Corps volunteers, have obtained postgraduate qualifications through the CRSPs, firsthand research experience outside the United States; and at least the beginnings of an understanding of tropical agricultural systems.

Faculty members, too, have greatly benefitted from their participation in CRSP projects. They have gained from the international experience and travel while working with the CRSPs. Conversely, several of the participating U.S. universities already had strong international programs, and the CRSPs benefitted from this built-in advantage.

We conclude that the CRSPs clearly have increased the institutional capacities of U.S. universities and host-country institutions.

4.5. Sustainability

4.5.1. Introduction

Because the goal of this evaluation was to provide an objective assessment of the degree to which the collaborative research support programs have had an enduring effect on agricultural production, economic development, and natural resources management in less developed countries and the United States, this section of the report will address how, or if, all the CRSP's activities have led to sustainability.

The CRSPs have made some sustainable contributions to agricultural development and natural resources management that are likely to continue beyond the life of the programs. For instance, the work of the soil management CRSP has improved the basic understanding of the principles and mechanisms that govern the life-support processes of the soils of the tropics by debunking several myths and replacing them with scientific findings. Their research showed that less than 7 percent of tropical soils are at risk of turning into laterite. It also showed that the danger of depleting organic matter from tropical soils is no greater than it is in soils of temperate climates. In Honduras, research on tropical soils has led to improved watershed management practices that appear to have decreased the sediment load in streams and have helped maintain downstream ecology, benefitting the nascent shrimp industry.

Research on small ruminants has had enduring and sustainable results in developing technological management practices that have encouraged the introduction or reintroduction of small ruminants among poor, landless, or smallholder rural people, allowing them to supplement their incomes, diets, or cash flow and thereby decrease their desire to

migrate to cities and exacerbate social, political, and economic problems there. These practices have also encouraged natural resource conservation by recommending sustainable stocking rates, animal disease prevention strategies, better forage cultivars, birthing dates consistent with weather-induced natural pasture availability, and integration of livestock rearing with agroforestry and other complementary activities. The pond dynamics and aquaculture CRSP has also exhibited aspects of sustainability. For example, CRSP activities introduced species and cultivation practices that have been adopted and modified by private-sector organizations in both Thailand and Honduras.

It is also important to point out that U.S. agriculture has benefitted in a permanent way from the CRSPs contributions to the creation and maintenance of germ plasm collections in peanuts, sorghum, millet, beans, and cowpeas, as well as their pathogens, now protected from destruction or loss and widely available for international use.

4.5.2. Sustainable institutional development

The ability of host-country agencies to sustain programs of agricultural research varies greatly. Many factors affect sustainability, including the general level of development of the country and varying abilities of governments to fund research and development from current accounts. In many developing countries the ability to provide long-term capital investment for these purposes is intimately linked to the participation of external donor agencies.

In almost all of the countries visited by the Team, 80 percent or more of the available research NARS funding was devoted to payment of staff salaries and benefits. That leaves little money available for operational research costs. **Based on our interviews, the evaluation team concludes that the most pressing financial problems facing most NARS is the shortage of recurrent cost funds.** CRSPs did not have a mandate, and have not done much, to affect the sustainability of agriculture research programs in developing countries. While they have provided a welcome source of scarce operating funds on a small scale to allow foreign-trained host-country researchers to continue to have modest programs of investigation, they have had essentially no impact on convincing host governments to allocate recurrent cost funding on a permanent basis to agriculture research.

As the national agricultural research systems and host-country universities gather strength, in part because the CRSPs have increased the professional skills of their scientists, and as the CRSPs move toward regionality, the significance of research and information networks is bound to increase. **We conclude that the CRSPs should, in future, be more active in supporting appropriate regional networks. Because the international agricultural research centers also support such networks and complement the work of the CRSPs in other ways, we further conclude that the CRSPs and the international agricultural research centers should actively pursue opportunities for more intensive, mutually beneficial cooperation including the formulation of formal collaborative research projects.**

4.5.3. Extension and replication of results

The CRSPs were intended to generate solutions to priority global problems through research and training of researchers. At the same time, in the countries where they functioned, CRSPs were intended to promote development of research capability to increasingly carry out independent research and assist neighboring countries. CRSP efforts were not the principle vehicles to extend research results, but they did establish scientific linkages and disseminate information to facilitate extension. Most of the CRSPs included components to demonstrate, at least on a research pilot basis, the applicability of results obtained. To disseminate results, most of the CRSPs used workshops, conferences, linkages with international centers, publications, and programs presented through U.S. institutions. In many of the countries visited by the evaluation team, the weakness of extension agencies and programs has much to do with the difficulty in demonstrating impacts at the farm family level. Also the CRSP guidelines did not give the CRSPs a mandate to carry out directly such extension programs. Furthermore, the collaborating host-country research institutions likewise often did not have any mandate to do extension work. Several of the CRSPs worked on plant or animal breeding. The results of these programs, improved breeds or varieties, have often not been offered widely to farmers for a variety of reasons, including lack of mechanisms to replicate the improved stock, weak seed industries, monopolistic governmental practices, and lack of investment capital for private involvement.

Both the small ruminant CRSP and the pond dynamics and aquaculture CRSP have had severe impacts to their programs because of political instability at sites in Peru and Rwanda, respectively. Although the situations leading to the departure of these CRSPs from these sites were no fault of the CRSPs, these situations deserve mention, discussion, and some analysis regarding sustainability. Everyone in the development community is aware that developing countries in general are prone to political instability. This potential has been recognized in USAID's new emphasis on democracy. It is clear that the sustainability of investments in Rwanda and Peru has been severely undermined, however, if not completely eliminated, by the turmoil in those countries. **Based on the CRSP experiences to date, the evaluation team believes that the possibility for instabilities of this nature should be incorporated into CRSP strategies and operational plans.**

5. Recommendations

5.1. Given that agriculture is the engine of growth for much of the developing world, USAID should continue to give high priority to agricultural and agribusiness development, including agricultural research.

5.2. The implementation of the provisions of Title XII of the Foreign Assistance Act through the CRSPs has yielded substantial benefits to U.S. and developing country agriculture. The association between USAID and the land grant universities should be continued.

5.3. The operative CRSP model has certain deficiencies: resource allocations are not sufficiently based on a rigorous evaluation of the merits of research proposed or undertaken, management structures are duplicative and therefore more costly than necessary, and there is a perception of an entitlement without time bounds and without periodic accountability. To overcome these deficiencies, we recommend:

a. Introducing a system of competitive bidding for the available research funds *among the CRSPs* on the same level that exists for projects *within* the better managed CRSPs.

b. Structuring agricultural research activities under a single umbrella Management Unit with specific CRSP projects focused around a research topic and individual research subprojects nested within it. This three-tiered approach would permit unified administrative and financial management control by this single Management Unit while retaining programmatic control of individual CRSP projects at the level of the university consortia.

c. Opening CRSPs to all interested and qualified universities through a more open and transparent procurement and contracting process.

5.4. In allocating the remaining resources available within the CRSPs, high priority should be given to projects that protect the investments already made in trained personnel of the national agricultural research systems and universities in developing countries instead of using these resources for new M.S. and Ph.D. scholarships.

5.5. If additional funds are provided to support existing CRSPs, they should be allocated to the items below in the following order of priority:

a. Research on major global or regional problems that require long-term, concentrated, *multidisciplinary* efforts;

b. Collaborative and cooperative projects with universities in developing countries having appropriate graduate programs.

c. Regional networks for applied agricultural research on major food and export commodities of developing countries and for scientific informational and electronic exchanges.

d. Formal collaborative projects between CRSP institutions and the international agricultural research centers.

5.6. To target and discharge CRSP responsibilities better, CRSP *programs* should have specific objectives and statements of anticipated benefits for developing countries and the United States. In addition, CRSP *projects* should provide specific statements of expected research project outputs.

5.7. If USAID wishes to assess the impacts generated by CRSP-like activities in the future, the overall budget for the program should contain a specific line-item allocation of funds that can only be used to conduct of impact assessments. Such assessments, to be bias-free and free of conflicts of interest, should be conducted only by independent researchers with no ties with the program.

5.8. There has been no global relevance in terms of CRSP product development and test marketing activities to date. USAID should discontinue funding these activities, which more properly belong in the private sector.

5.9. NifTAL and SMSS should revert to their previous independent status and should be funded through cooperative agreements with USAID. Inclusion in the CRSP has added an unnecessary bureaucratic layer to their activities and increased their transaction costs.

5.10. In selecting host-country sites, CRSPs should consider the probable efficacy of each country's sectoral infrastructure for dissemination of projected CRSP research outputs. If the infrastructure is determined to be weak, the proponents should recognize the risks inherent in the selection of that county for a CRSP program. For this reason, USAID Missions should be represented in substantive planning of host-country activities because they have the greatest appreciation of in-country infrastructures and other factors that need to be taken into account to increase the likelihood of technology transfer.

5.11. USAID should provide funding to projects designed to promote the utilization of proven technology packages developed by the CRSPs for U.S. and developing country producers and for host-country programs supported by USAID missions.

5.12. The role and responsibilities of USAID personnel in the management and administration of CRSPs would be clearer if funding were by means of cooperative agreements between USAID and any future management units.

5.13. Effective private-sector representation should be incorporated by the CRSPs into all Boards of Directors, technical committees, and external evaluation panels.

5.14. The CRSPs should replace annual external evaluation panel reviews by a combination

of external evaluation panel reviews on a biennial or longer cycle and peer review of project proposals and reports.

5.15. USAID should reexamine its commitments to livestock and fisheries activities within the organization and issue a policy statement on the roles therein of livestock and fishery research and development.

6. Lessons for the future

6.1. As designed and implemented, the CRSPs have faced two unresolved dichotomies. First, in the general objectives between research and development activities; second, in the allocation of resources between global and local research needs. The land grant model, which integrates resident instruction, research, and extension, has not been fully utilized in the CRSPs.

6.2. USAID must recognize that not all CRSP scientific outputs will have direct development application.

6.3. Activities directed at dissemination of CRSP research outputs and generation of impacts cannot be effectively mounted by CRSP scientists alone. These activities require the active participation of persons with additional skills and perspectives.

6.4. The experiences generated during CRSP implementation demonstrate that selection of host-country research sites have not always considered each country's sectoral infrastructure or likely capacity to disseminate and utilize the outputs generated by CRSP research.

6.5. CRSP program control mechanisms were not sufficiently well developed to prevent the reallocation of resources from their intended use in global programs into research on site-specific, local problems.

6.6. Due to the progressive nature of research and the time required to complete single experiments, long-term, stable funding is required to implement strategic research plans and to optimize the potential for development impacts.

6.7. When new scientific knowledge is sought through CRSP projects, it should have a strategic character so that it will be applicable within a reasonable time to ameliorating targeted development constraints.

6.8. The ecological approach used by the sorghum/millet CRSP in allocating its funds was useful. The soil management CRSP's division of research into different ecological zones had the effect of dividing research programs into isolated subprograms, each run by a single university.

6.9. While program continuity is important, Title XII legislation has led to a perception of "entitlement" among participating institutions that is not always a positive force in research design and implementation.

6.10. Universities have placed great emphasis on the training outputs of the CRSPs. USAID needs to recognize that universities are more likely to produce high-quality training outputs than to generate technological outputs or undertake applied research.

6.11. USAID's short-term planning horizons, instabilities in available funding, and shifting development priorities have had significantly adverse impacts on the CRSPs' abilities to work on the long-term research problems they were set up to solve; corrective measures should be taken.

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Annex A

Statement of Work: Collaborative Research Support Program

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I. Overview and introduction

USAID has allocated a large proportion of its development assistance budget to international agricultural research through various mechanisms. One mechanism is the Collaborative Research Support Programs (CRSPs) involving U.S. and host-country universities and other research organizations. Seven of the eight original CRSPs were agricultural in nature and received funding from the Office of Agriculture in the Center for Economic Growth of the Bureau of Global Programs, Field Support and Research (G/EG/AGR). These agriculture CRSPs were focused on subsistence crops (beans, cowpeas, sorghum, millet, and peanuts), small ruminants, and fish that were judged to have the greatest potential for impact in developing countries. The eighth original CRSP, the Nutrition CRSP, was completed in 1992 and is not included in this evaluation.

Through FY1993, G/EG/AGR allocated $201.8 million to the seven original agriculture CRSPs. Nine CRSPs currently receive funding from G/EG/AGR. This evaluation, however, is only concerned with the seven original agriculture CRSPs since the others (Sustainable Agriculture and Natural Resource Management and Integrated Pest Management) have only begun to be implemented recently. Financial and other information on the agriculture CRSPs is provided in Attachment 1.

Guidelines for the CRSPs were originally issued by USAID in 1977 and were revised and approved by the administrator in June 1985. Other minor amendments were made in 1989. The purpose of the guidelines is to outline general concepts and approaches to assist in the planning, management, and evaluation of long-term collaborative university research programs and to outline a mode of operation as mandated in Title XII of the International Development and Food Assistance Act of 1975. Title XII was enacted: "to provide program support for long-term collaborative university research on food production, distribution, storage, marketing, and consumption." The act also provides that "programs under this title shall be carried out so as to ... (2) take into account the value to U.S. agriculture of such programs, integrating to the extent practicable the programs and financing authorized under this title with those supported by other Federal or State resources so as to maximize the contributions to the development of agriculture in the United States and in agriculturally developing nations."

While the major thrust of a CRSP is the generation of solutions to priority global problems through research, a concomitant objective is the development of research capability in the countries where the CRSP is functioning so that the developing countries can increasingly carry out independent research and assist neighboring countries. As stated in the CRSP Guidelines, "While the CRSP effort itself is not the principal vehicle to extend research results, it can and should establish scientific

linkages and disseminate information to facilitate extension" (Section VI-B, p. 42). The guidelines further state that each CRSP effort should include a component to demonstrate on a research pilot basis the applicability of results obtained and that CRSP personnel should continue to manage research results until they can be passed along to an agency suitable for extending them. This may be accommodated through workshops, conferences, linkages with international centers, publications, and through American institutional programs. Also, application of the results should take place in the LDC where the results were generated, in other LDCs, and in the United States, as appropriate.

The effectiveness of the CRSPs is of increased interest as the agency seeks greater focus and concentration in its assistance programs along with a reduction in the amount of funding being provided to agriculture. The CRSPs in reality are more than "projects" with indefinite completion dates—they are program frameworks for providing financial and technical support over an extended period. Within this CRSP framework, U.S. and developing country sustainable agriculture and natural resources management research agendas are changing in response to new scenarios, new needs, new information, and new development priorities.

II. Objectives of evaluation

THE goal of this evaluation is to provide an objective assessment of the degree to which each of the CRSPs has had an impact on increasing agricultural production and development, and improving natural resource management through the development and dissemination of new and/or more appropriate sustainable agriculture technologies. The evaluation will also assess the extent to which the CRSP framework has responded to past agency expectations and objectives and if the CRSP model can be used to respond to future agency needs and requirements.

The objectives of this evaluation are to determine:

1. The specific impacts of the CRSP programs on agricultural development and production, to the extent possible quantified in dollar terms, and if data are available, on incomes and employment in the collaborating countries (both LDC and the United States), and their effectiveness in helping generate technologies and strengthen institutions for increasing sustainable agricultural production and natural resource management.

2. The returns (economic, social including human resource development, institutional, and environmental) on G/EG/AGR's $201.8 million investment.

3. The distinctive features of the CRSP framework that contribute to or detract from the effective leveraging of resources from the university community, other donors and host countries, with special emphasis on agricultural research and training support.

III. Key issues and questions

THE following key issues and questions are intended to assist the evaluation team in structuring their review. The team should also include additional issues and question that may arise during the course of their review.

A. Key issues

1. Relevance: Is there evidence that research being conducted is relevant, i.e., is it addressing major global constraints?

2. Effectiveness: Is there evidence of research effectiveness and that there is satisfactory progress towards stated project objectives?

3. Efficiency: Are products being produced at an acceptable cost compared to comparable alternative approaches in the private or public sectors? What alternative approaches could be used to improve efficiency?

4. Impact: What have been the impacts of CRSP interventions and where are they demonstrated? Are these impacts measurable? Were these impacts planned and included in the design of specific interventions, or did they occur by chance?

5. Sustainability: Are any positive impacts described above likely to continue after the completion of the CRSP? Which project components are most likely to continue without USAID funding? Have host-country institutions integrated CRSP activities into their overall programs? Have host-country staff received appropriate and adequate training?

B. Questions

1. Accomplishments and results

   a. What have been the CRSP's contributions and direct impact, in dollar terms and in terms of other changes that may be unquantifiable, on agriculture development and production in the collaborating developing countries, in other developing countries, and in the United States?

   b. What impacts have the CRSPs had on incomes, employment, value added, and nutritional status in the developing countries and the United States?

   c. For each CRSP, have original objectives been met or is satisfactory progress being made toward meeting those objectives?

d. What are the "lessons learned" that can be used to improve CRSP impacts and accomplishments for the future?

e. How have CRSPs affected the level of competence and productivity of developing countries and American scientists and their respective institutions to identify constraints, to then plan and conduct agriculture research, and to extend the results?

f. What factors should be considered when deciding to expand, continue, or terminate a CRSP?

g. What are the major important variables of "prime" or principal sites overseas versus individual sites at other locations and how successful have these been?

h. What are the target groups for which the CRSP research activities are being undertaken, are the research results and training appropriate, and are the results being extended to the producer?

i. For each CRSP, what are the anticipated impacts over the next three to five years?

j. What have been the indirect or "causality" impacts of the CRSPs?

2. Research direction

a. In both LDCs and the United States, are the CRSPs providing the types of research, training, and technical progress most needed in their subject matter areas to address priority global problems in sustainable agricultural production and utilization of food crops, livestock, fisheries, and natural resource management?

b. Do the CRSPs complement ongoing research of International Agriculture Research Centers (IARCs) and National Agriculture Research Systems (NARS)?

c. What are the roles and how effective are the external evaluation panels, board of directors, and technical committees in guiding the direction of CRSP research activities?

d. Are the CRSPs supporting realistic strategies and agendas developed through a functioning network process that insures realistic and effective research efforts?

e. Are the CRSP research programs designed to address multisectoral, biological, physical, social, and economic constraints?

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f. Are the multidisciplinary, interdisciplinary team efforts successful in producing results?

g. How have CRSPs developed new knowledge through collaborative research?

h. Relative to their scopes of work, how effective have the CRSPs been in helping to disseminate and transfer research results?

3. Linkages

a. Have the CRSPs established long-lasting networks among American institutions and scientists, and between American and HC research institutions and scientists?

b. How has CRSP networking with USAID Missions, BIFADEC, U.S. universities, HC institutions, nongovernmental organizations and private voluntary organizations, and the private sector helped identify and resolve priority constraints?

c. How have the CRSP networks disseminated and shared research information with their developing country research collaborators, technology transfer specialists, private sector and USAID field missions? How effective is this dissemination and how can it be improved in the future?

d. How effective are the linkages between the CRSP and USAID Mission staff and programs in the collaborating countries and how can these linkages be strengthened in the future to include a feedback loop from Missions to CRSP management on program changes?

e. How do the CRSPs network with IARCs and national research centers to complement research work and avoid duplication of effort?

f. Do expatriate resident scientists (full-time in HC) hamper or enhance the development of local leadership, program development, and sustainability?

4. Other questions and crosscutting themes

a. In addition to addressing the dissemination of research results to increase agriculture production, assess the dissemination of results to missions and USAID.

b. What do the external evaluation panel and administrative management reviews contribute to CRSP management? Are they objective and conducted by the appropriate technical specialists?

c. Have the universities provided the 25 percent required "cost sharing"

b. What do the external evaluation panel and administrative management reviews contribute to CRSP management? Are they objective and conducted by the appropriate technical specialists?

c. Have the universities provided the 25 percent required "cost sharing" contribution? How effective have these contributions been in helping meet CRSP objectives and are other cost sharing mechanisms possible?

d. Have formal buy-ins (through basic ordering agreements) and informal buy-ins (through direct mission grants) from USAID Missions along with HC, private sector and other donor agency contributions, if any, been a key aspect of the CRSPs? What are their magnitudes, have they made a positive contribution to the program, can missions easily access the CRSP through buy-ins, and how can they be more successful in the future?

e. Since institutionalization of interventions is critical to long-term sustainability, how effective have the CRSPs been in this regard and what are their prospects for the future.

f. How effectively have the CRSPs addressed gender issues and integrated women into their activities?

IV. Methodology, schedule, and dates

A. Methodology

THE evaluation team will be briefed on USAID guidelines for conducting evaluations and preparing reports and will receive copies of relevant documents. The team will be responsible for determining the actual methodologies to be used.

B. Tentative schedule

1. Team meetings: During the first one to two days in Washington, the team will be briefed regarding USAID evaluation methodologies and reporting requirements. Under the direction of the team leader, the team should then meet to determine the methodologies to be used and to define their individual roles and responsibilities. They should also begin their review of various project documents that will be assembled on each CRSP by the respective project officers and project directors. Based on this initial review, the team should develop an instrument for collecting data during subsequent meetings and site visits.

2. USAID/W meetings: For the remainder of the first week, the evaluation team will meet with G/EG/AGR staff (director, deputy director, division chiefs, and project officers) and technical officers in regional bureaus, especially those who have had experience with the CRSP in recent assignments. Based on information gleaned from these meetings and from project documents, the team will finalize the selection of U.S. and overseas sites to be visited so G/EG/AGR and/or regional bureaus can obtain mission and country clearances for the team's field visits.

3. U.S. site visits: For the next two weeks, the core team and the appropriate technical specialists will visit at least two U.S. sites, one of which may be the management entity, for each CRSP. During this time the team will also complete its review of project documentation. Possible U.S. sites to be visited are listed in Attachment 2.

4. Overseas site visits: For approximately eight weeks, the core team and the appropriate technical specialists will visit key overseas sites, will travel together, where feasible, and visit key countries. Discussions will be held with mission agriculture and program staff and the Mission director, especially those who have had multiple interactions with CRSP activities. Where several CRSPs are being evaluated in a single country, the team may need to divide into two or three groups for on-site field visits. Some countries where CRSPs are no longer

are no longer active, such as Brazil, should be visited to assess the sustainability of related activities. Possible sites to be visited are listed in Attachment 2. (Please note that "Weeks in location" includes travel time to and from the location.) Where possible, country visits should be combined, and the most economic airfares should be utilized, for example, visits to African sites should be done sequentially to avoid multiple roundtrips between the United States and Africa. Current USAID travel regulations and per diem rates will apply. In most cases, in-country ground transportation may be provided by the CRSPs.

5. Report writing, debriefings, and conference: At the end of the field visits, the core team will reconvene in the United States for approximately two weeks to draft its report. The core team will be assisted by the short term specialists for a week each. One week after submitting a draft report, the core team will spend a week in Washington to debrief the administrator, assistant administrators, USAID technical staff and others, and to prepare the final draft of their report. After submitting their final report, the core team will conduct a one-day conference to disseminate their findings. See section VI on page 10 [p. A–17 of this transcription] for further details.

C. Dates

The evaluation team should begin their work in Washington on or about 11 April 1994. All work, including the submission of the final report and the one-day conference, should be completed on or about 31 July 1994.

V. Evaluation team composition

THE core team will consist of an institutional management specialist, an agriculture economist and a rural sociologist. In addition, five part-time technical specialists (plant scientist, soil scientist, animal scientist, aquaculture specialist, and fisheries specialist) will provide input on specific CRSPs as well as various aspects of the overall evaluation of the CRSPs. The rural sociologist and the aquaculture specialist will be provided by USDA. The IQC contractor will provide all other team members. The IQC contractor will select a team leader from the other two core members. Selected USAID staff will also be involved in the evaluation.

The following provides a summary of the skills and major areas to be covered by the collective skills and qualifications of the core team and technical specialists. The appropriate IQC functional labor categories appear in parentheses. Where more than one category is provided, the IQC contractor should select a candidate meeting the requirements of at least one of those categories. The team leader must have a Ph.D. in an appropriate discipline and meet other above level 4 qualifications (i.e., a minimum of 20 years of relevant professional experience including at least eight years of overseas experience, preferably in a developing country, and ten years of supervisory and/or management experience). All other team members must have Ph.Ds in appropriate disciplines and meet other level 4 qualifications (i.e., a minimum of fifteen years of relevant professional experience including at least five years of overseas experience, preferably in developing countries; supervisory/management experience would be helpful but is not required). The maximum number of workdays required for each team member appears in parentheses. These figures are based on six workdays per week. In the case of the short-term technical specialists, the required number of workdays will occur at various times during the period of this evaluation based on the U.S. and overseas sites to be visited.

A. Core team

1. Institutional management specialist (agricultural project design/evaluation and institutional specialists): This person will cover all management and institution related issues of the evaluation. This individual must have an extremely broad background. Experience as a practicing agricultural research scientist is desirable. (90 days)

2. Agricultural economist (food and agricultural economists): This person will be responsible for all economic and financial aspects of the evaluation including those related to economic rates of return and cost benefit analysis and economic sustainability. (90 days)

3. Rural sociologist (to be provided by USDA): This person will be responsible for issues related to the transfer of technology from research to end users, the impact of the CRSPs on beneficiaries, gender issues including the role of women, and sustainability, and will carry out relevant analytical work. (90 days)

B. Short-term specialists

1. Plant scientist (agronomists and crop scientists): This person will be responsible for all agronomic aspects of the evaluation especially the legume and grain CRSPs and should have experience related to plant breeding. (66 days)

2. Soil scientist (soil scientists): This person will have specific responsibility for the soils management CRSP evaluation and will provide input into all soils related aspects of the overall CRSP evaluation. This person should have experience in soil management and soil fertility. (66 days)

3. Animal scientist (animal scientists): This person will assist with the evaluation of the small ruminant CRSP and must have experience with a variety of small ruminants, especially in LDCs. (36 days)

4. Aquaculture specialist (to be provided by USDA): This person will assist with evaluation of the Pond Dynamics/Aquaculture CRSP and should have a background in aquaculture research and extension, especially in LDCs. (30 days)

5. Fisheries specialist (aquaculturalists and fisheries specialists): This person will assist with the evaluation of the Fisheries Stock Assessment CRSP and should have experience in fisheries stock assessment, preferably in tropical waters. (24 days)

C. Other criteria

1. As a team, members should possess a wide range of technical expertise and professional experience, including considerable overseas experience.

2. One member of the core team, preferably the person selected to be the team leader, must have relevant evaluation experience to insure the evaluation methodology is sound and followed by all team members and that the data are analyzed in a professional manner.

3. The team leader will be responsible for coordinating the preparation of the draft report and preparing the final draft.

4. One of the core team members must have extensive knowledge of applied technology and extension to cover this important aspect of the evaluation.

5. At least one member of the team visiting Latin America should speak Spanish

and one member visiting West Africa should speak French. Language capability relevant to other countries being visited will also be useful but is not required.

6. None of the evaluation team members or the institutions they work for should have previous direct experience with any of the CRSPs as researchers, principal investigators, or as members of the board of directors, technical committee, or the external evaluation panel. The team members will likely come from the private sector, IARCS, developing country research institutions, non-CRSP universities, donor organizations, and U.S. government agencies. Although the rural sociologist and aquaculture specialist are being provided by USDA, which has been involved in various aspects of the CRSPs, it is assumed that the individuals selected have not had any recent direct involvement with any of the CRSPs.

D. USAID staff

It is planned that several USAID staff will help facilitate the work of the team. It is planned that G/EG/AGR, and possibly G/Program Office and the Center for Development Information and Evaluation (CDIE), will provide part-time members who will help facilitate work in USAID/NV and then accompany the team on at least part of their visits. Each regional bureau (Asia/Near East, LAC, and Africa) will be asked to provide a representative from USAID/W or field offices to assist with the evaluation. These regional representatives, if USAID/W based, will assist the evaluation team while they are in Washington to help obtain country clearances and make arrangements, and accompany the team on visits to field sites. They will also be on the USAID committee that reviews, provides comments, and then accepts the final report.

VI. Reporting requirements and conference

THE team will provide a written draft report two weeks after completing the field visits. The report will follow USAID guidelines which will be provided to the team. One week after submitting the draft report, the core team will spend a week in Washington conducting debriefing sessions and finalizing their report based on both the debriefing sessions and comments assembled by G/EG/AGR. The contractor will provide 100 copies to G/EG/AGR. After submitting the final report, the contractor will arrange a one day conference to disseminate the evaluation findings to USAID, universities, other donors and the private sector. Further details appear in section IV.B.5 on page 7 [p. A–13 of this transcription].

Attachment 1

G/EG/AGR CRSP Funding ($000)

Project title	Project number	FY of first obligation	Funding through FY 1993	FY of final obligation Under cur rent grant	Total authorized funding
Original CRSPs					
Sorghum/millet	936-1254	1979	$43,936	1995	$48,549
Bean/cowpea	936-1310	1980	39,385	1997	54,903
Small ruminant	936-1328	1978	47,909	1995	53,366
Soil management	931-1311	1981	34,406	1994	38,946
Pond dynamics/ aquaculture	936-4023	1982	11,123	1995	12,107
Peanut	936-4048	1982	19,455	1995	22,423
Fisheries stock assessment	936-4146	1985	5,614	1993	6,166
Subtotal			201,828		236,460
New CRSPs					
Sustainable agri-culture and natural resource manage-ment	936-4198	1992	3,840	1996	26,250
Integrated pest management	936-4196	1993	933	1997	7,500
Subtotal			4,773		33,750
Total			206,601		270,210

Attachment 2. Illustrative CRSP Evaluation Schedule

Location	CRSP	Team Members	Weeks in Location	Total Person Weeks
Washington/ Other U.S. (Details on next page)	All Seven	Core Team (3)	7	21
		Plant Scientist	4	4
		Soil Scientist	4	4
		Other Specialists (3)	3	9
Niger or Senegal	Bean/Cowpea	Core Team (3)	1	3
	Soils Management	Plant Scientist	1	1
	Peanut	Soil Scientist	1	1
Mali	Sorghum/Millet	Core Team (3)	1	3
	Peanut	Plant Scientist	1	1
	Soils Management	Soil Scientist	1	1
Kenya	Small Ruminant	Core Team (3)	1	3
	Sorghum/Millet	Animal Scientist	1	1
		Plant Scientist	1	1
Honduras	Bean/Cowpea	Core Team (3)	1	3
	Pond Dynamics/Aquaculture	Plant Scientist	1	1
	Sorghum/Millet	Soil Scientist	1	1
	Soils Management	Aquaculture Specialist	1	1
Brazil	Bean/Cowpea	Core Team (3)	1	3
	Sorghum/Millet	Plant Scientist	1	1
	Soil Management	Soil Scientist	1	1
	Small Ruminant	Animal Scientist	1	1
Indonesia	Small Ruminant	Core Team (3)	1	3
	Soils Management	Animal Scientist	1	1
		Soil Scientist	1	1
Philippines	Soils Management	Core Team (3)	1	3
	Peanut	Fisheries Specialist	1	1
	Stock Assessment	Plant Scientist	1	1
		Soil Scientist	1	1
Thailand	Peanut	Core Team (3)	1	3
	Soils Management	Soil Scientist	1	1
	Pond Dynamics/Aquaculture	Aquaculture Specialist	1	1
		Plant Scientist	1	1

Attachment 2 (continued). Illustrative CRSP Evaluation Schedule

U.S. Sites

CRSP	Management Entity	Other American Universities
Pond Dynamics/ Aquaculture	Oregon State University	Auburn, Hawaii, Michigan, Michagan State, UC-Davis, U. of Arkansas-Pine Bluff (UAPB)
Fisheries Stock Assessment	University of Maryland	Washington, Rhode Island
Soils Management	North Carolina State University	Texas A&M, Cornell, Hawaii
Peanut	University of Georgia	Alabama A&M, NCSU, Texas A&M
Bean/Cowpea	Michigan State University	Auburn, Clemson, Purdue, UC-Riverside, Minnesota, UC-Davis, Georgia, Wisconsin, Idaho, Nebraska, Washington State, Puerto Rico
Sorghum/Millet	University of Nebraska	Kansas State, Kentucky, Mississippi State, Purdue, Texas A&M
Small Ruminant	University of California - Davis	Colorado State, Missouri, NCSU, Texas A&M, Texas Tech, Utah State, Wisconsin-Madison, Washington State, Winrock

Note: Visiting all of the management entities, plus Texas A&M and the University of Washington, will result in at least two sites per CRSP.

Annex B

Small Ruminant Collaborative Research Support Program

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1. Introduction

ESTABLISHED in September 1978, the Small Ruminant Collaborative Research Support Program (SR CRSP) was the first such program. Its purpose was to increase the utility of small ruminants to human populations in many of the less-developed regions of the world. Establishing this program recognized the role small ruminants play in enhancing income, providing cash flow, increasing employment opportunities, and reducing risk in addition to providing meat, milk, hides, fiber, and fertilizer to a large percentage of the world's population, especially the rural poor.

Since this was the first CRSP, it had no model to guide the implementation of program strategies. Therefore, the Joint Research Committee (JRC), now the Joint Committee on Research and Development (JCARD) of the Board for International Food and Agricultural Development (BIFAD), now the Board for International Food and Agricultural Development and Economic Cooperation (BIFADEC), contracted with the Research Triangle Institute (RTI), Research Triangle Park, North Carolina, to do the initial planning and design of such a model. The Research Triangle Institute, working in close collaboration with a team of consultants from universities and private voluntary organizations (PVO), developed a detailed model for the small ruminant CRSP. This model was later followed, with minor modifications, in developing nine subsequent CRSPs.

The small ruminant CRSP was initiated in 1980 with a Title XII grant of $20 million and matching-fund support from participating U.S. institutions and host countries to cover the costs of the first five years of research. Additional Title XII grants have brought the total to $48.8 million. The initial program consisted of seventeen projects carried out in five host countries by thirteen U.S. universities and Winrock International, a private voluntary organization. Together they developed joint research projects on sheep, goats, and camelids (alpaca and llama).

As projects matured they were graduated, and resources were redirected to new or junior projects. In 1987 one such site, Brazil, was declared a graduate country by USAID Washington, which led the small ruminant CRSP to phase out Brazil. In 1990 political unrest led to closure of the small ruminant CRSP in Peru. As a result an agropastoral project was initiated in Bolivia in 1991. In 1993 activities in Morocco were considered mature, so the small ruminant CRSP was phased out there.

After fourteen years the work continues with nine U.S. universities, the private voluntary organization, and three host countries (Bolivia, Kenya, and Indonesia) participating. Ten principal investigators (PIs) are carrying out eleven multidisciplinary projects in an interdisciplinary manner. Principal areas involved include genetics, breeding, animal nutrition, animal health, range ecology, veterinary medicine, sociology, economics, and production systems.

1.1. Goals and objectives

"The primary goal of the SR CRSP is to improve the efficiency and sustainability of small ruminant production *using environmentally sound practices* in less-developed countries (LDCs) and in the United States by expanding the body of knowledge and its application to the solution of specific problems; to expand the capabilities of U.S. and developing country scientists to conduct research; to develop and test appropriate technologies designed to improve food and fiber production of small ruminants; to improve the small ruminant production capabilities of less-developed countries; to improve the economic position of the sheep and goat producer; and to extend the benefits of research and experience to U.S. producers."[1]

These goals and objectives are essentially the same as those proposed by the Research Triangle Institute and have been adhered to during the fifteen years of the program.

1.2. Program purpose

"The purpose of the program is to conduct collaborative research to develop and/or test technologies that improve small ruminant production by bringing together the resources of U.S. institutions having expertise in the disciplines of ruminant nutrition, genetics and breeding, range science, economics, sociology, health sciences, and systems analysis with institutions in the developing countries to facilitate the development of a base of knowledge and manpower from which improved management systems and increased efficiency of small ruminants can be achieved."[2]

1.3. Participating agencies

Initial participants were thirteen U.S. institutions (twelve universities and a private voluntary organization). The management entity for the SR CRSP is the University of California–Davis (UC-D). Host countries were selected to represent the major ecozones of the world with at least one in each zonal region to maintain the global mandate of the CRSPs. Five host countries were originally selected (Brazil, Indonesia, Kenya, Morocco, and Peru), and, together with the U.S. institutions, they developed joint programs on sheep, goats, and camelids.

Changes over time led to a reduction in the number of participants. There are now nine U.S. institutions and three host countries involved in the CRSP.

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1. ME, 1990; amended in 1994 to include "using environmentally sound practices."

2. ME, 1979b; ME, 1984; ME, 1989.

Present participating U.S. institutions	*Research discipline*
University of California, Davis (UC-D)	Breeding/genetics
University of Missouri, Columbia (UM-C)	Rural sociology
North Carolina State University (NCSU)	Animal nutrition
Texas A&M University (TAMU)	Animal breeding/systems analysis
Texas Tech University (TTU)	Range management
Utah State University (USU)	Range management
Washington State University (WSU)	Animal health
Winrock International Institute for Agricultural Development (Winrock)	Agricultural economics/ production systems
University of Wisconsin (UW-M)[3]	Networking

Former U.S. institutions	*Research discipline*
California Polytechnic Institute (CalPoly)	Reproduction
Colorado State University (CSU)[4]	Animal health
Montana State University (MSU)	Breeding/genetics
Ohio State University (OSU)	Forage production
Tuskegee Institute (TI)	Production systems

Present participating host countries and host-country institutions

Country	*Collaborating institution*	*Ecozone*
Bolivia	Instituto Boliviano de Tecnología Agropecuaria (IBTA)	Arid highland tropics
Indonesia	Agency for Agricultural Research and Development (AARD)	Lowland, high-rainfall tropics
Kenya	Kenya Agricultural Research Institute (KARI)	Cool, subhumid and semi-arid; 1500–2000 m altitude tropics; low, hot, humid tropics

Former host countries and host-country institutions

Country	*Collaborating institution*	*Ecozone*
Brazil	Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) (linkage status since 1986)	Semi-arid tropics
Morocco	Hassan II Institute of Agriculture and Veterinary Medicine (linkage status since 1993)	Semi-arid Mediterranean altitudes to mild altitudes
Peru	Instituto Nacional de Investigación y Promoción Agropecuaria (INIPA) (linkage status since 1990).	Cool, dry, high altitude tropics.

3. Joined the small ruminant CRSP in 1990.

4. Subcontract with Washington State University.

2. Findings

2.1. Scientific outputs or achievements

2.1.1. Research

The small ruminant CRSP has conducted research for almost fifteen years. In each of the six host countries the program has supported numerous research projects. Projects have ranged from highly focused disciplinary attempts to solve specific problems to broad-based, team-oriented, interdisciplinary field studies. Much of the work has involved cooperative efforts among scientists of various disciplines. Most of the research has been oriented to development, not research for the sake of research.

Since the program was planned before host countries were selected, the evaluation team found that several of the original projects were unilaterally planned and initiated by the U.S. principal investigators. prior to consultation with host-country counterparts to set research priorities. These projects included the sheep fertility work in Indonesia, the simulation modeling work that led to the Kenya dual-purpose goat project, and the veterinary project in Kenya.

From its inception the SR CRSP used a multidisciplinary approach. The evaluation team feels that the program in Kenya is a model for farming systems research (FSR), having included components in biology, economics, sociology, production systems, and animal health. Recently strong linkages have been made with extension, and the approach has now evolved into a true farming systems research and extension (FSR/E) model. A multidisciplinary approach was also followed in Indonesia, but at its inception it lacked an animal health component. Work in Brazil, Morocco, and Peru was also multidisciplinary. Workers in Bolivia are following a similar approach.

Animal projects require long-term research (five to ten years) before yielding results. Developing new breeds of goats and sheep requires fifteen to twenty years. Some projects of shorter duration already have provided information of direct practical use to producers. Only now are other projects beginning to provide answers. Data from still other projects became the basis for subsequent research, contributing to potential long-term benefits and the body of knowledge.

Examples of results with immediate practical applicability and long-term potential benefits and contributions to the body of knowledge are listed below.

2.1.1.1. Research in Indonesia

Research in Indonesia has concentrated on four components: genetics and breeding, feed resources management, socioeconomics, and animal health. The genetics and breeding program contains two parts: work with the prolificacy (multiple birth) gene in Javanese Thin Tail sheep and introduction and production of improved hair sheep breeds. The feed resources and nutrition component has concentrated on evaluating forage resources, grazing systems, feed requirements for lamb growth and reproduction, and feed supplements from by-products and other sources. It has emphasized the identification and evaluation of shade-tolerant legumes and the use of tree legumes as high-protein supplemental feed resources. Economics research has focused on the economic analysis of integrated small-ruminant production systems, the economic analysis of animal health and grazing management, and market analysis at two levels of trade, local and provincial (Indonesia Annual Report, 1993).

Early in the Indonesian program it was decided not to include an animal health component because of the scope of the Australian input into the Animal Health Research Institute at Bogor. The Australians developed a collaborative program with Indonesian veterinarians that covered the health needs identified in West Java villages.[5] A similar working collaboration was again established in North Sumatra in 1993 (Wilson, 1993).

Among their accomplishments, small ruminant CRSP scientists have

- identified a major gene ($FecJ^F$) influencing litter size in Javanese Thin Tail sheep that allows selection for the litter size that best fits feed and management resources (Inounu et al., 1993);
- developed the Sei Putih Hair Sheep breed (50 percent Sumatra, 25 percent St. Croix, and 25 percent Barbados Blackbelly) adapted for grazing under tropical tree crops;
- demonstrated that supplementing tropical grasses improved the growth and reproduction of Javanese Thin Tail sheep and the growth of Kacang goats (W.L. Johnson and A. Djajanegara, 1989);
- developed a grazing scheme in Sumatra for sheep under rubber trees that has reduced weed infestation as well as the use and cost of herbicides by 50 percent;
- developed a successful outreach pilot program (OPP) and outreach research program (ORP) for smallholders that has benefited over 300 farmers;
- established a forage evaluation nursery at the government research station in

5. W.H. Johnson (North Carolina State University), pers. comm., July 27, 1944.

North Sumatra which contains over sixty-three legumes (including trees) and grasses, the only nursery of its kind in southeast Asia;

- at North Carolina State University, in collaboration with Agricultural Research Service (ARS) scientists, identified adapted cultivars and performed basic research on the effects of shading on plant growth and perennial rhizomal peanuts. This research has wide potential application in Indonesia and the southeastern United States and in other, similar ecozones.

2.1.1.2. Research in Kenya

An important aspect of the SR CRSP work in Kenya was the pioneering and institutionalization of both multidisciplinary research and on-farm trials at the Kenya Agriculture Research Institute (KARI). The efforts of the small ruminant CRSP have resulted in the creation of social science and economics disciplines at the institute. Collaborative research by the small ruminant CRSP and the institute is aimed at assisting Kenya to achieve nutritional self-sufficiency by generating appropriate agricultural technologies through scientific research. Some noteworthy accomplishments include the following in which the Kenya small ruminant CRSP

- developed a composite breed, the Kenyan dual-purpose goat,[6] for milk and meat production in farming areas of higher potential (Cartwright, 1984a);

- evaluated forage crops from various parts of Kenya and other tropical countries to determine their suitability for western Kenyan conditions (Semenye 1993);

- developed a new vaccine against contagious caprine pleuropneumonia (CCPP) (Muthomi and Rurangirwa 1983; Rurangirwa et al., 1984; 1987a; 1987b; 1987c; 1987d; 1987e; 1990; 1991; Smith et al., 1994);

- developed the capacity to rapidly induce experimental ovine pulmonary carcinoma (OPC) as well as ovine progressive pneumonia (OPP) in neonatal lambs and characterized the resulting lesions and immune responses (Snyder et al., 1987; Garmendia et al., 1987; Ramirez et al., 1988);

- demonstrated that some individual Kenyan dual-purpose goats display more resistance or tolerance to the common stomach worm *Haemonchus contortus*, a worldwide problem in both sheep and goats (Kasmer et al., 1993);

- developed and validated a computer simulation model for small ruminants that has wide application in the United States and abroad (Cartwright, 1984a, 1988b; Cartwright and Blackburn 1987; Cartwright et al., 1987);

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6. The breed was registered with the Kenya Stud Book in May 1994.

- designed a model for communicating small ruminant CRSP project results;

- by social science research, established that the Kenyan dual-purpose goat Techpack had social acceptability at the project sites;

- assessed the economic viability of the Kenyan dual-purpose goat technology;

- launched the rapid multiplication of Kenyan dual-purpose goat by using approximately 200 farmers and 800 local does (Semenye 1994b);

- worked with a total of 150 farm families in western Kenya from the early 1980s to 1989. These farmers were allocated dual-purpose goats and were provided with the supporting production technology to facilitate on-farm, farmer-managed trials. In collaboration with the Kenya Agricultural Research Institute, two new sites were established in 1993 for expanded trials of the Kenyan dual-purpose goat technology in five new clusters, three in the semi-arid Katumani ecozone and two in the humid coastal Mtwapa ecozone. Although only five of twenty farmers in each cluster have received goats at this time, the evaluation team was impressed with the enthusiasm shown by the farmers who have been allocated the Kenyan dual-purpose goats (ME, 1993)

2.1.1.3. Research in Morocco

Research in Morocco included work in nutrition, genetic improvement, and range management. Noteworthy results include

- demonstrating that the Moroccan D'Man breed of sheep transmits its high prolificacy additively and contributes earlier puberty, longer breeding season, and more rapid growth (Bradford, 1989);

- identifying nutritional myopathy among sheep;

- demonstrating to farmers that productive culling procedures can improve the size and quality of their flocks. One example established mating schedules that have resulted in some cases in doubling production in poor-producing flocks (Bradford and Boujenane, 1993);

- developing supplemental feeding practices to optimize ewe and lamb performance in relation to seasonal grazing opportunities in mixed farming systems (primarily sheep and wheat) (Outmani et al., 1991; Guessous et al., 1994).

2.1.1.4. Research in Brazil

A multidisciplinary applied research approach produced a substantial number of tech-

nologies and management practices for hair sheep and goats raised under semi-arid conditions in one of the poorest regions of the world. Accomplishments include

- developing of a test in Brazil for identifying immune response to the bacterium that causes caseous lymphadenitis, a worldwide disease of sheep and goats (Brown et al., 1986a, b; Costa 1987).

- demonstrating that forage production and goat nutrition in Brazil's semi-arid forest regions was enhanced through environmental manipulation, such as, thinning tree canopies, which resulted in significantly more production of forage biomass beneath the trees (Kirmse et al., 1987).

- establishing the importance of several native Brazilian tree and shrub species as valuable forage plants for sheep and goats;

- demonstrating that the use of *caatinga*[7] forest in the Sertão region of northern Brazil for both animal and wood production could be an economically effective and sustainable enterprise;

- discovering that *caatinga* forest in Brazil recovers rapidly and has high potential as a sustainable ecosystem;

- learning that the major nutritional constraint in Brazil was the low digestible-energy content of forage from mid-September through December;

- learning that farmers in northern Brazil use goats mainly as a "living bank account" and more as a form of drought insurance than as a market commodity.

2.1.1.5. Research in Peru

Research in Peru focused on the improvement of the overall productivity of sheep and camelids (alpaca and llama). The research disciplines included animal breeding, health, nutrition (range and pasture), economics, and sociology. A summary of the research accomplishments follows:

- identified the competitive and interactive grazing behavior of sheep, alpacas, and llamas on Peruvian highland ranges;

- demonstrated that if properly used, cultivated forages could boost animal production by 15 to 20 percent;

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7. A *caatinga* forest is a low, scrubby forest with a high proportion of thorny legumes. It occurs on shallow soils, these often being underlaid by a hardpan at 50–60 cm.

- found that the dominant proportion of the livestock produced by highland peasant communities in Peru is raised in agropastoral communities, not, as previously thought, almost exclusively by pastoral communities;

- demonstrated that (1) camelids are better adapted to the ecosystem than sheep, yet sheep are the dominant herbivore raised by smallholders and on social cooperatives; (2) overgrazing, primarily by sheep, has led to severe deterioration in the productivity of these grazing lands; and (3) rotational grazing systems can aid in the rehabilitation of these lands and their vegetation;

- identified an antigen specific to ovine pulmonary carcinoma (OPC) virus that was useful in isolating the causative virus and in developing a serological test for carrier animals and eventually developing a vaccine (DeMartini et al., 1989) (this disease is responsible for severe losses of adult sheep in Peru);

- demonstrated that the high incidence of neonatal mortality among alpaca in Peru was related to the bacterium *Clostridium perfringens* type A enterotoxigenic *Escherichia coli.* An enzyme-linked immunosorbent assay to detect its presence was developed;

- documented nutritional constraints during mid to late dry seasons on high-elevation Andean grasslands and formulated approaches to alleviate these problems;

- assessed both indigenous and introduced small ruminants in terms of their ecological impacts, nutritional constraints and efficiencies, and the proper stocking rates and animal mixes under range conditions in Peru.

2.1.1.6. Research in Bolivia

Fieldwork was transferred from Peru to Bolivia and initiated in that country in September 1991. Work at this site is waiting for U.S. institutions to commit to the program fully while working with the host country on its role in this collaborative effort.

The major contribution to date has been a strengthening of Bolivian national agricultural research capacity through the Bolivian Institute for Agricultural Research (IBTA) by contributions in the form of training local scientists, performing socioeconomic research, and practicing interdisciplinary methods, on-farm research, and facilities development. Specific ongoing activities include:

- assessment of the levels of environmental risk faced by agropastoralists, including definition or description of past droughts, support system policy, and outlets for crop and livestock products;

- analysis of biosocial roles in agropostoral production systems, including labor re-

quirements and constraints, roles of women and children in household production activities and management decisions, and implications for future policy interventions;

- description of factors affecting livestock management strategies of agropastoralists as they relate to land tenure and livestock;

- development of a baseline profile of human resources in Bolivian research institutions and their current approaches to research.

2.1.1.7. Multicountry findings

In many instances, research was conducted on various problems in several host countries, including the following:

- documenting the degree to which rural women, children, youths, and the elderly play significant and often primary roles in the care, feeding, and management of small ruminants as well as in making major consumption and distribution decisions (Kenya, Peru, Indonesia, and Bolivia);

- defining the roles of the various family members in combined crop-livestock farming systems and identifying and clarifying the age and gender responsibilities of household members (Kenya and Indonesia);

- identifying and developing a plan to control the viral agent causing caprine arthritis encephalitis (CAE) in Kenya, Peru, and other parts of the world (Adams et al., 1983);

- characterizing by interdisciplinary effort the resource base in the Andean highlands of Bolivia and Peru as they relate to small ruminant production and larger farming systems.

2.2. Publications

Many of the program's substantive results have been documented in technical reports, journal articles, books, abstracts, and oral presentations. A substantial number have been translated into the principal language of the host country. During the past fifteen years, more than 1,600 publications and more than 300 technical reports and oral presentations were prepared (ME, 1993; 1994a). Publications were of the following types and numbers:

Publication types	*Number*
Books and chapters in books	86
Refereed journal articles published or in press	334
Journal articles submitted for review	117
Technical reports, bulletins, and proceedings	811
Abstracts of papers presented at meetings	585

These publications are listed in the Department of Commerce Bibliography and are available and distributed worldwide.

By September 1994, for each host country, the small ruminant CRSP will have published, in local dialects or languages and in English, a report of research-based technologies that have been evaluated for social, economic, and technical feasibility. These publications, in the form of technology packages (Techpacks), summarize current management recommendations and are distributed to local extension personnel. They, in turn, will disseminate information to producers of sheep, goats, and camelids. This process of transmitting the knowledge gained through research and validated under realistic conditions in the form of practical technological packages represents the type of dissemination envisioned by project planners at the beginning of the small ruminant CRSP (RTI, 1978f).

Significant Techpacks include:

- A report and technology manual on Brazil released in 1989 in both Portuguese and English (Shelton and Figueiredo, 1990);

- The 250-page production manual entitled *Sheep Production and Management in a Mediterranean Climate: The Agropastoral System of Morocco*, produced by the small ruminant CRSP breeding project. The manual is the first of its kind for North Africa and contains information useful to a wide range of production enterprises in the region (Berger et al., 1990);

- A new and comprehensive reference book entitled *Genetics of Reproduction in Sheep*, which includes contributions from fifty scientists from seventeen countries, the result of a small ruminant CRSP co-hosted world conference on

sheep genetics and reproduction (Land and Robinson, 1983);

- Two Techpacks for management of Kenyan dual-purpose goats, entitled *Nutrition and Management for Dual-Purpose Goats Research Highlights* (Semenye, 1991) and *On-Farm Research and Technology for Dual-Purpose Goats* (Semenye and Hutchroft, 1992).

2.3. Training

Training host-country and American students is one of the most vital aspects of the small ruminant CRSP. From 1978 to 1994, 480 men and women participated in the SR CRSP-supported formal degree programs, workshops, seminars, and professional meetings (ME, 1994b). Training such a large number of people was made possible through a combination of tuition scholarships often provided by participating universities and donors while the small ruminant CRSP covered the remaining costs. Approximately 80 percent of these students obtained advanced university degrees. Slightly more than half of them were enrolled at U.S. institutions, mostly at universities participating in the small ruminant CRSP (ME, 1994b).

Approximately 58 percent of persons in degree programs were from the United States, 42 percent from the host countries. Approximately 71 percent of degree-program participants were male, 29 percent female. Twenty-eight percent of the degree participants were awarded the Ph.D, and 64 percent received the M.S. or equivalent degree. *CHECK MANUSCRIPT HERE The completed studies for B.V.M./D.V.M. degrees or B.S./B.A. degrees.* Among the major disciplines in which the degrees were granted were breeding and genetics (19 percent), range management (20 percent), nutrition (16 percent), and economics (13 percent). Other disciplines included animal health, sociology, reproduction, and production systems.

While the cost of this training amounted to $10.1 million ($30,000 per U.S. M.S./B.S. degree; $50,000 per U.S. Ph.D. degree; $15,000 per non-U.S. M.S./B.S. degree; $30,000 per non-U.S. Ph.D. degree), the real value of the degree training program goes beyond the costs and the numbers of students trained. A large number of the students from the host countries conducted thesis research in their own countries, thus contributing significant knowledge about local production of small ruminants. Many participants who earned M.S. and Ph.D. degrees currently serve as coprincipal investigators in small ruminant CRSP activities. Still others hold key positions in their research institutions, such as the small ruminant CRSP–trained dean of veterinary medicine, University of La Nolinas, Peru.

At the same time, the SR CRSP implemented a program of technical training. This program ranged from informal training sessions to formal workshops lasting several days. In the past fifteen years, approximately 2,000 host-country participants attended over 100 sessions supported or sponsored by the project. Participants at these sessions have included farmers, technicians, extension workers, project personnel, and host

government administrators. Some of these sessions were so successful that they are now annual events. One in particular, the annual SR CRSP Scientific Meeting in Kenya, will hold its twelfth meeting later in 1994.

The evaluation team found that much of the training in specific disciplines was conducted at collaborating U.S. institutions. For instance, most of the animal health training was supplied by Washington State University and Colorado State University and nearly all the Kenyan genetics/animal breeding students were sent to Texas A&M University.

2.4. Contributions of the small ruminant CRSP to U.S. institutions

The small ruminant CRSP has enabled participating U.S. universities to contribute more to international development. During the past fifteen years, all but two of the SR-CRSP universities have held either USAID-funded strengthening grants or program support grants, which have provided complementary financial support in the form of travel grants, courses, and curriculum development.

The small ruminant CRSP has been the driving force in some U.S. institutions in giving an international perspective to graduate and undergraduate programs. Material derived from host country research and development programs has been incorporated into lectures and seminars. At the University of Missouri–Columbia, a campuswide undergraduate major in international studies and development has been proposed. At several universities the small ruminant CRSP faculty has initiated interdisciplinary courses in international development. The small ruminant CRSP has been instrumental in stimulating some institutions to develop with sister universities abroad academic exchange agreements that have led to the exploration of possible new research collaborations with kindred organizations. Exposure to the small ruminant program has provided some faculty with their first experience in international development in their fields.

The small ruminant CRSP has increased the breadth and scope of training of international students, and has been culturally enriching for U.S. and foreign students through their interaction. For foreign students, the close ties developed between themselves and their professors associated with the small ruminant CRSP program constitute an effective, long-term relationship. American students were offered opportunities to work with in-progress development projects through research for advanced degrees and internships, some of which were at SR CRSP research sites (ME 1994b).

Involvement in the SR CRSP has led to the identification of new categories of research within collaborating faculties' disciplines. In sociology, for example, the field of ethnoveterinary (traditional animal medicine) research and development has emerged as an area of study where the small ruminant CRSP can contribute knowledge and experience. In Peru several indigenous plants have been used for years

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in an attempt to treat internal and external parasites and some infectious diseases. Assessment of their efficacy and the evolution of indigenous agricultural knowledge may provide biological control alternatives and management strategies useful to U.S. agriculture, which faces increasing problems with degradation of the environment and food quality.

At some universities, teaching and funding at the graduate level is formula driven. That is, the more students in a program, the greater the state funds contributed. Because of the presence of the SR CRSP, some universities have invested more state funds in expanded research programs, and laboratories and have purchased equipment to facilitate graduate student instruction and research, as contributions toward the university's requirements to match small ruminant CRSP funds.

The presence of the small ruminant CRSP on some campuses has stimulated faculties to obtain Fulbright research and teaching fellowships, National Academy of Science (NAS) grants, and USAID-funded grants from the Program in Science and Technology Cooperation. They have used these fellowships and grants to develop joint projects with animal and social scientists at non–SR CRSP universities, to use their expertise in other USAID projects and activities, to participate in international task forces and steering committees of professional societies, and to become involved in World Bank projects in small ruminant CRSP countries. For example, because Texas Tech already was involved in Peru's small ruminant program, it accepted the request by Peru that it also manage the livestock sector development program being financed by a $1.3 million World Bank loan.

Because of their involvement in SR CRSP, several universities have become recognized world leaders in the areas of small ruminants, range livestock management and production, sheep and goat diseases, and camelid nutrition and diseases. Many institutions have purchased goats and hair sheep for use in their collaborative research programs. As a result, faculty, students, and U.S. producers have had opportunities to see and work with breeds and types of animals that normally would not have been available to them (ME 1994c).

The small ruminant CRSP has worked with and supported Winrock International's projects in Trinidad and Tobago and Antigua, where a ruminant production project was co-funded by Winrock International and the government of Trinidad and Tobogo. A similar situation in Haiti involving the multiplication of improved goats for meat production was fostered through a project co-funded by USAID, Winrock International, and the Arkansas Methodist Church.

Scientists with the small ruminant CRSP have participated in many small ruminant activities outside the small ruminant CRSP proper. Through a technical assistance project involving scientists of the small ruminant CRSP and co-funded by USAID and Winrock International, training and technical assistance were provided to private voluntary organizations. Various workshops, short courses, and training sessions were held, and a number of materials were developed in or for these events. These include

the *Goat Health Handbook* and Techpacks on goat management as well as the publication by Winrock Scientists of *Sheep and Goats in Developing Countries* (De Boer and Fitzhugh, 1983), which resulted from a project funded by the World Bank.

2.5. Contributions to U.S. agriculture

Strong collaborative research linkages have been developed among numerous U.S. agricultural institutions, both public and private, thereby strengthening their contributions to U.S. agricultural research and extension programs. Participation in SR CRSP research has increased knowledge and understanding of the following:

- sheep production on U.S. rangelands, and the impact of sheep on cool-season plants at high elevations in the United States;
- llama nutrition and feeding, which is particularly helpful as llamas continue to gain popularity in the United States;
- adaptability of production and management of cultivated forages grown in the United States (these forages include orchard grass, timothy, rye grass, red and white clover, and alfalfa);
- hair sheep, introduced into the southeastern part of the United States;
- grazing under tree crops as a means to reduce weeds, which reduces the use of herbicides, a goal that has environmental importance;
- ovine progressive pneumonia (OPP) and assisted in developing an eradication procedure (Cutlip et al., 1994);
- the slant-tube technique for rapidly screening legumes for root growth and elongation.

Major contributions of SR CRSP have leveraged additional funds. One activity has centered on the initiation of a project at Texas A&M University to identify genetic markers that are correlated to small ruminants' resistance to internal parasites.[8] The implications of this have widespread potential in sheep and goat production worldwide. Washington State University scientists were recently awarded a USDA NRICGP grant entitled "T-Helper Lymphocytes and Immunity Induced by *Haemonchus contortus* Gut Antigens."[9]

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8. J. Taylor, pers. comm., 1994.

9. Travis McGuire (Washington State University), pers. comm.

Winrock International's early involvement with the small ruminant CRSP enabled the organization to utilize the experience and information gained from operating its model grade-A goat dairy in Arkansas to develop goals, objectives, and research plans for the small ruminant CRSP. These goals in turn influenced activities of the dairy and contributed to the development of the Central States Dairy Goat Marketing Cooperative involving producers from Arkansas, Missouri, and Oklahoma. The organization has been effective in organizing the sale of breeding animals for export, and it stimulated Winrock's staff to conduct an economic analysis of goats marketing in the United States.

The small ruminant CRSP has been the primary source of continued support for research in sheep diseases at Colorado State University (subcontracted by Washington State University) in its collaborative work with Peru, which may eventually lead to new vaccines for control of important diseases of sheep in the United States.

With SR CRSP support, Brazilian and University of California animal pathologists developed a test for identifying the immune responses to the bacterium that causes caseous lymphadenitis. This finding led to the development of a vaccine that can be used wherever the disease plagues sheep and goats.

The development of sheep and goat simulation models by Texas A&M University is having an impact on the U.S. research community and the sheep industry. An additional project was initiated in Texas A&M's Range Science Department to link these models to models in forage dynamics and diet selection.

2.6. Linkages

Numerous linkages have been developed among participating U.S. institutions and between U.S. institutions and host countries.

2.6.1. Participating university linkages

Strong linkages have developed among U.S. scientists and institutions engaged in the CRSPs. The structure of the CRSP management assures that each university and its administrative and scientific staff are engaged in cooperatively planning and conducting research. The result has been both disciplinary and interdisciplinary collaboration directed toward solving mutually agreed upon research problems. More importantly, collaborating institutions have established effective and continuing working linkages in areas of mutual interest and compatibility. Prior to the initiation of the SR CRSP, such linkages essentially did not exist.

2.6.2. Host-country linkages

The evaluation team found that current collaboration between U.S. and host-country institutions and scientists is notably effective despite the fact that the program was designed without host-country participation (RTI, 1978a-f) and consequently several research projects were imposed on the host country without consideration of its national priorities. Examples of this were the fertility work in Indonesia and the simulation modeling work in Kenya. This deficiency was partially corrected in planning for the 1996–2000 project extension. The evaluation team found that approved potential projects in Albania, Honduras, and Kenya were planned in collaboration with host-country institutions and scientists except for part of the Kenya Animal Health Proposal. Project 2 of that proposal was endorsed by the Kenya Agricultural Research Institute; Project 1 (T. Yilma's proposal), however, was not planned in collaboration with either the principal investigator of Project 2 (T. McGuire) or the host country (Kenya Agricultural Research Institute). The unsuccessful proposal for Indonesia also was planned in complete collaboration with the host country. (The evaluation team did not have access to other unsuccessful proposals.)

The evaluation team found an excellent example in Kenya of how intercountry linkages can be fully developed. The six-person SR CRSP staff of scientists is composed of five Kenyans and one expatriate from Uganda. The site coordinator is an official with the Kenya Agricultural Research Institute. Scientists at the Kenya research institute are assigned to the small ruminant CRSP and work collaboratively with the small ruminant CRSP resident scientists. Scientists from U.S. institutions participate through short-term site visits, visits by field personnel to U.S. institutions, and by conducting experimental work at locations in the United States. The small ruminant CRSP is fully integrated into the Kenya Agricultural Research Institute. On-site responsibility for research administration, both fiscal and scientific, rests with Africans. Intracountry linkages were also effective and included participation in the National Council for Science and Technology, the Annual Kenya Agricultural Research Institute Scientific Conferences (patterned after the annual Kenya–SR CRSP Scientific Meeting), the Organic Matter Management Network, and the National Christian Council of Kenya (ME, 1994e).

In Indonesia the evaluation team found the small ruminant CRSP activities fully integrated into the Indonesian Central Research Institute for Animal Science (CRIAS) and collaboration was excellent. However, even after fifteen years of small ruminant CRSP activity, two of three resident scientists in Indonesia were expatriates. Although the site coordinator was an Indonesian, the expatriates continued to have the major responsibility for administrative, fiscal, and scientific affairs. This was due in part to the change in the field site from Java to North Sumatra. Persons trained early in the program were from Java, and most of them are now engaged in administrative and research activities at the Indonesian Central Research Institute for Animal Science and are unavailable for assignment to CRSP activities.

The situation in Bolivia is less hopeful. Most of the resident scientists are non-tenured staff of U.S. institutions, and this causes one to question the sustainability of

the program after SR CRSP funding ceases (EEP 1992).

2.6.3. USAID mission linkages

Over the life of the program, the relationships between the CRSP and the host-country USAID missions have been inconsistent, and in several instances, highly contentious. Changes in USAID objectives and the personnel and objectives of USAID missions have exacerbated these problems, especially in Indonesia. Also, early on, the failures of U.S. researchers to brief missions fully on program plans and to take into consideration a mission's country strategy appear to have contributed to these sometimes rocky relationships. Although USAID Kenya only reluctantly agreed to Kenya's becoming a host country earlier in the project (1980), the evaluation team found the current support for the small ruminant CRSP by USAID Kenya to be outstanding and commends that Mission for integrating support for the program (as CRSP funds were reduced) into the Kenyan national agricultural research project supported by USAID, the Government of Kenya, and the Mid-West International Agricultural Consortium. In summary, the evaluation team found that both parties have worked at solving the problems and that at present linkages between the program and missions appear to be excellent.

2.6.4. Linkages with international agricultural research centers

Early in the planning for the SM CRSP program, an effort was made to work collaboratively with the international agricultural research centers to avoid duplications of effort. However, few formal linkages have been developed with them. Although informal linkages have been made with CIAT, CALI, IRRI, ICARDA, ICRISAT, ICRAF, ILCA, and ILRAD. The Indonesian project has had a strong linkage with CIAT, from which it obtained over forty accessions of acid-tolerant forages. A semiformal relationship that developed between the animal health component of the Kenya SR CRSP program and ILRAD persists to this day.

2.6.5. Networking

The SR CRSP was instrumental in forming the Indonesian Small Ruminant Network (ISRN) and the Small Ruminant Network for Asia (SRUPNA), now supported by the International Development Research Center (IDRC).

The Latin American Small Ruminant Network (RERUMEN) was originally located in Peru but was moved to Bolivia in 1993. This disruption had a detrimental effect, and the network is just becoming fully functional again. Recently it joined the information superhighway with the establishment of an electronic bulletin board that can be accessed through INTERNET.

Networking in Africa in collaboration with ILCA's SRNET has had only modest success. This may change, however: Kenya's small ruminant CRSP scientists attended an SRNET planning committee meeting July 10–15, 1994.

In addition to formal networks, other activities provide opportunities for linkage. For example, the annual SR CRSP Scientific Meetings in Kenya have included participants from eastern, central, and southern Africa, and ILCA's scientists regularly attend.

2.6.6. International linkages

Many formal and informal linkages have been forged with other international organizations. Strong linkages have been developed with the Indonesia International Animal Science Research and Development Foundation (INI ANSREDEF), the European Union (Prince Leopold Institute for Tropical Medicine), the Australian Center for International Agricultural Research (ACIAR), the International Development Research Center in Canada (IDRC), the Wageningen Agricultural University in the Netherlands, the University of New England in Australia, and the Nitrogen-Fixing Tree Association (NFTA).

The Kenya program has collaborated with the International Service to National Agricultural Research (ISNAR), ILCA, the International Goat Association (IGA), the American Society of Animal Science (ASAS), and the African Feed Resources Network (AFRNET). They also recently developed a linkage with the Newala Goat Project in Tanzania whereby the Kenyan dual-purpose goat technology package was introduced into the project near Mtwara with a $10,000 SR CRSP grant. However, this linkage has been terminated due to the recent funding reduction, and plans for a similar linkage with Uganda have been postponed (Semenye, 1994).

The Indonesia program has had numerous contacts with researchers from the western Pacific rim, particularly in the Indonesia-Malaysia-Thailand growth triangle (IMT-GT). They recently collaborated with the Indonesian Society of Animal Science in hosting the seventh AAAP (Asian-Australasian Association of Animal Production) Animal Science Congress held in Bali, Indonesia, which was attended by 1,100 scientists from the international community.

2.6.7. Other donor organizations

Since the early 1980s, the SR CRSP has leveraged substantial funds to complement its ongoing programs. Such support has benefitted research, workshops, special studies, and training. Donor organizations included IDRC, the Rockefeller Foundation, ACIAR, the International Atomic Energy Commission (IAEC), the Food and Agricultural Organization (FAO), the Integrated Project for Arid Lands (IPAL), and the World Bank.

3. Conclusions

3.1. Fulfillment of goals and objectives

The primary goal of the SR CRSP was to improve the efficiency and sustainability of small ruminant production in both less-developed countries and the United States (ME, 1990). The evaluation team found that major progress in attaining this goal has been made by the various disciplines involved in the program, although only recently has research been extended to any significant degree to smallholder farmers. Especially impressive was the work done in Brazil, Indonesia, and Kenya by projects in animal health and nutrition, breeding and genetics, production systems, economics, and sociology.

A major objective of the program in Kenya was to develop, then release, Kenyan dual-purpose goats to smallholders. Although the Kenyan dual-purpose goat has been developed and registered as a breed, the breeding project in Kenya is lagging far behind its schedule to produce adequate numbers for release to smallholder farmers. The demand far exceeds the supply. The production systems project, in response to this demand, has recently moved to complement the breeding project by establishing several upgrading programs in collaboration with private breeders.

The animal health projects have made impressive contributions through their development of vaccines and control programs for CCPP, CAE, OPP, and OPC. The major objective of the project in Kenya, however, was to develop of a multivalent vaccine, and this objective has not yet been attained. In Brazil, Indonesia, Morocco, and Kenya the work in feed and forage resources, grazing systems, and nutrition has made a major contribution to goat or sheep production or both, and the evaluation team judges that those workers have made significant progress toward attaining their goals and objectives. Although the work in *Haemonchus* resistance was not a primary goal at the outset of the animal health project, the discovery of and research in this genetic trait could have a major global impact. As is the case here, the great breakthrough discoveries that researchers make are often accidental rather than planned.

3.2. Relevance

The research thrust has closely followed the original plan developed by the Research Triangle Institute (1978a-g) with some modification as experience was gained in each host country. Ecologically, the program has been nearly global in nature. Some research projects (the prolificacy work in Indonesia and Morocco and work with camelids in Peru) might be considered to have limited application, but it should be remembered that research conducted by the various disciplines has been aimed primarily at improving the livelihood of the smallholder farmer in less-developed

countries, as mandated by the Title XII legislation. The many accomplishments cited in section 2.1 above bear this out.

A review of the original Detailed Program Plan substantiates the hypothesis that the original program and initial projects were developed without significant participation of the host countries (RTI, 1978a-g). The final Detailed Program Plan was delivered in June 1978, and host-country site selection began in late 1978. Thus the research projects were unilaterally planned by principal investigators), some of whom had little if any experience in developing countries.

Although the original research projects were conceived unilaterally, subsequent research was agreed upon by the collaborating U.S. and host-country scientists and was aimed at solving problems in the host countries that were highlighted in country development strategies or national plans. The hair sheep work in northern Sumatra was part of Indonesia's transmigration program. This work also supported the Government of Indonesia's goal of exporting goats and sheep to meet a portion of the import demand for three million head per year in middle eastern countries.[10]

3.3. Effectiveness

As the first CRSP, the small ruminant CRSP was the pioneer in the development of the CRSP model. With modifications over time, this model has worked and has been productive. The graduate and technical training of people alone makes the investment in the small ruminant CRSP worthwhile because food security in less-developed countries depends on trained scientists working on the cutting edge of science similar to the successful agricultural research program conducted in the United States by the USDA, the Agricultural Research Service, and the land grant universities.

3.3.1. USAID

Many of the problems of the CRSPs can be placed at USAID's doorstep. Admittedly, many of these problems are symptomatic of large, inefficient bureaucracies. On the other hand, many are unique products of the USAID system. Some of these problems are

- continually changing USAID goals and objectives, e.g., the belated emphasis on impact;
- lack of continuity of USAID mission personnel and the accompanying changes in country priorities;

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10. Post Report Sequence Number: 002, American Embassy, Jakarta, 06/16/94.

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- failure to appreciate the major funding, institutional, and professional inputs made by universities, private voluntary organizations, and host countries in the CRSPs. USAID grants can be looked on as "seed" money in as much as the small ruminant CRSP has attracted 145 percent of the total USAID grants from other sources;

- poor understanding of agriculture by decision makers;

- antipathy toward animal agriculture and refusal to recognize the integral role of livestock in the efficient use of land, feed, and human resources in the production of food, generation of income, provision of employment, and provision of security and continuity to farming enterprises, most of which are crop-livestock combinations;

- failure to recognize the difference between a grant and a contract. USAID needs to treat grants as grants rather than contracts, or worse yet, direct projects of USAID. Typically, other granting agencies ask for proposals, evaluate the proposals, award the money, and ask for evidence of the end product. USAID should take a close look at NSF, NIH, IDRC, and other similar agencies for examples of appropriate grant administration;

- the three project officers assigned by G/AGR over the years to monitor the program have dedicated their efforts to the success of the program. This, however has resulted in much macro- and micro-management of the program.

3.3.2. BIFADEC/JCARD

Much the same can be said for the contributions of BIFADEC and JCARD (formerly BIFAD and JRC, respectively). Frequent changes in executive directors, with most having a tenure of two years or less, has resulted in ineffectual leadership. The effectiveness of JCARD has been exceptional when the chairperson has been a strong leader, but such leadership has been spotty. Staff at BIFADEC has not been strong, particularly from a public relations standpoint.

3.3.3. Management entity

The small ruminant CRSP management entity has provided inconsistent leadership. Since 1985, the position of director has been held by four interim (or associate) and five permanent directors. The first director provided strong and effective leadership and coordination of the program. Such cannot be said for subsequent directors (the current director excepted because he has just been appointed to the position). The host university has failed to give this program a high priority and only recently has appointed a highly qualified tenured professor to the directorship and agreed to provide housing for the management entity on campus. At present, university

commitment appears to be firm, but this may be an instance of too little too late. Support staff to the director has been adequate, and the long tenure of the assistant director has added a strong measure of stability to the program.

The small ruminant CRSP as originally planned and implemented was unwieldy in terms of manageable funding and the number of institutions, projects, and work sites. The management entity responded over the years by reducing the number of work sites to three, limiting to two the number of sites that each principal investigator could collaborate with, and reducing the number of projects from seventeen to ten.

The administrative structure of the management entity included councils, boards, and committees. The administrative council has been unwieldy, costly, and ineffective. One member indicated he was not certain what his responsibilities were to the council. Representation from host countries on these groups has not been optimized until recently. Industry representation has been conspicuously absent.

The board seems to have functioned well in recent years and has been assertive—for example, in its recommendation regarding the Bolivian projects in response to the criticisms made by the external evaluation panel in its evaluation of that program. The external evaluation panel has only been effective in the most recent five years, which underscores the importance of having a strong, evenhanded chairperson. The technical committee was burdened with much infighting in the early years, especially in regard to the work in Kenya. Valuable time was wasted getting the breeding project underway because of the struggle among principal investigators at various universities for control of the project. The technical committee has been criticized for promoting only the self-interest of the members. This, in addition to USAID criticism along similar lines, led to the open bidding process for the new proposal (future 1996–2000) in which only one of the current principal investigators was included. Several principal investigators withdrew from consideration, and only one who submitted a proposal was successful.

3.3.4. Collaborating universities

Collaborating universities have supported the program with high levels of matching funds. In most instances, collaborating principal investigators have been scientists who are recognized world leaders in their discipline. One of the objectives of the program was to provide these scientists with opportunities to enhance their knowledge of, and contribute to, international development. In that respect the program has been outstanding. In the early years some universities failed to place a high priority on the program, with the result that they were eliminated from participation. Similar problems have manifested themselves in launching the new site in Bolivia, and these problems need to be resolved.

Also, principal investigators should keep the original objectives of a project in mind and not be diverted into other interests that have little to do with those

objectives, e.g., the work on prolific sheep in Indonesia,[11] the ethnoveterinary work in Indonesia and Kenya, and *Haemonchus*-resistance work in Kenya. Other funds should be sought for such work if it has a high priority in the United States or host country. Precisely this was done by Washington State University researchers, who recently received a USDA grant as the major source of funds to continue the *Haemonchus*-resistance research.

In addition, principal investigators do not always fully collaborate early on with their counterparts in the host countries (as pointed out before). Principal investigators have been criticized for not fully taking into consideration the host countries' priorities when selecting projects, and in some cases for having displayed arrogance. In the recent proposals for extension of the program (1996–2000), the three successful proposed projects, those in Albania, Honduras, and Kenya, have documented their collaboration with host-country USAID missions, ministries of agriculture, and collaborating institutions.

3.3.5. Collaborating host countries

Host countries have contributed substantial amounts of resources to support the small ruminant CRSP, attesting to the importance they place on animal and agricultural research and the benefits that might accrue to them. They have assigned quality scientists to the program and selected outstanding individuals for training. They are to be commended for this input and support. After more than fifteen years of collaboration with U.S. institutions, Brazil and Morocco have in effect graduated from the program, which was envisioned in the original CRSP plans. Other countries such as Indonesia and Kenya, however, continue to collaborate after fifteen years, although this may be due to the nature of the projects (development of new breeds of goats and sheep, undertakings that require fifteen to twenty years to complete). Recently Indonesia has made a dramatic move to provide more funds to ensure that the work of the small ruminant CRSP in hair sheep breeding and nutrition projects continues after small ruminant CRSP funding ceases. Again, this attests to the high priority placed by the Government of Indonesia on this project.[12]

3.4. Efficiency

- The efficiency of the program has been hampered by interference and micromanagement by USAID Washington. Funding has traditionally been delayed by several months each year, and this prevents completing project work in a timely fashion. Refusal of country Missions to approve travel by U.S. principal investigators (the Mission in Indonesia denied the techical committee permission to meet in that country), and the necessity for all foreign travel to be approved by

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11. This work is continuing in a collaboration among UCD, CRIAS, and CSIRO.

12. Pers. comm.

USAID Washington has caused inconvenience and delays. In addition USAID interference has prevented the extension of results to other countries (for instance, sharing prolific sheep results with Malaysia). At the same time, it can be said that G/AGR project managers have given the program their unqualified support.

3.5. Impacts

3.5.1. International economic impacts

- In Kenya, the introduction of dual-purpose goats and improved forage production practices has been estimated to result in a 66 percent increase in food yields from goats for smallholder families. Expressed on a per hectare basis, each dual-purpose goat generates $52 in additional income for the goat producers (ME, 1989). To date, however, less than 500 smallholder farm families have actually received dual-purpose goats produced by the small ruminant CRSP–Kenya Agricultural Research Institute project.

In the region in western Kenya most impacted by goat distributions to date, Semenye and Getz (1993) reported that protein production increased. Meat yield has increased by 60 percent. Milk has become available for families with lactating does (in a 60-day period farmers can obtain up to 30 liters of milk per doe).

On average, 90 liters of milk can be obtained from local cows per year if the farmer has sufficient resources to maintain a cow. The same amount of milk can be produced by three dual-purpose does at only 60 percent of the maintenance cost needed for one cow. Goat technological packages have generated meat and milk proteins, forages, increased crop production (double-cobber maize), increased crop yields after manure application, and increased cash income for household needs. In western Kenya, the identification of sweet potato vines as a suitable early weaning feed for kids allowed farmers to obtain an additional 87 liters of goat milk for family consumption or local sale.

More recent studies in newer clusters of farm families receiving the new goats document that Kenyan dual-purpose goat does are producing on average 63 kilograms of milk per 90-day lactation, yearling kid weights of 20 kilograms, and 182 kilograms of manure. Farmers are getting a return of $44.88 against variable costs of $22.90. The gross margin per doe-kid was $16.98 (Semenye, 1994b).

- A new vaccine against contagious caprine pleuropneumonia (CCPP) was developed and shown to be efficacious in on-farm trials in Kenya. The disease affects at least 48 million goats in Africa and Asia and, if untreated, has a mortality rate greater than 80 percent. The new vaccine has an extended shelf life and, when properly used at the recommended regimen, is highly effective.

If the vaccine were widely available, it could prevent an average of 82 annual local outbreaks—involving an estimated 300,000 goats in Kenya alone. Before vaccine production was fully transferred to the Kenya Veterinarian Vaccine Production Institute, one million doses of the new CCPP vaccine were produced. Since the transfer of responsibilities, the production of the new CCPP vaccine has been given low priority by government officials, and actual vaccine output has declined significantly.[13]

- Returns to research investment by the farmers adopting Techpacks developed by the SR CRSP in West Java were estimated to be between 17 and 19 percent (Valdivia, 1993).

- In Indonesia, scientists focused on developing sheep that produce two or more lambs per year. A major prolificacy gene was identified and a highly prolific strain of Javanese Thin Tail sheep was developed that averages 2.8 lambs per litter, nearly double the average in West Java. However, the claim that "this means a potential annual increase, in sheep produced in this province, of 1.5 million head, which adds $18 million per year to farmers' incomes" (ME, 1989) is valid as a potential impact; but since smallholder farmers have not adopted the technology, the claim remains unsubstantiated. Later research has shown that the low prolificacy line outperformed the high profligacy line under current nutrition and management conditions and, therefore, few smallholders should strive for increased lambing rates unless they were able to improve concomitantly the level of nutrition and management (Bradford, 1994; Inounu et al., 1993).

- On-farm testing of the CRSP Sheep Techpack through the Outreach Pilot Project (OPP) in Indonesia demonstrated the potential to increase yields by 50 percent over the traditional system. An economic surplus model was then used to evaluate the OPP/CRSP effort in West Java (Valdivia, 1993). All costs of the program were considered and discounted against the net benefits of the OPP Techpack. Preliminary results, assuming an adoption rate of 20 percent peak adoption achieved in twelve years, yielded an internal rate of return of 19.2 percent. Sensitivity analyses varying the rates of adoption and including effects of spillover adoption in neighboring provinces yielded rates of return of 22.9 to 24.8 percent. The distribution of the gains from research, given existing market conditions, was estimated to result in producers capturing 77 percent of the economic surplus generated.

- CRSP researchers in Indonesia have developed grazing systems in which sheep at stocking rates of up to ten animals per hectare are used to control weeds under the trees on rubber plantations. These systems are estimated to reduce plantation labor costs by 18 to 31 percent. In addition, the systems are said to have saved Indonesia an estimated $51 million annually by eliminating the cost of the

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13. Letter from T. McGuire to J. Hall.

herbicides previously used on the plantations and to have had the indirect benefit to the environment of reduced herbicide application.

- Demonstration that the Moroccan D'Man breed of sheep transmits its high prolificacy additively to first cross and backcross progeny makes it possible to use local genetic resources to increase prolificacy in Moroccan sheep to different degrees in accord with the requirements of management and feeding systems. However, the claim that "if 10 percent of Morocco's 10,000,000 ewes were replaced with D'Man crosses, this would generate an estimated $5,000,000 in additional gross annual income to producers" (ME, 1989) is only conjecture.

- Studies in Bolivia have shown that returns to CRSP sheep research are approximately 40 percent. Approximately 50 percent of these benefits are attributed to on-farm household consumption. The balance results from sales or trading in animal products. Most of these receipts are estimated to be used to purchase other food products in local agropastoral communities. Finally, it is estimated that approximately 27 percent of the income of the poorest smallholder families is derived from sheep raising.

3.5.2. Domestic impacts

- Small ruminant CRSP research in genetics and parasite research have identified genetic resistance to parasites in sheep. However, the claim that "Parasite-resistance in sheep that is estimated to save U.S. sheep producers nearly $40 million per year" (ME, 1989) is valid only if parasite-resistance can be incorporated into U.S. sheep breeds, and at present this has not been demonstrated.

3.5.3. Host-country institutionalization

The program has had a major impact on strengthening the research capabilities of all the host country National Agricultural Research Systems (NARSs) and a university in Morocco. For example, economics and sociology disciplines have been incorporated in the Kenya Agricultural Research Institute and the Indonesian Central Research Institute for Animal Science as a result of the program. In addition, farming systems research and extension has been institutionalized within the Kenya Agricultural Research Institute with additional assistance from CIMMYT and ILCA.

Funds from the program have also been used to construct animal facilities in all host countries and to establish a sheep research station in Morocco. Laboratories have been upgraded by the addition of needed instruments and equipment. In Peru, Brazil, and Kenya, laboratories for animal health research and diagnostics have been developed.

Movement of small ruminant CRSP-trained scientists into major positions of

research, education, or government is having a major impact on host countries. An example is the small ruminant CRSP–trained scientist from Peru who was appointed the dean of veterinary science at the National Veterinary Institute (ME, 1994c).

3.6. Sustainability in the future

Continuation of the program in Indonesia is assured. After the team's visit, word was received that the Government of Indonesia had injected significant increases in recurrent funds into the Indonesian Central Research Institute for Animal Science to fund small ruminant CRSP–supported work in the future.[14] The SR CRSP recurrent funds provided by U.S. institutions to North Sumatra amount to about $120,000 per year[15] and, prior to the recent increase in funding, were nearly equal to the entire recurrent funds provided by the government of Indonesia for the nationwide CRIAS program.[16] SR CRSP funding has taken a remote substation and transformed it into an active, functional, and productive research site.WHERE DOES QUOTE END It would be a tragedy if this work were to cease, since it has had a great impact on the country's transmigration program. Here a closer working relationship with the USAID Mission might have been productive. In order to maintain the program, the government of Indonesia must inject more funds into CRIAS if it is to attain its goal of becoming a major sheep exporter in the future.

The program in Kenya is likely to be continued after SR CRSP funding ends in 1995 although on a reduced scale. The USAID Mission in Kenya is to be commended for incorporating some of the program into the Kenyan national agricultural research project supported by USAID, the Government of Kenya, and the Mid-West International Agricultural Consortium.[17] Salaries of some of the SR CRSP staff in Kenya are already being provided by the NARP project. Fortunately, the nongovernmental organization Lagrotech has become involved in continuing efforts in the Maseno area of western Kenya, and that work is likely to flourish. Fieldwork at the Mtwapa and Katumani sites will likely continue because the Kenya Agricultural Research Institute's regional staff has been involved in the field supervision and training.

Lagrotech has been monitoring the Kenyan dual-purpose goats in the Maseno area and reports that their numbers have dwindled since the SR CRSP ceased activity there in 1989. The report raises concern about adaptability and sustainability of the breed. Lagrotech has initiated an upgrading program whereby 240 indigenous does are being

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14. ME, E-mail dated 7/29/84.

15. K.R. Pond, pers. comm.

16. Personal communication from Dr. H.M. Rangkuti, CRIAS director.

17. $960,000 was included in Phase II NARP.

crossed with Kenyan dual-purpose goat rams to provide a source of breeding stock because there are not sufficient Kenyan dual-purpose goat breeding does available to meet demand (Lagrotech, 1993).

The program in Bolivia is likely to cease with the termination of CRSP funding. As a result of the 1993 external evaluation panel report, which recommended that the program there be seriously revised because of an apparent lack of commitment to the program by U.S. institutions, the small ruminant CRSP Board of Directors recommended that the Bolivian site be closed. Although this problem has been largely overcome, most Bolivian researchers are nontenured faculty, and those positions will be closed out with termination of CRSP funding (EEP, 1992; EEP, 1993).

Annex C

Sorghum/Millet Collaborative Research Program

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1. Introduction

THE International sorghum/millet (INTSORMIL CRSP) was initiated in 1979 to provide research funding for the period 1979 through 1995. In the beginning, six U.S. land grant universities were involved, namely, Kansas State University (KSU), University of Kentucky (UK), Mississippi State University (MSU), University of Nebraska at Lincoln (UN-L), Purdue University (PU), and Texas A&M University (TAMU). The University of Nebraska (UN-L) was selected to be the management entity. The institutions were said to encompass the majority of U.S. scientists (90 to 92 percent) working on these two major crops at that time. In the course of budget restrictions, UK dropped out, carrying with it much of the early socioeconomic input; this left five U.S. universities in the group which persists to this date.

1.1. Objectives

The broad objective of the sorghum/millet CRSP was "to increase grain sorghum and pearl millet production in those countries where they are a principal food crop. This was to be achieved by research and training in conjunction with less-developed country (host country) scientists, the international and regional research centers, and other government and private development agencies." (Grant Agreement USAID/BIFAD, University Nebraska, July 1979.)

A less formal purpose statement was developed soon after as follows: "To improve the production, marketing, and utilization of grain sorghum and pearl millet in less developed countries and to strengthen capabilities of less-developed country institutions to generate, adapt, and apply improved technology to local conditions." (Global Plan for Research, INTSORMIL CRSP, 1985.)

1.2. Responses to decline in funding

The Administrative Management Review Report of May 1989 summarized the impact of these budget cuts on the sorghum/millet CRSP for the period 1979–89:

- "A decline in the number of U.S. principal investigator scientists from 82 to 30, a loss of 52.
- "Termination of the sociological and anthropological projects (University of Kentucky and Mississippi State University).
- "Elimination of some and curtailment of other economic research; market research

dropped and other forms of economic research were initiated.

- "Discontinuance of work at two U.S. institutions (University of Arizona and Florida A&M).

- "Discontinuance of entomological grain storage research (Kansas State University).

- "Budgetary assistance terminated for Brazil, Mexico, the Dominican Republic, the Philippines, India, and Kenya; budgetary assistance reduced for Botswana, Colombia, and Honduras."

"It has been necessary to reduce advanced degree training programs that were funded through research assistantships. At the peak year (1984–85), sixty-nine graduate degree students were in training. The number declined to thirty-four in fiscal year 1988, a 50 percent drop. The brunt of this decline was borne by U.S. graduate students. This is unfortunate because assistantships are the only means of using CRSP funds to provide international experience for U.S. graduate students.

"Since the last budget cut, the INTSORMIL CRSP has operated from a straight-line budget, that is, at the same level for the past three years. With annual inflation rates of four to five percent, this has meant that INTSORMIL has experienced annual budget cuts at least equal to the rate of inflation. With this annual reduction there is a limit to how long INTSORMIL can remain effective under straight-line budgets. Travel and other essential expenditures will have to be curtailed. Fewer trips per year reduce contacts between host country and U.S. scientists, the essence of the program.

"Unfortunately, budget cuts have resulted in discontinuing INTSORMIL programs in `graduate' countries where U.S. investment has a high ratio of payoff. CRSPs went into countries like Mexico and Brazil to avail themselves of the institutional capabilities developed in these countries so that higher payoff from research could be achieved at less cost. Furthermore, sorghum/millet research could be done more easily in these countries because they have an ecology similar or identical to many developing countries where USAID works. In fact, possibilities for revitalizing relationships with these countries warrant reconsideration among priority approaches open to the CRSP."

The management entity reported that nineteen of the twenty-three projects are seriously underfunded relative to the capacity of the principal investigators and developing country collaborators to utilize funds efficiently for research.

"The impact of the first budget cuts was not completely negative. The reduction forced closure of some projects or activities that were low performers or in which host country collaboration was lacking. The point has been reached, however, where additional budget cuts will hamper the continuation of successful projects; there does not seem to be any more fat or low-return projects to cut."

2. Findings

2.1. Scientific output

According to the administrative management review of 1989, the sorghum/millet CRSP,between 1980 and 1989, operated thirty research projects at five U.S. institutions and six overseas locations. At present this CRSP works in the following six ecogeographic zones represented by:

Ecogeographic zone	*Collaborating country*	*Collaborating programs*
West Africa	Niger, Mali	Senegal ICRISAT/ W. Africa
East Africa	Sudan	Kenya ICRISAT/E. Africa
Southern Africa	Botswana	SADCC/ICRISAT
Central America,	Mexico	ICRISAT
Mexico, Caribbean	Honduras	CIMMYT/CLAIS
South America	Columbia	Brazil CIAT
Asia	India (pending)	ICRAIT

SOURCE: Global Plan INTSORMIL, 1989.

The constraint-based global plan for 1989 shows four areas of technical thrusts: germ plasm enhancement, sustainable production systems, sustainable plant protection, and crop utilization and marketing.

2.1.1. Constraints

"Sorghum and millet are grown in some of the harshest environments and poorest and most fragile land-resource areas of the world. This results in very low and unstable grain production of these primary food crops grown by millions of people in developing countries in the semiarid tropics.

"There are many constraints to sustainable production of sorghum and millet. The major constraints include poor and erratic rainfall, poor physical and chemical properties of soils, inadequate production technology, plant diseases, insect pests, grain traits such as color and shape that adversely affect utilization, low-yielding cultivars, lack of germ plasm with such improved traits as tolerance to biotic and abiotic stresses, lack of trained researchers, poor technology transfer systems, and flawed pricing and marketing systems.

"If control could be achieved of striga and quela bird damage or if sustainable cul-tural systems could be developed that would function under severe drought

the economic return would more than pay for the cost of the entire CRSP collaborative program from its inception in one year."

2.1.2. Germ plasm enhancement and conservation

"Stability of sorghum and pearl millet production ecosystems could be enhanced by developing increased resistance to biotic and abiotic stresses, improved yield potential, better adaptation, and improved grain quality. The INTSORMIL germ plasm enhancement and conservation discipline covers an array of research activities encompassing basic propriate, into most of the economically important traits or stresses in sorghum/millet in collaboration with scientists from other disciplines and host countries. The discipline serves as a focal point to integrate multidisciplinary research to better understand the factors contributing to the ecological fitness of sorghum/millet. Increasing understanding of the genetic processes regulating sorghum ontogeny facilitates the development of more stable and sustainable production systems using genotypes with increased ecological fitness. Improved genetic materials developed by INTSORMIL research represent the best genetic combinations available using present methodology. Research activity is devoted to collecting and conserving diverse germ plasm from LDC research sites to use to create and maintain a broad genetic base for sorghum/millet. Germ plasm collections occupy a unique position in research activities.

"An array of research techniques are utilized to improve sorghum and millet. In millet, breeding methodologies for open-pollinated species include pedigree, mass and gridded mass selection, and S_1 and S_2 progeny performance. In sorghum, breeding methodology for self-pollinated species include pedigree and backcross methods. Genetic male sterility of sorghum allows the use of mass election and gridded mass selection in random mating populations."

2.1.3. Sustainable production systems

"As technologies move from the experiment station to regional and farm trials, site specific factors and farmers' constraints become very important in determining which technologies will be successful. Introduction of new technology will generally require that it not only raise farmers' yields but also be profitable and fit into existing systems of production. Without these characteristics, farmers will not adopt new technologies. Moreover, in the public interest, technologies must be examined for their long-run impact on the resource base, that is, their sustainablity. This concern with sustainability is especially important in the agricultural systems that require high amounts of purchased input as is true in developed countries.

"This sustainability concern needs to be interpreted differently where levels of purchased input are extremely low, as is true in most agricultural systems in sub-Saharan Africa. Sustainable systems in much of the developing world must have the capacity to feed a rapidly increasing population. These new production systems also need to reverse

the environmental destruction resulting from rapid population growth and the breakdown of the fallow rotation system. To reverse this trend and produce crops with higher levels of nutrition for poor farmers and consumers, purchased inputs will be necessary in sub-Saharan African agriculture and in Central American small-farmer systems. Sustainability needs to be a pragmatic concept with its principal emphases on improving human welfare as well as on maintaining and improving the resource base.

"The analysis of technologies at the farm level, both potential and in place needs to be an on-going process in technology development and is especially important in the low-input systems of the Sahel and Central America."

2.1.4. Sustainable plant protection systems

Insect pests and plant diseases are major contributors to unstable and reduced sorghum and millet yields in many developing countries, and to higher production costs in the United States. The negative impact of insect pests on traditional, subsistence-level sorghum and millet growing systems may be dramatically increased by improving varieties through plant breeding and superior cultural practices. The negative impacts of pests and diseases further constrain yield increases and stability, increase risk to crop production, and are deterrents to sustainable agriculture. In the United States, the public mandate for safe food, clean water, and conservation of wildlife requires a new and enlightened approach to integrated pest management that is biologically and ecologically based, not pesticide based. The sorghum/millet CRSP collaborative research projects in entomology and pathology focus on developing management strategies to produce sustainable and resilient sorghum/millet production systems. The biointensive insect pest and disease management tactics include plant resistance to insects and pathogens, biological control, and the manipulation of cultural practices. These management tactics are also ecologically compatible, safe to humans, and persistently effective. Such a management approach requires support by ancillary biological and ecological research to ensure proper implementation in developing and developed agriculture systems. The insect pests of sorghum and millet on which research is focused are sorghum midge, greenbug, sugarcane aphid, panicle feeding bugs, stalk borers, millet head girdler, and the armyworm complex. The most important sorghum diseases include such panicle diseases as grain mold, smuts, ergot, downy mildew, anthracnose, and other foliar spotting diseases caused by fungi and bacterial pathogens, plus seeding diseases and stalk and root rots, particularly charcoal rot. A similar group of diseases that warrant attention in millet include ergot, kernel smut, downy mildew, charcoal rot, and seeding diseases. In addition there are species of the parasite striga that attack both sorghum and millet. The ecogeographical zones of major focus for research on all these pests and disease include, West Africa (Mali and Niger), Southern Africa (Botswana, Zambia, and Zimbabwe), and Central America (Honduras).

2.1.5. Crop utilization and marketing

2.1.5. Crop utilization and marketing

The present utilization level of sorghum and millet, traditionally major food crops of the African and Asian semiarid tropics, may not be sustained in sub-Saharan Africa despite increasing human population of these areas because imported wheat and rice are increasingly being substituted for them. This shift is due to many factors including the importation of surplus wheat and other cereals for famine relief, greater ease of preparation for these imported cereals, taste preferences of urban consumers for wheat and rice products, and population shifts toward urban centers which lack an effective food production and marketing system for traditional cereal crops.

Processing sorghum and millet to use in traditional diets requires daily expenditures of time and energy to dehull and mill the grain, plus cooking time. Attractive prepared shelf-stable foods produced at the local level from sorghum and millet are needed.

Compared to maize, wheat, and rice, relatively little effort has gone into improving sorghum and millet as human foods. Improvements of other cereals, including such new developments as quality protein maize, may result in further declines in the use of sorghum and millet unless the food and nutritional quality of these crops is correspondingly improved. Better nutritional quality is expected to increase consumer demand for these traditional cereals and any improvement of these crops for use as human food will also result in an improvement as livestock feed.

Before the food and nutritional quality of sorghum and millet can be enhanced, research must ascertain the chemical, compositional, structural, and processing properties of the presently available cultivars of these crops. Progress has been made in defining grain characteristics that affect food quality, but simple tests to predict quality are still needed. Some cultivars contain potentially distasteful or harmful components including tannin and cyanogenic glycosides. These antinutritional factors are thought to confer pest resistance and therefore their elimination may leave the crops unacceptably vulnerable. Careful assessment of these components with respect to their harmful and beneficial effects will be necessary.

2.2. Projects and publications

The following projects are listed as active in in INTSORMIL's strategic plan for the next decade (1993):

Sustainable plant protection systems

Agroecology and Biotechnology in Stalk Rot Pathogens of Sorghum and Millet. L.E. Claflin and J.F. Leslie (KSU-108).

Low-Input Ecologically Defined Management Strategies for Insect Pests on Sorghum. Henry N. Pitre (MSU-105).

Role of Polyphenols in Sustainable Production and Utilization of Sorghum and Millet. Larry G. Butler (PRF-104B and PRF-104C).

Disease Control Strategies for Sustainable Agricultural Systems. R.A. Frederiksen and R.W. Toler (TAM-124).

Plant Pathogen RFLP Mapping. R.A. Frederiksen (TAM-124A).

Integrated Insect Pest Management Strategies for Sustainable Agricultural Systems. George L. Teetes (TAM-125 Part I).

Biological Control Tactics for Sustainable Production of Sorghum. Frank E. Gilstrap (TAM-125 Part II-A).

Biological Control Tactics for Sustainable Production of Millet. Frank E. Gilstrap (TAM-125 Part II-B).

Development of Plant Disease Protection Systems for Millet and Sorghum in Semiarid Southern Africa. G.N. Odvody (TAM-128).

Sustainable production systems

Modeling Millet and Sorghum Establishment and Growth and Sustainable Crop Production. Richard L. Vanderlip (KSU-106).

Improved and Sustainable Dryland Cereal Production Technology for Smallholder Farmers in Botswana. Naraine Persuad (KSU-107).

Sustainable Production of Sorghum and Pearl Millet in Fragile, Tropical Acid Soils. Lynn M. Gourley and Guillermo Muñoz (MSU-111).

Economic and Sustainability Evaluation of New Technologies in Sorghum and Millet Production in INTSORMIL-Priority Countries. John H. Sanders (PRF-105).

Resource Efficient Crop Production Systems. Max D. Clegg and Stephen C. Mason (UN-L-113).

Nutrient Use Efficiency in Sorghum and Pearl Millet. Jerry W. Maranville (UN-L-114).

Physiologically Derived Cultural and Genetic Enhancements of Water and Temperature Stress-Induced Limitations. Jerry D. Eastin (UN-L-116).

Mechanisms of Environmental Stress Resistance in Sorghum and Pearl Millet Relative to Sustainable Production Systems. C.Y. Sullivan (UN-L-123).

Germ plasm enhancement and conservation

Pearl Millet Germ Plasm Enhancement for Semiarid Regions. W.D. Stegmeier (KSU-101).

Breeding Sorghum for Tolerance to Infertile Acid Soils. Lynn M. Gourley (MSU-104).

Development and Enhancement of Sorghum Germ Plasm with Sustained Tolerance to Drought, Striga, and Grain Mold. Gebisa Ejeta (PRF-107).

The Enhancement of Sorghum Germ Plasm for Stability, Productivity, and Utilization. Fred Miller - (TAM-121).

Germ Plasm Enhancement through Genetic Manipulation for Increasing Resistance to Insects and Improving Efficient Nutrient Use in Genotypes Adapted to Sustainable Production Systems (jointly with the Soil Management CRSP). Gary C. Peterson and Arthur B. Onken (TAM-123).

Tropical Sorghum Conservation and Enhancement in Honduras and Central America. Dan H. Meckenstock (TAM-131).

Breeding Sorghum for Stability of Performance Using Tropical Germ Plasm. David J. Andrews (UN-L-115).

Breeding Pearl Millet for Stability Performance Using Tropical Germ Plasm. David J. Andrews (UN-L-118).

Crop utilization and marketing

Chemical and Physical Aspects of Food and Nutritional Quality of Sorghum. Bruce R. Hamaker and Allen W. Kirleis (PRF-103B).

Utilization and Quality of Sorghum and Millet. L.W. Rooney (TAM-126).

Host-country program enhancement

Botswana, M.D. Clegg

Egypt, J.D. Eastin

Senegal, David J. Andrews

South America (including **Colombia/CIAT, Guillermo Muñoz**

Honduras, Darrell T. Rosenow
Sudan, Gebisa Ejeta
Mali, L.W. Rooney and M. Tarore
Niger, John D. Axtell

2.3. Research and methodology development

The following sorghum/millet CRSP contributions to parental lines are now available to meet the needs for variety development pearl millet and grain sorghum are from the "Strategic Plan for the Next Decade," 1994.

Pearl millet

- Rust resistance
- Millet blast resistance
- Semidwarfness
- Higher biomass production
- Improved downy mildew resistance
- Increased earliness
- Male sterility (cytoplasmic)
- Adaptability to low fertility
- Greater tolerance to weeds
- Greater tolerance to drought
- Increased yield

Sorghum

- Downy mildew resistance
- Head smut resistance
- Sorghum midge resistance
- Corn leaf aphid resistance
- White fly resistance
- Shorter stalk length, more erect leaves
- Greater lodging resistance, easier threshing
- Improved yield, better yield stability
- Kernel rot resistance
- Anthracnose resistance
- Resistance to Greenbug Biotype C,E,I
- Bank's grassmite resistance
- Increased protein
- Increased combining ability
- Reduced pigmentation of endosperm
- Greater osmotic adjustment capacity
- Better amino acids balance in kernel
- Improved resistance to variable weather
- Improved kernel characteristics, thinner pericarp
- Greater root mass, greater leaf area retention
- Greater tolerance to heat, drought, salinity
- Reduced tendency for stalk to senesce; better source of fodder
- Reduced tannin/better bird resistance/improved nutritional quality

Some varieties released in joint effort with ICRISAT, other IARCs, and/or NARS:

- Dwarf grain pearl millet (Nebraska)

- Severe 6A (greater grain and stover production than the Segaolane pearl millet standard)
- Malisor 84–7 head bug resistant sorghum for Mali
- Sorghica Real 40 acid soil tolerant sorghum for Columbia
- Sorghica Real 60 acid soil tolerant sorghum for Columbia
- Sureno, Tortillero, and Catracho sorghum hybrids for Honduras
- SRN 39 striga tolerant sorghum for Sudan, Niger
- Hageen-Dura 1 (HD-1) high food-quality sorghum for Sudan NPM-3
- NAD-1 and Sepon-82 (released in Niger based on Texas sorghum germ plasm)
- Greenbug resistant (Biotype E sorghum used in many sorghum releases by U.S. seed company)

Screening protocols developed

- Sorghum: Long smut, grain mold, drought
- Sorghum: Head bug resistance
- Pearl millet: Ergot, downy mildew
- Striga resistance: Nondestructive gel assay for screening individual host seedlings for production of striga germination stimulants (STRIGOL)

Methodologies developed

- Protocols for assessment of polyphenols in sorghum grain
- Simple method for detoxifying tannin in high tannin grain sorghum
- In vitro culture of sorghum callus
- Bioassay for bird repellency in sorghum lines

Crop management specialists working on sorghum developed improved production packages for coping with soil-water conservation, moisture stress, and more effective nutrient use for low-input production. Crop protection specialists have contributed significantly to more environment-friendly pest management practices, and expanded the frontiers of knowledge on many of the most important diseases and insects of sorghum and pearl millet. (INTSORMIL Annual Report, 1989–90).

Biotechnologists working with sorghum have achieved more advanced genome maps and gene identification, and have transformed specific sorghum plants through particle bombardment. Food technologists have helped LDCs to improve the nutritional content of local foods and have helped them to produce a wider range of products including flours, weaning foods, and novelty foods. Perhaps their most important contribution has been to show how sorghum may be substituted for corn in industrial product development. (Fred Miller, 1990 Sorghum Symposium, Australia)

2.4. Training output

The sorghum/millet CRSP trained a large number of scientists (see annex table C.2.4.1) for the less-developed countries. Six categories of training were reported;

B.S., M.S., Ph.D., postdoctoral Fellows, short-term program (specialties), and visiting scientists. From the master list supplied by the management entity, a brief summary table was compiled reflecting only degree training. From all categories, the record shows that 739 trainees were supported by INTSORMIL. Of the 622 academic degrees awarded to students from 75 countries, 34 received B.S. degrees; 280 M.S. degrees; and 308 Ph.D. degrees. Women represented 24.9 percent of the total academic degrees awarded.

2.5. Technology generated

Most of the technology generated by the sorghum/millet CRSP has been in the form of germ plasm enhancement and methodology development covered in section 2.3., research and methodology development. In addition, new white food quality grain sorghum were identified, tested, and found to be superior food sources for Africa and superior feed grain for U.S. livestock producers. Sorghum is now being grown in Honduras in combination with soil building crops such as Leucena (a woody legume). They are using terrace cultivation to help stabilize hill farms.

2.6. Management

The sorghum/millet CRSP management entity oversees 25 to 28 projects in five U.S. land grant universities and eight to nine collaborating host countries. The evaluation team was impressed with the excellent documentation, availability of information, helpfulness, and general knowledge of the entire program exhibited by the INTSORMIL Management Office.

Interviewing scientists and close study of the five-year external evaluation panel review (1990–93) revealed that, in general, the scientists felt that the management office was effective, concerned, and very useful. Opinions varied on the need to revise the reporting system to reduce duplication, but most felt that they spent too much time being reviewed. The "over-review" problem may need to be addressed by USAID rather than the CRSP staff itself, because many of the monitoring processes were decided when the CRSPs were founded and are included in the initial guidelines.

Frank discussions about territoriality, collegiality, and the willingness to face the hard decisions required to effectively prioritize and reorganize revealed that there may be a need for a "new approach." Most of the scientists interviewed did not want an outsider committee to realign or redirect their programs. In any program as comprehensive as INTSORMIL, one is going to find varying degrees of effectiveness among projects: Some seem redundant; some seem to have more potential than others; some do or do not seem to have an adequate balance between the United States and the host countries, and some adhere more than others to the original goals.

In times of less budget constraint, less competitiveness would be expected than during this current period of declining support. It will be a superhuman task to grade

and assign limited future support as against what may be needed. The suggestion to open up the allocation of support to competitive bidding is somewhat naive because this CRSP already includes most of the U.S. scientific community that is working on these two crops. It may be that the overall sorghum and millet research program will have to be distributed along the lines of the centers of excellence concept with crop improvement at one university, biotechnology at another, strategies for insect and disease management at a third, and so on.

2.7. Linkage

INTSORMIL has developed strong professional ties to ICRISAT, SAFGRAD, SADCC, CLAIS (Latin America), and EARSOM, and there is an effective interchange of germ plasm, methodologies, and literature. Many organizations have suffered declining support, so the number of conferences, workshops, and site-visits has diminished over the past five to eight years, which is most unfortunate because the background pool of germ plasm development and the payoff from integrated pest management, biotechnology, and utilization are ready to bear fruit.

The relationship between INTSORMIL projects and USAID missions ranges from excellent to nonexistent depending on the principal investigator, the ADO personalities, and how early and how well the project was introduced to the mission. If the mission has not been convinced that a research project fits into their strategic plan, very little more than polite tolerance may be expected. If the PI and HC collaborator approach the Mission with a collegial approach, a workable relationship can be developed but must be followed up with close and frequent communication. There are two sides to this problem, but the evaluation team questions the wisdom of establishing a research site in a country in which that crop or methodology is not already considered important to the USAID mission.

3. Conclusions

3.1. Relevance

The relevance of the work of the sorghum/millet CRSP must be considered in an immediate as well as a future context. INTSORMIL scientists framed a comprehensive picture of the constraints facing production, marketing, and utilization of these two crops within the first five year period of the project. The CRSP fashioned meaningful training and research programs to resolve these constraints. Many very valuable accomplishments have been achieved and are listed in this report, but many thrusts have not yet borne the fruit they are likely to bear if continuing support is provided.

Science seldom solves a puzzle as neatly as it is shown to do in science fiction. In fact, one might conclude that new varieties, new production technologies or methods of pest control, or new ways to utilize crop products may be only a partial or even temporary solution. In general, any single output is usually built on a great many previous steps or other building blocks and, in turn, contributes to future solutions and outputs. A very important example of this chain of events can be illustrated by the sorghum breeding program. Male sterile sorghum lines, identified in 1937 by J.C. Stephens (Jr. Am. Soc. Agron. 29:690), paved the way for hybrid seed production). The findings of Quinby and Kapper (Advances in Agronomy 6:305, 1954) illustrated the expression of hybrid vigor in sorghum "deliberate hybridization" and showed that most lines of sorghum have four recessive nonlined brachytic dwarfing genes. They also identified the loci for genetic control for sensitivity to photoperiod and temperature. From these bases the Sorghum Conversion Program was initiated and continues to this day at Texas A&M University. This program allowed breeders to develop sorghum varieties of various heights and degrees of sensitivity to day-length, making them adaptable anywhere in the world.

As a result of the work by the Sorghum Conversion Program, modern breeders can incorporate any number of desirable characteristics into the converted lines. This program is used by sorghum breeders in India, South Africa, Australia, and elsewhere as well as the United States. Breeders exchanging germ plasm may advance a line a few steps and this work may be picked up by another breeder.The resulting improvement can be a truly cooperative accomplishment. The collection, characterization, and conservation of sorghum germ plasm has made great strides in the past fifteen years as a result of INTSORMIL, ICRISAT, ICIAR, and other research centers in developed and developing countries.

It is said that sorghum and millet are grown in some of the harshest environments in the world. At present, these regions that are too hot, too dry, or too fragile for maize or other grains are only a small fraction of total arable land, but if the concerns with global warming and diminishing soil moisture availability in the future are realized to a degree that is only 20 percent of the worst case scenario, crops that will

grow in what may be expanded areas inappropriate for cultivation of other grains and then sorghum and millet could become key players in man's food, feed, and industry base.

Some of the constraints most often listed for sorghum and millet are these:

- Poor and erratic rainfall
- Poor physical and chemical properties of soils
- Inadequate production technology
- Plant diseases, insects, and bird problems
- Low-yielding cultivars
- Lack of germ plasm with improved traits
- Lack of trained researchers
- Poor technology transfer systems
- Inadequate pricing and marketing systems
- Lack of stable processed foods from these crops

One might add that because there has been so little industrial interest in sorghum or millet, the tremendous potential for industrial use (alcohol, methane, fiber, medicinal, and so on) is sadly unrealized compared to that information known for maize, wheat, rice, and barley. The INTSORMIL CRSP has tried to address each of these constraints in a purposeful way during the past decade. The vast amount of scientific literature, graduate training, and improved germ plasm generated is impressive. How well these outputs have been put into use depends on many factors, most of which are beyond the sorghum/millet CRSP mandate. If an agricultural system is lacking an adequate seed industry to multiply and distribute improved germ plasm, or provides inadequate financial support for in-country scientists, even the best methodologies or cultivars may not achieve their useful potential.

A brief look at these two crops as future food security may be of interest. It has been established that both these crops are among the most photosynthetically efficient crops in the world, they can grow under less favorable conditions of soil fertility and soil moisture than maize, they have longer seed viability than maize, and they can produce biomass levels equivalent to maize.

While sorghum is a major feed grain in the United States, and millet only a minor specialty crop, in the semiarid world both crops are used for human food and are vital to survival. In times of stress, millet in fact may be of greater importance than sorghum to the developing world because it has greater digestibility and better protein quality the equal of wheat, barley, and rice.

The industrial uses of sorghum and millet are yet to be explored. Under favorable conditions, pearl millet can produce 22 metric tons per hectare of dry matter in 85 days along with 3 to 8 metric tons per hectare of grain. Millet, unlike sorghum, does not have antinutritional factors such as tannin. Under irrigation, sorghum can produce a fresh weight of 60 metric tons per hectare, which will make 5,000 liters of ethanol plus average grain yields from 4 to 8 metric tons per hectare.

3.2. Effectiveness

The 1989 management review team and this evaluation team agree that the INTSORMIL CRSP is functioning smoothly and, except for budgetary constrictions, without management problems. The team was impressed with the scientific calibre, concern, and energy of the CRSP staff in the United States and at host country sites. To a person it was expressed that diversion of research energy into extension-type activities or more public relations would have reduced scientific output. It was felt that this should be done by a better qualified, separately funded team of specialists.

The Board of Directors has had to spend more time on budgetary than policy matters and there has been criticism that response to suggestions from the Board of Directors and the external evaluation panel are often not forthcoming for quite some time after their meetings, making quick response and correction difficult.

The technical committee stated that serious and sometimes painful decisions had to be made. On their behalf, the management entity felt that the technical committee gave valuable inputs into reactions to budgetary problems. The CRSP model was found to be highly productive, defensible and workable. There is some overlap of projects but this will probably adjust itself in the future reorganization as new priorities are set.

3.3. Efficiency

For the U.S. dollars invested in the CRSP effort, there have been many direct and indirect multipliers. In general, faculty salaries, university salaries, and teaching programs have been provided at no cost to the CRSPs. The actual dollars spent have been highly monitored and accounted for, the scientific production and training achieved for the United States and host countries have been significant, and the problem-solving philosophy of land grant universities has reached more than seventy-five countries.

The sorgnum/millet CRSP has been very effective in leveraging additional funds from other sources to support CRSP activities. It has been very effective in obtaining USAID mission buy-in funds and has had a very high output per dollar invested in its training programs. The sorghum/millet CRSP has one of the highest host-country to U.S. expenditure ratios of any of the CRSPs and has supported numerous resident scientists to promote program development.

The universities contributed far more than the required 25 percent matching funds, but they also demand an overhead level that many scientists feel is too high and takes excessive amounts away from their individual project support. Everyone needs more money, but no one needs support more than the host-country scientist. To many host-country scientists, even $30,000 a year is barely survival level for their research program. Assistance beyond USAID support needs to be vigorously sought for the HC programs.

3.4. Impacts

3.4.1. Social impacts

In the early days of INTSORMIL activity, in-depth studies of village sorghum farmers in Central America by the socioeconomics component from the University of Kentucky. The farmers' attitudes toward, and expectations from, research were transmitted to the biological scientists. Food quality was given with as much importance as yield and this helped to guide agronomists and plant breeders in that favorable direction.

The University of Kentucky contribution was eliminated at the first major budget cut of INTSORMIL. This was unfortunate. Had a socioeconomics unit been retained, the CRSP would have been better prepared to show how valuable its research output had been over the life of the project.

Although sociological studies are scant among most of the CRSPs, one could state that improved production has increased food access and food security, has made positive contributions to human nutrition, and has helped to stabilize or improve farm income.

New varieties of pearl millet and sorghum which are able to grow in less fertile, lower rainfall regions have greatly improved family food security in Colombia, Honduras, Niger, India, and in the Caribbean. One cultivar, HD-1, released through the joint efforts of ICRISAT, NARS-SUDAN, and INTSORMIL, gives farmers yield increases of 15–20 percent. It is presently being grown on 243,000 ha where it is greatly improving farm income resulting in a higher standard of living.

The release of millet and sorghum varieties with greater resistance to disease and insects has helped farm families create a safer environment through reduced use of hazardous chemicals.

The striga-resistant sorghum cultivar SRN-39 has freed sorghum growers from the backbreaking job of pulling this parasite from the crop plant.

Research that has improved the food quality and cut preparation time of these two vital grains has greatly improved the nutrition of the rural poor, reduced cooking time, and helped to conserve vital fuel wood.

3.4.2. International impacts

In early 1991, CRSP scientists from Mississippi State University, in collaboration with their colleagues at the Instituto Agropecuaria Colombiano released two improved sorghum cultivars, Sorghica Real 60 and Sorghica Real 40, adapted to the almost two

million acres of acid, aluminum toxic soils of the Llanos region of Columbia. At that time it was estimated that over 50,000 hectares would be planted with these varieties. To date, six private seed companies have requested 100 metric tons of foundation seed to be increased and sold to local farmers. The potential market value of the sorghum from this area has been estimated at $5 million annually.

CRSP scientists at Texas A&M developed the sorghum breeding lines subsequently used by Dr. Gebisa Ejeta, an ICRISAT plant breeder, and his colleagues at the Sudan Agriculture Research Corporation to develop a new hybrid sorghum released in 1983 to farmers in the Sudan. Hageen Dura 1 is a high food quality sorghum hybrid now being used under irrigated conditions on 35,229 hectares in the Gezira Irrigation Project or 12 percent of the total Gezira crop area in the 1991–92 crop year.

With appropriate fertilization, Hageen Dura 1 can produce up to 150 percent more than local sorghum varieties grown under traditional systems with no fertilizers.

Annex D

Bean/Cowpea Collaborative Research Support Program

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1. Introduction

1.1. History

The bean/cowpea Collaborative Research Support Program (B/CP CRSP) was initiated in 1980 after a comprehensive two-year planning effort involving knowledgeable professionals and laypersons worldwide. From the beginning, this CRSP was oriented toward constraints to production, and appropriate research was designed to resolve widespread problems in growing and utilizing these two important sources of protein and carbohydrate.

In the beginning, this CRSP was comprised of ten U.S. land-grant universities and thirteen host countries involved in eighteen projects. By 1991 there were twelve U.S. institutions and eleven host-country institutions addressing nine projects on the common bean (*Phaseolus vulgaris*) and four on the cowpea (*Vigna unguiculata*).

Michigan State University was selected to be the management entity for the bean/cowpea CRSP. The following institutions are currently involved:

University of California–Davis
Purdue University
Clemson University
University of California–Riverside
University of Georgia
University of Minnesota
University of Nebraska at Lincoln
University of Wisconsin
University of Puerto Rico
Washington State University
Michigan State University

The current overseas research collaborators include the following institutions (see list of acronyms for details):

EMBRAPA (Brazil)
INIFAP (Mexico)
ICTA (Guatemala)
IRA (Cameroon)
ISRA (Senegal)
INIA (Ecuador)
SEDA (Dominican Republic)
University of Nigeria, Nsukka
Bunda College of Agriculture (Malawi)

1.2. Duration

Research programs for this CRSP were designed to cover the period 1980 through 1997. The first two years were spent in contractual negotiations between the United States and host-country institutions, with research efforts beginning in the third year. It was during this first five-year period that administrative and program deficiencies emerged and reorganization and other adjustments were made.

In May 1986, a new three-year grant was awarded. In 1989 this grant was extended for another three years to March 1992. The current grant period extends through April 1997, but as with most CRSPs, plans are underway to extend the research beyond the 1997 date.

1.3. Objectives

The original objectives of the Bean/Cowpea CRSP were set forth in the BIFAD Grant Document, September 30, 1980, as follows:

> To engage U.S. universities in partnerships with developing countries to increase the availability of beans and cowpeas, especially for the rural and urban poor who rely on them as important contributions to family diet and income.

The CRSP's objectives were part of a global plan, the result of inputs from approximately one hundred leaders working in food legumes in U.S. and international universities, research institutes, government, and industry. This early compilation of major goals and constraints provided guidance in a broad sense for this CRSP to develop the following comprehensive statement of purpose:

> To overcome constraints to the production, distribution, storage, utilization, and marketing of beans and cowpeas, which are important resources of dietary protein and carbohydrate. (Bean/Cowpea CRSP Extension Proposal for 1995)

A wide range of academic disciplines have been mobilized to address these constraints. The disciplines include agronomy, soil science, biotechnology, plant breeding, entomology, plant pathology, harvesting, handling, storage technology, food processing, and socioeconomics. The CRSP has a global mandate to collaborate with research institutions and governmental and nongovernmental agencies to help improve the nutritional and economic status of the world's peoples as it relates to these carbohydrate and protein foods.

Dynamic institutions and projects undergo changes as they mature. The basic goals of the CRSP are the same, but it is now capable of addressing problems the nature and scope of which have expanded tremendously because of the successful training of scientists and support staff in the host countries, making them "full partners in research." In the beginning most of the research activity was U.S.-based with limited activity in the host country. Gradually, through training, the host-country teams have been increasingly capable of handling complex research themselves. Now we hear the term "shuttle research," meaning that the expensive high-tech portion of a project is done in the United States and the feasibility and adaptability trials are completed in the host country.

When this CRSP began, biotechnology was in its infancy. Now it has been

integrated into almost every project in the form of variety development and enhancement, disease and insect resistance, response to day length, and tolerance of such major biotic stresses as drought and high temperature.

1.4. Adjustments to budget cuts

It was observed overall that each of the CRSPs adjusted to their declining budgets differently. The bean/cowpea CRSP has had a built-in review procedure for trimming portions of research projects that had little chance to make a significant contribution to the project within the time allotted or were out of step with the United States–host-country research sequence. These approaches and adjustments worked successfully for the first decade, but now deeper cuts are anticipated.

The approach to the future involves consolidating research efforts on a regional basis, reducing activities to fit within the anticipated budget of $2.3 million, and maximizing and documenting the impacts of research outputs. The elements vital to research must be protected, but these elements will be expected to assist several projects in addition to their own. Genome mapping, for example, may be supported at one institution, but the results will be used to help characterize germ plasm in projects at several other institutions, an approach known as the centers of excellence method in which each United States and host-country research institution will concentrate in the research area in which it is most competitive or has the professional advantage.

This approach is to be commended for protecting the accelerator and multiplier elements of the project that show greatest promise to obtain breakthrough results in the near future. The global plan will still guide this CRSP, but activities will be scaled down. New training commitments are unlikely, but existing graduate programs will be supported to completion.

2. Findings

2.1. Scientific output

Thirteen projects are listed in the bean/cowpea CRSP, nine for the common bean (*Phaseolus vulgaris*) and four for the cowpea (*Vigna unguiculata*). Each project is organized under the supervision and management of a U.S. institution headed by a principal investigator (PI). In the host country, the counterpart responsible for the project collaboration and activities is called the host-country principal investigator.

The bean/cowpea CRSP has made a major commitment to include women in its research efforts and offer them training opportunities. Their participation in CRSP activities is evident. In addition, a specialist in women in development is an integral member of many United States–host-country project collaborations. Unlike many other CRSPs, the Bean/Cowpea CRSP has maintained its agricultural economics and socioeconomics components.

The bean/cowpea CRSP lists twelve major projects as of May 1994 (see appendix table D.2.1).

In addition, two projects were completed in 1992. Those were the Insect Pathogens in Cowpea Pest Management for Developing Nations (between Brazil and the Boyce Thompson Institute) and Agronomic, Sociological, and Genetic Aspects of Bean Yield and Adaption (between Guatemala and Cornell University). These research projects were designed to help mitigate constraints facing these crops globally. Many of these constraints can be best addressed through improved germ plasm accomplished by adding or selecting for genetic traits for drought tolerance, disease resistance, improved plant architecture, and improved of food quality. It should be noted that six of the eight projects on *Phaseolus* (beans) concentrate on breeding and selection, one accents nutritional quality, and one is primarily oriented to plant pathology.

Within the four cowpea projects, one addresses pest management, a second considers production and cultural practices, a third is devoted to post-harvest relationships, and the fourth investigates problems in processing and preservation. The major constraints and areas of research concentration listed by this CRSP (in order of importance as listed in the global plan of 1989) are given in appendix table D.2.2.

Table D.2.1. Bean/cowpea CRSP projects

Title of project	Host-country/U.S. institution
Preservation of Post-Harvest Cowpeas by Subsistence Farmers in Cameroon	Cameroon/Purdue University
Biology, Epidemiology, Genetics, and Breeding for Resistance to Pathogens of Beans with Emphasis on Those Causing Bacterial and Rust Diseases	Dominican Republic/University of Nebraska–Lincoln
Molecular Approaches for the Control of Bean Golden Mosaic Virus	Dominican Republic/University of Nebraska–Lincoln
Improving the Productivity of *Phaseolus* Beans under Conditions of Low-Input Agriculture through Genetic Selection of Host Cultivars and Rhizobium Strains for Enhanced Symbiotic Efficiency	Ecuador/University of Minnesota
Improvement of Bean Production in Honduras through Breeding for Multiple Disease Resistance	Honduras/University of Puerto Rico
Improving Dry Bean Nutritional Quality and Acceptability	INCAP/Washington State University (project reorganized and relocated in FY 1992)
Improvement and Host Pathogen Co-Adaption in Malawi, a Secondary Center of Diversity	Malawi/University of California–Davis
Improving Resistance of Environmental Stress in Beans through Genetic Selection for Carbohydrate Partitioning	Mexico/Michigan State University
Appropriate Technology for Cowpea Preservation and Processing and Study of Its Socioeconomic Impact on Rural Populations	Nigeria/University of Georgia (project completed in Nigeria in FY 1992; then new utilization project relocated to Ghana)
Program to Develop Improved Cowpea Preservation and Processing and a Study of Its Socioeconomic Impact on Rural Populations	Senegal/University of California–Riverside
Program to Develop Improved Cowpea Cultivators, Management Methods, and Storage Practices for Semiarid Zones	Dominican Republic/University of Wisconsin–Madison
Breeding Beans (*Phaseolus vlugaris* L.) for Disease, Insect, and Stress Resistance and Determination of Socioeconomic Impact on Smallholder Farm Families	Tanzania/Washington State University

Table D.2.2. Major constraints and areas of research concentration

Beans

1. Diseases, fungal
2. Digestibility
3. Socioeconomic aspects of farming systems/Women in Development
4. Bean golden mosaic virus
5. Drought stress and tolerance
6. Germ plasm diversity
7. Biological nitrogen fixation
8. Soil factors
9. Participatory research
10. Heat stress and tolerance

Cowpeas

1. Field insect pests
2. Seed storage pests
3. Utilization and nutrition
4. Heat stress and tolerance
5. Drought stress and tolerance
6. Economics and marketing
7. Sociocultural aspects of farming systems/Women in Development

The scientific accomplishments of the bean/cowpea CRSP are significant and numerous. They range from the simplest technology to cutting-edge manipulation of genetic material. In the improvement of germ plasm, special screening procedures are being developed for lab, greenhouse, or field evaluation. These protocols may have even more global value than the varieties developed because they may facilitate research and reduce the time spent by other researchers.

Plant breeding by its very nature is one of the most multi-institutional and cooperative forms of research. CRSP is assisted by the international agricultural research centers CIAT and IITA (and vice versa) and by linkages with other institutions that share protocols, germ plasm, and research information. Without trying to establish primary credit, a brief look at the tremendous output of this CRSP shows that these variety-development projects have contributed to the resolution, or the anticipated resolution, of many of the major constraints (see appendix table D.2.3).

Table D.2.3. Variety releases, 1984–1994

Beans

Variety	Country	Attributes
Anacoana	Dom Rep	Field resistance rust, WB, BGMV
Bayo Victoria	Mexico	Drought resistance
Dorado	Honduras	Rust, BGMV, bacteria blight resistance
Don Silvio	Honduras	Rust, BGMV resistance
EAP 10-88	Honduras	Common bact blight, anthracnose resistance
EAP 12-88	Honduras	Common bact blight, anthracnose resistance
Flor DeMayo 38	Latin Am.	Rust, mosaic, common blight tolerance
Negro Durango	Mexico	Drought resistance
Pinto Villa	Mexico	Drought resistance
PC 50	Caribbean	Rust resistance, high yield

Beans in the United States

Alpine (Great Northern)	Rust resistant
Aztec (Pinto)	Anthracnose resistant
Black Hawk (Black Bean)	Common bean mosaic virus resistance
Chinook (Lt. Red Kidney)	Common bean mosaic virus resistance
Mayflower (Navy type)	Halo blight, anthracnose, rust tolerance
Sierra (Pinto type)	Rust resistance
Starlight (Large bright)	Bacterial blight resistance

Cowpeas

Variety	Country	Attribute
Melakh	Senegal	Early maturity (drought escaping), resistant to aphid-borne cowpea mosaic virus and bacterial blight
Mouride	Senegal	Early (drought escaping), resistant to aphid-borne cowpea mosaic virus and bacterial blight

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The list of parental material generated by scientists working with the bean/cowpea CRSP includes:

Higher yielding potential (B, CP)
Improved heat and drought tolerance (B, CP)
Wide range of maturities (B, CP)
Higher levels of yield stability (B, CP)
Increased fixing ability (B)

CRSP scientists accomplished the first successful cross between the teparay bean and the common bean using the embryo rescue technique. This interspecific cross carried the extremely heat tolerant characteristics of the tepary bean into the *Phaseolus* species for the first time. This cross holds great promise for future breeding programs for heat tolerance and drought resistance.

Although the biological crop protection project in Brazil was relocated in 1992, the CRSP integrated pest management project made a significant impact in the microbial (parasitic fungal) management of insect pests of cowpea and bean. The project is being continued by CRSP-trained scientists. From preliminary studies it was found that, while this biological control did not work well under arid conditions, it had greater effectiveness in the more humid areas of cowpea and bean production. This project, which has great potential for future pest control without the use of chemical pesticides, collected over 300 strains of entomopathogenic fungi in Latin America. Researchers have developed a low-cost technology for the biological control of cowpea *Chalcodermus* weevils and *Empoasca* leafhoppers using a spray application of fungal conidia.

Protocols are usually defined as procedure-specific packages of information or techniques. *Technology,* however, is the term for a chain of larger procedures, such as the best management practices for crop or animal production. The list of protocols generated by the bean/cowpea CRSP for the laboratory, greenhouse, and field screening is quite lengthy and includes:

- description of the first cloning of a disease-resistant gene and its transfer from one crop variety into another;

- description of a method of transfer of an ALPHA AM inhibitor gene from common bean into garden pea;

- presentation of the procedure for using monoclonal antibodies to identify and detect common bean mosaic virus;

- preparation of methods using random amplified polymorphic DNA (RAPD) to develop gene markers for bean common bacterial blight;

- development of a method of successful production of Analean by Mesoamerican F_1 crosses;

- presentation of a rooting method for testing for resistance to common blight using detached trifoliate leaf stems;

- determination of molecular markers for Bean Yellow Mosaic Virus using DNA probes and dot blot assay;

- development of a dry inoculum technique to provide a rapid and effective method for inoculating beans for angular leaf spot, anthracnose, and common blight;

- creation of a diagnostic test for identification of four gemini viruses of beans;

- development of a precise procedure for evaluating food quality characteristics for dry beans;

- presentation of a method of steam extraction of bean flour using drum dehydration to make shelf-stable rehydratable bean products;

- development of a method to prepare improved biological nitrogen fixing inoculant;

- presentation of an alternative procedure for hand-pounded cowpea flour production that reduces labor approximately 45 percent;

- development of a procedure to reduce cooking time of common beans and speckled butter beans through soaking in chelated salt.

The most frequent measures of scientific output are the number of scientific journal articles published, the number of papers presented at scientific meetings, and, while not listed as scientific papers, the extension publications that help to move a technology from laboratory to farmer.

A complete listing of all publications generated by this CRSP appears in the bean/cowpea CRSP bibliography of publications 1984–1994 prepared by the management entity. There were 725 refereed journal articles, and 1,541 scientific papers published elsewhere.

2.2. Training output

This CRSP prepared a comprehensive record of training accomplishments including academic degree training and nondegree and workshop activities. The bean/cowpea CRSP supported 318 students for academic degrees, 50 percent of whom were from host countries, 22.1 percent from other less-developed countries, and 17.9 percent

from the United States. The table D.2.1 shows the numbers of degrees granted.

Table D.2.1. CRSP training accomplishments — degrees granted

Degree	Male	Percent	Female	Percent	Total
BSc	60	59.4	41	40.6	101
MSc	77	53.8	66	46.2	143
PhD	41	55.4	33	44.6	74
Total	178	56.0	140	44.0	318

Source: Bean Cowpea CRSP Training Recorded 1984–1994, management entity, Michigan State University

Table D.2.2. Disciplinary training—distribution by gender

Discipline	Male	Female
Food sciences	13.7	15.8
Social sciences	7.4	2.1
Pest management	12.6	7.4
Agronomy	29.5	11.6
Total	62.2	36.9

The bean/cowpea CRSP trained 936 persons in nondegree programs, 27.4 percent of whom were women, and 72.6 percent were men. Workshops were often cosponsored with such IARCs as IITA, CIAT, or with foreign institutions. Two international symposia on cowpeas were held with IITA, one in 1984 and one in 1990.

Topics of B/CP CRSP workshops include:

a. Bean quality
b. Biotechnology
c. Biological nitrogen fixation
d. Biosafety in bioengineering
e. Computers

f. Drought responses of beans
g. Farmings systems research
h. Socioagricultural aspects of bean production
i. Tepary beans
j. Yield barriers in beans

Workshops and symposia are usually followed up with written publications to document the state-of-the-art information presented. Each conference was so recorded and may be found in the bibliography of the bean/cowpea CRSP prepared by the management entity.

2.3. Technology generated

- The bean/cowpea CRSP initiated the practice of allowing a fallow period and delaying bean planting until November 15 to avoid white fly transmission of the Bean Golden Mosaic virus in the Dominican Republic. This practice was made into enforceable law. The technology has reduced BGMV incidence and increased yields.

- A package of practices developed in Malawi, but of use wherever bruchids infested cowpea seed are stored, involves placing the harvested dry cowpeas on a black-painted sheet-metal base, then covering them with clear plastic film under a hot sun. All stages of cowpea weevils (adult, larvae, pupae, and eggs) are killed by this method. After this solar heating, the "disinfested" seed may be stored in wood ashes or triple-bagged in polyethylene sacks for holding for up to two years.

- A sequence of practices to make cowpea meal for village consumption was developed. The dry cowpeas are first soaked overnight and then dried. The seedcoats are separated by abrasion, and the clean cotyledons are ground using a simple mechanical grinder.

- Numerous technologies generated by the Brazil/Boyce–Thompson Institute CRSP Project will have lasting value. The use of fungal pathogens to manage insect pests of cowpea and bean in humid regions is now well institutionalized in parts of South America. The methods of producing fungal conidia in mass quantities for this purpose was developed and the training of personnel to carry on this important technology ensures sustainability.

Through the CRSP, a senior pathologist at the University of Wisconsin has established the world's leading laboratory on gemini viruses, a virulent class of viruses that is devastating beans and tomatoes in many countries worldwide. Recently one such virus was found in fields in Florida, where it is thought the whitefly vector was blown in from the Caribbean by Hurricane Hugo. Universities in California, Texas, Utah, and Hawaii are also interacting with this lab, as is CIAT. Currently the countries working with and being assisted by the CRSP team include Nigeria, Malawi, South

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Africa, Zimbabwe, Taiwan, Thailand, Bhutan, Nepal, Pakistan, India, Sri Lanka, Indonesia, Egypt, Jordan, Lebanon, Spain, Argentina, Brazil, Colombia, Ecuador, Peru, Costa Rica, Honduras, Nicaragua, Guatemala, Mexico, Cuba, Dominican Republic, Jamaica, and Haiti. The countries actively collaborating to build this type of virus detection and diagnostic capacity number sixteen. The Costa Rican government, for example, issued an emergency memorandum declaring the problem with the whitefly gemini virus complex an emergency and allowing growers to apply for funds to offset their losses from this disease. With government endorsement, the host-country CRSP team at the University of Costa Rica is to become the center for the diagnosis of these serious pathogens, not only for Costa Rica but for all of Central America. This "vote of confidence" is a testimonial to the expertise gained through their association with the CRSP. Costa Rica has the professional capacity to diagnose this problem, and whatever they lack in experience with this pathogen is being supplied through CRSP collaboration.

The CRSP gemini virus team at the University of Wisconsin is working closely with such members of the U.S. private sector as Agracetus, Asgrow Seed, Petoseed, and Harris Moran Seed. Two of these companies are major tomato breeders for the world seed market. Initial experiments on tomato antiviral strategies appear promising, and work with them on bean-infecting gemini viruses has direct implications for beans. Studies with beans will be available in the near future. The bean food-science project at Michigan State University is cooperating with Gerber Products to develop a procedure to predigest beans using selected enzymes. A protocol for soaking, milling, and predigesting them was developed and used for producing drum-dried bean meals suitable as a weaning food.

Based on earlier Nigeria and University of Georgia research on cowpea *akara*, a common Nigerian doughnut-type ball, the CRSP team entered into a collaboration with Johnson Ranches of Corning, CA, to develop a partially or fully cooked, frozen form of *akara* made from the dry cowpea mix developed by the project to be sold as a fast-food. Plans call for the University of Georgia to provide the technology to process the blackeye-pea base for freezing and microwave reheating with Johnson Ranches providing marketing opportunities through commercial and wholesale food manufacturers, distributors, and retailers.

The CRSP University of Georgia team has been approached by Southern Frozen Foods, the leading processor of cowpeas in Georgia, about technology to make a related legume, the speckled butterbean, easier to cook. The CRSP–developed procedure recommended and subsequently adopted involved soaking seeds in a mixture of chelated salts. The company projects that this procedure will reverse its loss of considerable business. Discussions are underway with the CRSP team to lend the company equipment and supply technical advice in exchange for research support from the company.

Through the University of Georgia, the manufacturer of the Insta-Pro low-cost extruder in Des Moines, Iowa, in conjunction with Lisabi Mills of Lagos, Nigeria, was

involved in developing technology for cowpea processing. Another company, H.J. Heinz, has expressed interest in reducing the oligosaccharide content of legumes using germination techniques derived from this project's work.

For the first time, transgenic beans containing outside genes have been developed. The University of Wisconsin and a private research firm, Agracetus, produced new genetically altered bean plants. The potential benefit of this technology for U.S. agriculture far surpasses its application in beans.

Monoclonal antibodies are being used by the Prosser Laboratory at Washington State University to identify and trace strains of bean common mosaic virus. This is important to prevent the spread of seed-borne virus diseases and is being used by the regulatory agencies of many states. The USDA is using this technique to purify the national bean collection at Pullman.

2.4. Management

Comments on the bean/cowpea CRSP management style from it being overdirected to it being the best managed of all the CRSPs. In general, nearly all the scientists interviewed gave a favorable rating to the MO, that even though most felt that they spent too much time being reviewed and reports required too much detail and involved a great deal of duplication.

Because of the delays in publishing the findings by the technical committee, external evaluation panel, and Board of Directors, which often came one to two years after a review, responding to criticism was difficult. Many scientists felt that they would have handled what they termed impact statements more effectively if this had been programmed more strongly in the log frame. Verifiable indicators do just that and have been there in USAID programs for several decades.

The scientists, in general, are impatient with the time it takes to obtain USAID mission approval for country clearance. The Mission side of this problem, however, is a different story, and it is quite obvious that Mission input was lacking in the early development of the CRSP mechanism.

2.5 Linkages

Professional linkages between bean researchers extend far beyond the major collaborating institutions listed in the bean/cowpeas CRSP. Another type of important linkage develops as outside experts are asked to serve on CRSP reviews, take part in workshops, or help plan and execute symposia. As with the two other crop CRSPs, this CRSP has had a checkered relationship with the USAID missions; with some missions the CRSP researchers have developed close, durable linkages whenever the research component serves the mission's strategy; but with some others, problems with incompatible personalities were noted.

As with most of the CRSPs, linkages operate at various levels. Some are formal linkages such as those with IITA and CIAT in which there is frequent sharing of information, germ plasm, and workshop responsibilities. Others with foreign research institutions are less formalized and quite infrequent, but highly worthwhile, such as those with the Southern African Development Coordinating Committee (SADCC), Semiarid Food Grain Research and Development Project (SAFGRAD), or the German Agency for Technical Cooperation (GTZ).

This CRSP has close working relations with the Bean Improvement Committee (BIC), the bean commissions in various U.S. bean-producing states, and with nearly all of the leading commercial bean seed companies.

3. Conclusions

3.1. Relevance

Beans and cowpeas are among the most important sources of carbohydrate and protein for poor people throughout the world. While the common bean is consumed worldwide, almost 83 percent of the cowpea consumption is in Africa. The United States consumes approximately three kilograms of dried beans and cowpeas a year per person; Mexicans eat almost 15 kilograms, and in some African and Latin American countries consumption exceeds 30 kilograms per person per year.

This CRSP has vigorously addressed pertinent constraints, it has significantly prevented genetic erosion, and it has added to germ plasm diversity through collection, characterization, and conservation. It has generated a wide range of improved cultivars for general and specialized use, broken new ground in genetic transformation and genome mapping, and prepared detailed protocols to streamline, improve, and expand resistance-screening and improve responses to biotic stress.

The bean portion of this CRSP concentrated predominantly on plant breeding, and some observers felt it was not well balanced. On the other hand, the cowpea portion was more diverse. These observations deserve analysis.

In essence, beans have a very long list of fungal, viral, and bacterial diseases that are either too expensive to manage with chemicals or impossible to avoid or control because procedures would be too damaging to the seed or the environment. Thus, breeding for resistance to diseases and other biotic stresses such as drought and heat, and for extended photoperiod, is highly desirable.

In the developing world, cooking time is a problem of such magnitude that many sociologists and nutritionists feel that nutritional well being is as much tied to fuelwood availability as food scarcity. This CRSP has made significant genetic and technological contributions toward resolving this serious constraint.

The objectives stated in this CRSP have been carefully considered during the program's life, and most have been met. Of the remaining objectives, virtually all seem to have enjoyed significant progress.

The current scientific situation is quite different from that of the early 1980s. Since then CRSP training has made equal partners of host-country institutions in planning and in a modest level of complex research, and both have created opportunities to test cutting-edge research output through cooperation between the host-country institutions and their U.S. counterparts.

This CRSP has contributed significantly to food self-sufficiency, the capacity of a region to produce directly all the food it consumes. While this CRSP has contributed to expanded bean production and thus to food security in the less-developed countries, a CRSP study on this subject showed that home food production may contribute to availability or access yet not be the best economic path if off-farm employment opportunities are available.

3.2. Effectiveness

A well-functioning agricultural system includes production, supply, marketing, regulation, research, extension, and teaching segments. If the chain is weak or pieces are missing, the development process faces serious barriers to success. The scientific effort and output of the bean/cowpea CRSP would be difficult to fault, but the utilization of research results has not enjoyed wide adoption because of weak links in the agricultural system, especially supply and extension functions. This is not a fault of the CRSP except to be warned that site selection in a host country with an inadequate agricultural system should have been avoided. On this subject, mission advice might have been very helpful.

The evaluation team witnessed two very notable examples of effective program activities, both of which were heavily dependent on nongovernmental intervention to promote adoption.

In Senegal, World Vision International, a nongovernmental organization, helped to evaluate, encouraged dissemination and adoption, assisted in seed increase, and even helped to market two new highly adaptable cowpea varieties, Mouride and Malekh, developed in the drought resistance project. There is a great need to produce food in this part of the Sahel, now too arid to grow peanuts and millet, and if this nongovernmental organization had not been there to energize this dramatic development there is no telling when the local extension service or other governmental agency might have been able to implement their adoption. As an outgrowth of the NGO's activity and initiative, there have emerged several seed entrepreneurs, trucking and handling companies, and market operations. Even export prospects are now being considered.

The project in Malawi for bruchid reduction in cowpea has been well documented and has been a very effective program. This technology will also augment the program in Senegal in the future. The technology of solar dryer and triple-polyethylene bagging has been given enough publicity that most likely it will spread on its own from key demonstration sites. The parastatal resources in Cameroon are helping, but seldom do governmental agencies move things as fast or as well as private organizations.

The failure to enlist better host-country government cooperation to disseminate improved varieties and technology experienced by all the commodity CRSPs was due in part to forces beyond their control. The only prevention might have been to have

made better site selections, obtained more feedback from Mission agricultural officers, and assured in advance that host governments would acknowledge the intervention and help in its adoption.

The missions felt that CRSP projects are not properly explained to them and they are not shown how the projects relate to Mission strategy, often appearing isolated from country needs. The two-year rotation of most agricultural officers in Missions is often not conducive to building a good understanding with CRSP programs. Mission personnel feel that they could have helped track impact of CRSP projects, and they did do this when personalities were compatible. Mission clearance delays often reflected the priority of the CRSP in the Mission program but were not meant to be obstructional.

The project director of the bean/cowpea CRSP has been quite adept at protecting high-priority projects from budget uncertainties. The board of directors (BOD) enhanced the prioritization process of this CRSP by declaring that there would be no rollover of year-end funds.

3.3. Efficiency

THE bean/cowpea CRSP has shown great courage in setting and revising priorities and in its pruning processes over the life of the program. According to scientists interviewed, if projects appeared ineffective or peers felt that some elements could be eliminated, the changes were made, kindly but firmly.

The record keeping of the bean/cowpea CRSP appears to be in excellent hands. Facts and figures were made available to the evaluation team in a very responsible manner. The scientific corps felt that there was high delivery on the USAID money invested in this CRSP. Because of the long history of budget cuts, the board has had to devote a great deal more of its time to budget matters than to policy or long-range, more visionary, aspects of this very important CRSP. Delays in the arrival of funds from USAID create an undue burden on the board, the program director, and the host university, the last of which must advance operating funds until the money is transferred from the federal accounts.

Because it has a later close-out date, this CRSP has not had to address the subject of alternative funding as urgently as some others, but it has done a very thorough job of planning for the future on a basis of declining funds.

3.4. Impacts

3.4.1. Social impacts

The reports from the socioeconomists and from women in development reflect the heavy involvement of village women in bean flour and cowpea meal production. It is expected that cottage industries will develop. One development of particular interest is

the variety of women's group involved and their management practices. Having great respect for the determination of African women' groups, I would commend this process and expect success.

The cash-crop production of beans and cowpeas is male dominated in Africa, but the production of beans and cowpeas for consumption by the family is a woman's responsibility—so whatever can be done to help women is well worth the investment. This CRSP has directly involved FRAM groups, especially women's groups, in the early stages of applied research to help assure that new technologies, varieties, and other research outputs suit the social and economic context and are likely to be adopted by farmers and consumers.

The bean/cowpea CRSP currently has an active socioeconomic team, but this component was not introduced until FY 1991 and FY 1992. Therefore it has not had a chance to record the many ways in which these two high-protein crops have improved nutrition, income, and lifestyles.

3.4.2. Institutional impacts

The commodity CRSPs brought the Sahel, the Honduran hillsides, and the velds of Southern Africa into U.S. university classrooms and research labs and introduced concepts of and possible solutions to world constraints. The many foreign graduate students sponsored through CRSPs globalized fellow students who, in turn, helped them appreciate the American way of life. The discussions with graduate students at each of the commodity CRSPs reflected their admiration of U.S. educational participation and freedom to interact with their instructors in the classroom and laboratory. When asked if their training in the United States in biotechnology would be applicable when they returned home, it was almost unanimous that "probably not for now, but we need to know for the future as scientists."

Trainees expressed great appreciation for the U.S. agricultural system and the effectiveness of the multidisciplinary approach to problem solving as experienced in the American land grant university system. Interviews with graduates in their home country showed their great loyalty to their U.S. alma mater and their close bond to their major advisor.

It was obvious that there had been institutional changes at both the NARS centers and host-country universities when U.S. trainees returned home. Some graduates showed great initiative to make improvements, but many, when faced with the reality of low salary and inadequate support, saw the CRSP linkage as a life-or-death link to continued professionalism. If that small support is removed, we have an obligation to teach returnees how to access alternative funding sources.

At Bunda College in Malawi, a strong residue of multidisciplinary competency in bean research has been demonstrated, Senegal has a strong research capability in cowpeas, and in Brazil the bean/cowpea CRSP has generated a durable plant

pathology and entomology complex as a result of its integrated pest management project there.

3.4.3. Sustainability

Interviews with host-country scientists make one realize how fragile the NARS centers really are, how dependent they are on outside funding, and how continued research depends on so few individuals. There is also the consideration that most or all of the excellent graduate training may be lost 20 to 25 years ahead due to retirement.

To achieve research sustainability, some feel that decisions must be made to establish centers of excellence in key regional sites for research and training. This would require development of a critical mass of teachers-researchers who could in turn generate future researchers-teachers. This concept has borne fruit in the Philippines at the UPLB, in Thailand at Kasetart, and in Honduras at EAP.

We do not live in an ideal world, so stop gap research programs are sometimes the only choice in the face of declining agricultural research budgets. The least that could be done to help make small isolated research teams more sustainable would be to provide strong network support, at least minimum operating funds, and at least a yearly opportunity to attend a regional or international scientific conference.

Another question related to sustainability is directed toward the CRSPs themselves. If funding declines too far or is terminated, what is going to happen to these significant research potentials? Perhaps some aspects may be picked up by the university involved; quasi-government–quasi-industry support might be forthcoming, or all must be held in abeyance until society once again appreciates the value of agricultural research and is willing to support this fundamental endeavor.

Annex E

Soil Management Collaborative Research Support Program

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1. Introduction

1.1. History

The soil management CRSP, initially called INTSOIL and TropSoils, was founded in 1981 under Title XII of the United States Foreign Assistance Act. The program was planned and conducted jointly by six American universities and nine collaborating host-country institutions. The CRSP was funded by a grant from USAID (Grant No. DAN-1311G-00-1049-00) with support from matching funds from participating American and host-country institutions, buy-ins from USAID country missions, and other donors.

1.2. Objectives

The overall goal of the Soil Management CRSP has been to increase food production, conserve the natural soil resource base, and increase the efficiency of fossil energy use through improved soil management practices in developing countries. Since its inception in 1981, there has been a distinct shift in its objectives. It went from expanding the soil knowledge base and understanding basic processes in the 1980s to technology transfer and adoptions of soil and water management practices by diverse user groups in the 1990s. Two specific objectives of the soil management CRSP program in 1981 were

- cooperation with national institutions and international centers to develop and adapt, improved soil management technology for productive, sustained farming systems in marginal lands of the tropics on an agronomically, economically, and ecologically sound basis, and

- to foster the transfer of such technology through a network of institutions with similar interests.

These objectives were later modified in the 1989–94 extension proposal and program plan to incorporate two additional objectives, namely,

- to develop new technology and adapt it for diverse user groups, primarily the peers in developing countries, and

- to provide training in the principles and practices of soil management to developing country personnel through participation in the research program, training workshops, and research networks.

The proposal for the 1994–99 extension refocuses the soil management CRSP program to emphasize the sustainable use of natural resources, maintaining or improving environmental quality and developing useful products, as follows:

- to achieve sustainable increases in soil and water resource productivity so that developing countries can meet their basic needs while enhancing their natural resource base and environmental quality;

- to help land users to employ soil- and water-management methods and products that improve food security and enhance economic well being, and

- to foster national policy research, encourage advisory systems, and, along with other user groups, employ globally applicable soil and water-management products developed by the soil management CRSP.

1.3. Participating agencies

Different agencies participated at different evolutionary stages of the soil management CRSP. Initially, six American universities participated. These were

Cornell University (CU)
University of Hawaii (UH)
University of Kentucky (UK)
North Carolina State University (NCSU)
University of Puerto Rico (UPR)
Texas A&M University (TAMU)

The consortium of six universities developed a collaborative plan with eleven participating host-country institutions:

Instituto Nacional de Investigaciones Agrarias (INIA) — Peru;
Soils Research Institute (SRI) — Indonesia;
Central Research Institute of Agriculture (CRIA) — Indonesia;
Bogor Agricultural University (IPB) — Indonesia;
ICRISAT Sahelien Center (ISC) — Niamey, Niger;
Institut National de Recherche Agronomiques (INRA) — Niger;
Institut de Economie Rurale (IER) — Mali;
Empresa Brasileira de Pesquisa Agropecuaria (EMPRAPA) — Brazil;
Instituto Colombiano Agropecuaria (ICA) — Colombia;
Centro Internacional de Agricultura Tropical (CIAT) — Colombia; and
Secretaria de Estado de Agricultura (SEA) — Dominican Republic.

The primary host-country participants worked in three major agroecological zones: the humid tropics (Peru and Indonesia), the semiarid tropics (Niger and Mali), and the acid savannas (Brazil). A fourth, the Steeplands Program formulated by the University of Kentucky in the Dominican Republic, was discontinued because of funding con-

straints, as was the involvement of the University of Puerto Rico. Of the four principal participating American universities, Cornell University was to work in acid savannas in Brazil, the University of Hawaii in the humid tropics of Sumatra in Indonesia, North Carolina State University in the Upper Amazon Basin in Peru, and Texas A&M University in the West African Sahel in Niger. In addition to these primary responsibilities, North Carolina State University also worked in Indonesia and Brazil, and Texas A&M developed a program in Mali.

Participating agencies nominated North Carolina State University for the management entity role. The management entity was authorized to negotiate and execute a grant agreement with USAID, and agreements with participating American universities to implement the program. The management entity staff was composed initially of the director, the associate director, the administrative officer, the communication specialist/ editor, and secretarial support with language competence in Spanish and French.

In 1991, the soil management CRSP was expanded to include four additional agencies previously supported by USAID cooperative agreements. These were 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).

2. Findings

ALL principal investigators in soil management CRSP are established scientists with sound credentials and international reputations. Most of the original objectives were met although to varying degrees in the different ecosystems. Specific findings are summarized below.

2.1. Scientific achievements

The soil management CRSP has expanded the soils knowledge base and reshaped our understanding of basic soil management principles. It has determined that the fundamental principles governing soil systems are global in application. Consequently we now know better how to manage the soils of the tropics. These scientific achievements are documented in 150 refereed journal articles, 117 proceedings articles and book chapters, and 33 technical bulletins (see annex table E.2.1.1). A total of 300 scientific publications have been generated by the soil management CRSP. Beginning with a modest three in 1981, the number of publications grew to 60 in 1962. In this total number, a wide array of subjects are covered by the soil management CRSP publications, including (a) land-use options, (b) plant nutrients, (c) soil acidity, (d) expert systems, (e) soil inventories, (f) physical properties, (g) networks, (h) reclamation, (i) watershed management, and (j) training. The number of publications distributed since 1990 has exceeded 120 per year (see annex table E.2.1.2). Publications have been distributed globally, 23 percent to Central America, 22.7 percent to South America, 19.2 percent to the United States, 19.1 percent to Africa, 9 percent to Europe, 5.9 percent to Asia, and 0.9 percent to Oceania. Most frequently requested publications include those on the subjects of land-use options, nutrient management, and sustainable agricultural systems.

The scientific body of knowledge accumulated by soil management CRSP scientists has helped dispel several myths about the difficulties of cultivating soils in the tropics. These misconceptions include excessive risks of laterization, the quality and quantity of soil organic matter content and its supposed high rate of depletion, and the abundance of sunshine and moisture for year-round cropping (Sanchez and Logan, 1992). The science of soils of the tropics has been greatly advanced with regard to properties and processes that affect productivity, environmental quality, and susceptibility to degradation. The soil management CRSP has enhanced our understanding of several important soil processes, including (a) soil variability and soil management, (b) processes of soil erosion by water and wind, (c) nutrient cycling by legumes, trees, and wind-borne dust, (d) bypass, or macropore, flow with attendant effects on water and nutrient transport in the soil profile, and (e) water table dynamics in red-yellow Oxisols in relation to soil mineralogy. The soil management CRSP has helped collaborators improve their soil inventories and their overall understanding of the land resource base.

Table E.2.1.1. Number of journal articles, conference papers, and book chapters written by soil management CRSP participants[a]

Year	Journal articles	Conference papers	Books/ chapters	Bulletins	Total
1981	3	-	-	-	3
1982	6	2	2	-	10
1983	2	2	2	-	6
1984	5	2	3	2	12
1985	7	5	3	1	16
1986	15	9	2	2	28
1987	10	11	1	4	26
1988	15	4	2	2	23
1989	16	6	4	4	30
1990	15	11	2	2	30
1991	17	15	7	6	45
1992	31	18	4	7	60
1993	7	-	-	3	10
1994	1	-	-	-	1
Total:	150	85	32	33	300

[a]Compiled from Tropsoils, 1994c.

Specific examples of scientific achievements in soils of the tropics include

- Developed a GAPS simulator that has improved the understanding of the way water moves through the soil-plant-atmosphere continuum.

- Advanced the understanding of the importance of soil acidity, including aluminum toxicity and calcium deficiency, on the inhibition of root development in the subsoil of acid soils in ecosystems in the tropics, including humid (Indonesia), savanna (Ceriado, Brazil), and semiarid (West Africa Sahel) to help realize the agronomic potential of these soils.

- Conducted research and developed technology on chemical processes of these soils to exploit soil-water resources fully and minimize risks of drought stress.

- Quantified the ability of various soils to store organic carbon to enable scientists to focus on soils that have the potential to emit high levels of carbon dioxide into the atmosphere.

- Developed multidisciplinary analytical methodologies that facilitated the integration of soil data with agronomic, agroclimatic, and economic data as they relate to long-term productive capacity of the resource base.

- Developed a comprehensive and reliable database on world soils that has helped understand resource base potential and restraints. This database is used by international agricultural research centers, national agricultural research institutes, U.S. universities, FAO, UNDP, and other international organizations.

Table E.2.1.2. Number of publications requested and their subject category

Year	No. requested from 1980–91	Subject category[a]	No. requested from 1973-92
1980	18	Land-use options	296
1981	20	Soil fertility	271
1982	67	Inventory	104
1983	33	Expert systems	79
1984	50	Soil acidity	71
1985	53	Soil physical properties	46
1986	90	Networks	43
1987	120	Soil rejuvenation	39
1988	43	General	32
1989	120	Watershed management	7
1990	140	Information systems	5
1991	137	Training	0
Total	891	Total	993

[a] Recalculated from Smith and Smyth, 1994

2.2. Technological output

The soil management CRSP has developed appropriate technologies for sustainable management of soil and water resources in harsh environments. Following are some notable examples of such technologies.

2.2.1. Alternatives to slash-and-burn

Experiments at Yurimaguas, Peru, yielded several alternatives to slash-and-burn agriculture (Sanchez et al., 1982; Sanchez and Salinas, 1981; Nicholaides et al., 1985). The soil management CRSP researchers have shown that with appropriate inputs as many as forty-three consecutive crops can be grown without yield reductions. These data show that permanent cultivation of acid infertile soils is possible, thereby avoiding adverse effects of slash-and-burn production methods. Problems of soil acidity and nutrient deficiencies can be managed with judicious liming and fertilizer practices. Each hectare under sustainable management practices saved 11 hectares per year from deforestation for irrigated rice system, 4.6 hectares for low-input systems, 8.8 hectares for continuous cropping, and 10.5 hectares for legume-based pastures (SM CRSP, 1992). These systems enable farmers to grow as many as seven stable crops where previously they could grow only one or two. Over a three-year period, seven continuous crops (five rice and two cowpeas) can produce as much as fourteen tons of grain per hectare where the traditional system produces less than two. Aluminum, calcium, and phosphorus constraints are severe limitations to continuous cropping in Oxisols of the Brazilian Amazon (Smyth and Cravo 1990a, b; 1992), but these constraints can be corrected through judicious management. Management of soil organic matter is crucial to sustaining productivity on most soils of the tropics (Duxbury et al., 1989; Sanchez and Miller, 1986).

The soil management CRSP has demonstrated that permanent cultivation is possible on infertile soils of the humid tropics. In these improved systems tree crops also form an important component. Growing hedgerows of *Cassia reticulata* and using pruning as mulch can improve soil fertility and stabilize cowpea yield. Research results on peach palm have also been very encouraging (Szott et al., 1991a, b).

Sustainable agricultural technologies developed by soil management CRSP have provided alternatives for coca growers in Peru and Bolivia. By combining annual food crops with perennials, continuous cultivation provides an orderly transition from coca production to sustainable agriculture. Producers can diversify their crops, reduce deforestation, and improve socioeconomic level of living (TropSoils, 1992).

2.2.2. Low-input farming systems for resource-poor farmers

Enhanced scientific understanding of soils of the tropics has helped identify systems of soil and crop management that can improve and sustain yield with low levels of off-farm inputs. These low-input systems include replacement of traditional crop varieties with a rotation of improved and acid-tolerant cultivars. Nutrients are recycled by returning crop residues to the soil, and losses are minimized by controlling erosion and reducing leaching. These practices of nutrient conservation are complemented by supplemental fertilizer application, integrated pest management techniques, and the use of leguminous fallows for soil rejuvenation.

2.2.3. Livestock systems for the humid tropics

The soil management CRSP has developed systems to improve soil fertility, reclaim degraded pastures, and enhance beef and milk production in the humid tropics of Latin America. Growing improved grass and legume forage varieties developed by CIAT with judicious use of inputs can rejuvenate abandoned pastures (Scholes and Sanchez, 1991). Use of minimum tillage and applications of rock phosphate can establish palatable grass and legume species in place of undesirable ones. If implemented, these improved pasture systems can produce live-weight gains in cattle six to eight times higher than those produced on native pastures (TropSoils, 1994d). Adoption of improved grass and legume forage varieties suitable for acid-tolerant soils have greatly enhanced animal productivity. Several experiments conducted in the Amazon Basin have shown that these pastures have remained stable and productive for more than a decade even with low rates of fertilizer application. Studies on nutrient balance have shown that more than 80 percent of phosphorus, potassium, and calcium is recycled in these improved systems. Live-weight grains in such systems are six to eight times higher than those produced on traditional pastures. There are at least 10 million hectares of degraded pastures in the Amazon Basin. The soil management CRSP has developed management systems to rejuvenate such areas.

2.2.4. Management of acid savannas

Identification of soil-related constraints such as high acidity, aluminum toxicity, calcium deficiency, low phosphorus availability, and subsoil compaction (Kamprath, 1984) and development of simple technology to alleviate these constraints have revolutionized agriculture in the Cerrado region of Brazil and in other acid savanna ecosystem in Latin America. Judicious management of soil organic matter and nitrogen content is crucial to fertility enhancement (Lathwell and Bouldin, 1981). In addition to nutrient deficiency, shallow rooting has been linked to degraded soil structure. Adverse effects of soil compaction are aggravated by acid subsoil. Soil fertility and structural conditions can be drastically improved by legume green manures (Lathwell, 1990). Several legumes have been selected for tolerance to prolonged drought stress and survival in the dry season. Under favorable conditions, some legumes (e.g., *Carvalia brasiliensis* and *Mucuna aterrima*) can produce 5 tons per hectare of dry matter and over 100 kg/ha of nitrogen (TropSoils, 1993b). Because of these improved technologies developed by EMBRAPA and the soil management CRSP, there has been a significant increase in soybean production, enabling Brazil to capture a significant proportion of international trade. Acid savannas in Brazil already produce 40 percent of the nation's soybeans, 35 percent of its coffee, and 42 percent of its cattle (TropSoils, 1994d). Similarly, improving pastures (using introduced species and applications of lime and phosphorous) have drastically improved stocking rate without jeopardizing productivity and environmental quality.

2.2.5. Sustainable management of soils of the West African Sahel

Four principal soil-related constraints to agronomic productivity in the Sahel identified

by the soil management CRSP are (a) soil acidity, (b) low P availability (c) high soil temperature, and (d) drought stress accentuated by excessive runoff loss and water and wind erosion. The foundation for increased, sustainable agricultural production in the region is the newly heightened understanding of the mechanics of local ecology and biodiversity of soils and natural vegetation (TropSoils 1991). Simple but effective technologies developed by the soil management CRSP include (a) mulch farming based on use of crop residue, (b) green manuring based on plowing-under of *Sesbania*, (c) applying farm-yard manure for soil fertility enhancement, (d) contour ridges to minimize runoff and decrease adverse effects of sand blasting, (e) establishment of vegetative barriers, and (f) water harvesting technologies (Scott-Wendt et al., 1988a, b; Wilding and Hossner, 1989; Manu et al., 1991a, b; Zaongo et al., 1993). Results are encouraging, fertilization combined with various ridge-tillage practices can increase sorghum and cowpea grain yield by 157 percent and 123 percent, respectively, and improve water and nutrient use efficiency (TropSoils, 1993, 1994b; Payne et al., 1991, 1992). Contour strip rainfall harvesting technologies can increase millet and sorghum yields by as much as 119 percent and 59 percent, respectively (TropSoils, 1994d). These technologies are applicable to about 17 million hectares of land in the West African Sahel.

2.2.6. Food crops–estate crops–livestock system for Sumatra

The soil management CRSP has developed mixed farming systems for sustainable management of acid soils in Sumatra. Basic components of the technological package include (a) *Mucuna* fallowing for preventing erosion, conserving water, regulating soil temperature, improving nitrogen availability by 30 to 60 kg/ha of nitrogen, decreasing lime requirement from 5 ton/ha to 1 ton/ha, and controlling *alang* or *Imperata cylindrica*; (b) establishment of vegetative barriers on the contour based on vetiver grass and woody perennials including *Gliricidia sepium, Flamingia congesta, Paraserianthes falcataria,* or *Leucaena leucocephala* for erosion control, runoff management, and providing feed and forage for cattle; (c) development of a paddy rice system for lowlands or valley bottoms for intensive cultivation of rice; and (d) identification of agrisilvicultural systems based on growing food crop annuals within the corridors of estate crops planted in the east-west direction (Dierdolf et al., 1989). Green manures can be effectively used for aluminum detoxification (Hue and Amien, 1989).

2.2.7. Planted fallows and agroforestry systems

Managed fallows, consisting of quick-growing leguminous annuals and woody shrubs and trees, improve the efficiency of natural fallowing. This system restores soil fertility and improves soil structure in two to four years rather than the twenty years needed by natural fallowing. The soil management CRSP found that the nitrogen fixing ability of these fallows is less important that their biomass production. Additionally, the yield of the following grain crops is often proportional to the biomass produced by the planted fallow. Some important leguminous annuals are kudzu and mucuna. These legumes can supply most or all of the nitrogen required by

succeeding nonleguminous crops. Soil management CRSP research in the Brazilian Cerrado has shown that biological nitrogen fixation by legumes can supply sufficient N to grow 6 to 8 t/ha of maize, the equivalent of 150 kg/ha of nitrogen fertilizer. Several trees and woody shrubs are also efficient soil rejuvenators, including *Inga edulis, Cassia reticulata,* and *Paraserianthes falcataria.* These species can be grown in agroforestry systems involving food crops and livestock systems. TropSoils scientists have observed that agroforestry systems are soil-specific and are not applicable in all soils and ecoregions. In addition, several tree crops provide viable alternatives to grain crop systems. An encouraging tree crop is the peach-palm, which also lends itself to a silvopastoral system.

2.2.8. Sediment control on steeplands in Honduras

The steepland program in Honduras has shown encouraging results in reducing erosion by use of crop residue mulch, stone barriers, and contour hedges of vetiver. Attempts are also being made to develop models for predicting erosion risks on steeplands in other ecoregions.

2.2.9. Land-clearing technology

TropSoils made a notable contribution to development of appropriate methods of land clearing and reclamation in the humid tropics (Sanchez et al., 1983; Alegre et al., 1986, 1988; Bandy et al., 1986; Arya et al., 1992). Experiments conducted in Peru and Sumatra showed that experimental plots cleared with chain saws and machetes produced yields 22 percent higher than plots cleared with a straight bulldozer. In addition to scraping topsoil, bulldozers caused subsoil compaction and accelerated soil erosion.

2.3. Mechanisms and instruments of technology transfer

The Soil Management Support Services (SMSS) project and Nitrogen Fixation by Tropical Agricultural Legumes (NifTAL) project have been extremely successful in identifying mechanisms and developing instruments of technology transfer. More specific achievements of the soil management CRSP with regard to technology transfer include SMSS, NifTAL, and the Technology for Soil Moisture Management (TSMM) project.

2.3.1. Soil Management Support Services project

The SMSS project has been extremely effective in providing technical support services to the national programs in fifty-five countries in soil resource characterization, land capability assessment, arranging workshops in soil taxonomy, and providing field manuals and guidelines in several regional languages (Eswaran et al., 1992, 1993). The project has established linkages with national and international programs, leveraged funds with several donors, and established a unique global database on soil resources that is extremely useful in translating what we know into

how we manage soils. The database is widely used by several organizations including IBSNAT, international agricultural research centers, FAO/UNDP, U.S. universities, and less-developed country institutions (Eswaran, 1991).

2.3.2. Nitrogen Fixation by Tropical Agricultural Legumes project

Biological nitrogen fixation is critical to attaining agricultural sustainability for resource-poor farmers (Bohlool et al., 1992). Rhizobial inoculation is an important tool to improve nitrogen status and enhance yields (Singleton et al., 1992a). The NifTAL project has operated as a development-cum-training center in transferring rhizobium technology for improving nitrogen status in soils of developing countries. It has provided rhizobium technology to national institutions and commercial sectors in both the United States and overseas. It has also developed simple and routine tests for quality control assessment of the rhizobium inoculant (Graham et al., 1991). Commercial companies have adopted this rhizobium technology in Thailand, the Philippines, Indonesia, India, Zambia, Honduras, and elsewhere. In Thailand, the Bangkok Seed Company now produces 400,000 units of inoculant annually.

NifTAL has developed Financial Analysis for Inoculant Manufacturing Enterprise (FAIME) to help entrepreneurs evaluate financial and technical variables as they relate to establishing or redesigning inoculant manufacturing facilities (TropSoils, 1994d). In addition, NifTAL has also developed a comprehensive repository of rhizobial strains that helps to identify the most effective rhizobia for legumes. NifTAL has identified several drought-resistant legumes that can provide as much as 100 kg/ha of nitrogen to the following, nonlegume crop. Several nitrogen-fixing trees have also been identified, including *Inga edulis* in Peru, which improved crop yield by 34 percent (Singleton et al., 1992b).

2.3.3. Technology for Soil Moisture Management project

The TSMM project has implemented a soil-water management program in Niger, Mali, and India that is oriented to practical applications, and developed successful linkages with several national programs (Singh et al., 1990).

2.3.4. Decision support systems

The soil management CRSP has developed several software systems to transfer technology. Important among these are the Acidity Decision Support System (ADSS) (Yost, 1991), and the Phosphorus Decision Support System (PDSS) (Yost et al., 1988; Itogo, 1992). The ADSS software is being used in the United States, Indonesia, Brazil, Colombia, and several other countries (Amien, 1986). It allows users to turn raw information into lime requirements and costs and returns to make soil specific recommendations.

The Fertility Capability Classification System (FCC) is designed to use soil classification for soil fertility management (Sanchez et al., 1982; Buol, 1987). The FCC

groups soils according to the fertility management problems they represent. The soil management CRSP also designed a GAPS that makes simulation modeling more accessible to users. A Winrock project in Southeast Asia has used GAPS to predict the way various multipurpose tree species respond to particular climates and soils and it has been used to predict how fluctuations in temperature and precipitation affect crop growth in the United States. The soil management CRSP has developed a mass-balance model to understand long-term changes in soil N pools and helps predict the N required to reach the target yield (Osmond et al., 1992). The Automated Land Evaluation Systems (ALES) enables planners to assess the physical and economic consequences of various land management choices (TropSoils, 1994d).

2.4. Training output

The graduate-level component of the soil management CRSP has been very successful. The soil management CRSP has provided degree-related training to 105 students from all participating institutions (annex table E.2.4.1.). These trainees came from both developed and developing economies representing thirty-one countries worldwide (see annex table E.2.4.3). In addition, there are thirty-six students including students from Togo, Mexico, and Zaire currently enrolled in graduate programs at all participating universities (annex table E.2.4.4). The soil management CRSP has been a unique source of funds for American students to obtain training in tropical soils.

A survey of soil management CRSP alumni (Ursone and Smith, 1994) showed that 46.2 percent are employed by a university, 23.1 percent by a national government, 23.1 percent by an international agricultural research center, and the remainder by miscellaneous organizations. These alumni include teachers, researchers, policymakers, program leaders, and extension agents, who have helped strengthen the capability of participating host-country institutions in soil management research and development programs. Several trainees now occupy key positions in their national programs. Alumni interviewed experienced professionally rewarding associations with the soil management CRSP and looked forward to maintaining close linkages with their peers and former professors. In addition, short-term training and workshops funded by bilateral programs and several donor organizations are regularly organized by SMSS and NifTAL including FAO, UNDP, and SIDA.

2.5. Linkages

The soil management CRSP achieved its objectives through networking. The Red de Investigación de Suelos Tropicales (RISTROP) Network developed in 1986 is an example of an effective partnership with national institutions in developing countries. RISTROP involved 31 scientists from 15 national institutions in Latin American countries who participated in the soil management workshop held at Yurimaguas, Peru. By 1990, the network had grown to include 15 Central and South American countries and more than 100 collaborating scientists. The network has been successful in transferring and validating improved soil management technologies throughout tropical Latin America. RISTROP also collaborated with the Texasgulf Corporation in

Table E.2.4.1. Graduate-level training provided by the soil management CRSP, 1981–93 (number of students).

Year	M.S.	Ph.D.	Total
1981	1	1	2
1982	-	1	1
1983	2	-	2
1984	2	1	3
1985	3	3	6
1986	5	3	8
1987	2	11	13
1988	6	7	13
1989	3	9	12
1990	5	9	14
1991	7	6	13
1992	8	3	11
1993	4	3	7
Total	48	57	105

* Recalculated from soil management CRSP. 1994

defining fertilizer marketing potential in Latin America. The 1988 Workshop on Acid Tropical Soils Management and Land Development held in Yurimagnas, Peru, involved participants from 16 African countries and was conducted in collaboration with IBSRAM. The soil management CRSP work in Sumatra identified the role of women in managing home gardens (Colfer 1991). The Integrated Management of Agricultural Watersheds (IMAW) project in Niger has used methodology based on local knowledge, customs, and cultural preferences.

The soil management CRSP established strong working lineages with a number of international agricultural research centers (CIP, CIMMYT, CIAT, IFPRI, ILCA, ICRISAT, ICARADA, IITA, IRRI, ICRAF), other international agricultural institutions (TSBF and IBSRAM), and several donor organizations (Rockefeller Foundation, IDRC, PI, GTZ).

Table E.2.5.1. Geographic distribution of trainees graduated by July 1994 from Cornell, Hawaii, and North Carolina

Country	M.S.	Ph.D.
Argentina	-	1
Austria	-	1
Bolivia	1	1
Brazil	2	4
Brundi	1	-
Burkina Faso	1	-
Cameroon	1	
Colombia	-	2
Costa Rica	-	1
Domin. Republic	-	1
Fiji	-	1
Germany	-	2
Haiti	2	-
Indonesia	1	10
Iran	1	-
Jamaica	-	1
Kenya	1	3
Malaysia	1	-
Mali	1	1
New Zealand	-	1
Nicaragua	-	1
Niger	1	1
Peru	1	4
Philippines	1	1
Senegal	-	1
Switzerland	1	-
Taiwan	-	2
Thailand	-	1
Uruguay	-	1
United States	18	24
Zaire	1	1
Total	36	69

Table 5. Soil management CRSP enrollment of graduate students in 1994 at all participating institutions.

	1994 Student Enrollment		
	MSC	Ph.D.	Total
NCSU	1	10	11
TAMU	1	8	9
NifTAL	2	4	6
CU	-	5	5
UH	-	5	5
Total:	4	32	36

The soil management CRSP also developed linkages with private, volunteer organizations. These linkages were particularly important to NifTAL in providing training in biological nitrogen fixation technology. Some specific examples of these linkages include Grammins Bank in Bangladesh; Plenty in Canada; ATI and BAIF in India; MBM and Save the Children in Indonesia; CARE, Save the Children, and Winrock International in Nepal; International Institute of Rural Reconstruction in the Philippines; ATI in Sri Lanka; and ACDI in Uganda.

Linkages have also been made with the private sector. Important among these are Texasgulf, Inc.; the potash and phosphate institutes in Brazil, INPOFOS in Andean countries, and the ALCAN Bauxite Mining Company in Jamaica. The soil management CRSP established close cooperation with several USAID missions including those in Bolivia, Costa Rica, Honduras, Indonesia, Jamaica, and Niger.

2.6. CRSP mechanism and the management entity

Bringing four universities together to develop a coherent, well-coordinated program was a challenge because for the last few years the effectiveness of soil management CRSP's management entity was questionable, universities were often divided, and the Board of Directors was not functional. This situation arose primarily due to a lack of clear operating guidelines for the management entity and director in their interactions with the host institution.

The modus operandi of the soil management CRSP management entity has raised several issues that are important lessons for the future:

- The management entity is crucial to the CRSP's success. In recent years, the management entity had serious problems that limited its effectiveness. These problems arose because of a lack of clear guidelines regarding responsibilities of the host institution, and the failure to establish clear channels of communication

between the director and the host institution, between the director and the board, and between the technical committee and the director.

- The external evaluation panel often was, in fact, not independent. One of the external evaluation panel members also served on a management entity staff, which may have led to conflicts of interest and biased opinions. Peer review may make this a better process.

- There should be close inter-CRSP cooperation. Lack of cooperation is exemplified by separate programs with Texas A&M University and North Carolina State University on rhizobia and mycorrhizae by peanut and bean/cowpea CRSPs and no involvement by the soil management CRSP. There is also a lack of involvement by the small ruminant CRSP in soil management CRSP work in animal-based systems in Sumatra. There is also a lack of collaboration between the pond dynamics/aquaculture and soil management CRSPs in Honduras in assessing the impact of land use on sediment load and water quality in streams feeding shrimp ponds.

The CRSP mechanism and its effectiveness can be greatly improved by the following actions:

- Opening CRSP programs to other universities and institutions to bring in new ideas and provide strengths in several disciplines that the four universities do not have.

- Resolving the conflicts involved in the management entity by establishing guidelines for effective coordination and clearly defining the director's responsibilities to and interactions with the host institution.

- Because the external evaluation panel is not deemed very effective, developing mechanisms for peer review of the technical program.

- Assigning *full-time* responsibility of looking after the soil management CRSP to one principal investigator at each participating U.S. institution.

3. Conclusions

3.1. Fulfillment of objectives

The soil management CRSP participants at North Carolina State University, University of Hawaii, Texas A&M University, and Cornell University and their collaborators have fulfilled the initial objectives with particular reference to the following projects in different ecosystems:

3.1.1. Humid tropics

Research programs developed techniques to address the issues of:

(1) production-demand pressure, land clearing pressure, and weeds and inadequate resource information in Peru, Indonesia, and Bolivia,
(2) inadequate soil resource information and landscape restrictions in Zaire, Bolivia, and Costa Rica,
(3) inefficient use of water resources and high erosion rates in the Philippines, and
(4) soil acidity, nutrient deficiency and losses, soil physical limitations, and diversity of potential users in Indonesia, Thailand, and the Philippines.

The soil management CRSP program identified sustainable management options for principal crops and pasture-based systems that include:

(1) low-input systems,
(2) technologies for mechanized continuous cultivation,
(3) improved legume-based pastures,
(4) paddy rice cultivation systems, and
(5) agroforest systems.

The soil management CRSP developed two important decision support systems: the Acidity Decision Support System (ADSS) and the Phosphorus Decision Support System (PDSS). These are computer programs for diagnosing and evaluating the impact of soil management technologies.

3.1.2. Semiarid tropics

Research programs in Mali, Niger, and Honduras fulfilled their objectives by developing, validating, and testing technologies for the resource-poor farmers of the arid and semi-arid tropics. In addition to understanding basic principles, significant progress

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has been made in identifying appropriate technologies for:

(1) soil and water conservation with simple and effective methods, e.g. ridges, residue mulches, dust traps, rock bunds, alley cropping, and microcatchments,
(2) nutrient cycling and fertility enhancement through organic amendment, green manuring and cover crops, alley cropping, and
(3) restoration of degraded lands through afforestation, microcatchments, nutrient cycling, etc. An outstanding feature of the program is the testing of improved technologies on farmers' fields on watershed basis. Identifying technologies for rejuvenation of degraded lands in the Sahel and in the steeplands of Central America is also important to fulfilling the original objectives.

3.1.3. Nitrogen fixation in tropical agricultural legumes

The NifTAL program developed one of the world's most comprehensive repositories of rhizobial strains (1,924) and gathered from a wide array of tropical legumes (Smith and Smyth, 1994). The collection is a valuable resource for developing genetic technologies for improvement of the rhizobium-legume symbiosis. NifTAL also has been successful in developing linkages with private-sector legume inoculate production by developing and field-testing economic, efficient, and reliable fermentors for use in Africa, Asia, and the Americas. NifTAL also fulfilled its training objectives and organized ten courses providing training to 209 participants from 53 countries.

3.1.4. Soil management support

The Soil Management Support Service and its collaborators have done an outstanding job in developing a unique databank on world soil resources. Soil moisture and temperature regimes have been computed for about 15,000 stations worldwide. Technical support has been provided to more than 50 countries through on-site visits, workshops, and symposia by providing publications and methodological guidelines. SMSS is credited with developing the Global Soil Regions Map, which has accurately assessed aerial distribution of soil orders over a total land area of 138.3 x 106 km^2, and which includes Inceptisols (21.8 percent), Aridisols (18.5 percent), Entisols (10.6 percent), Alfisols (9.8 percent), Ultisols (8.1 percent), Oxisols (7 percent), Mollisols (6 percent), Spodosols (3.5 percent), Vertisols (2.2 percent), and others (12.5 percent). This invaluable map is among the major accomplishments of the SMSS objectives.

3.1.5. Technology for soil moisture management

The Technology for Soil Moisture Management program fulfilled its goals with regard to identifying and adopting techniques for assessment of soil-water in crop-livestock management systems for rainfed conditions, identifying and validating technologies for increasing agricultural productivity in rainfed agriculture, and strengthening the capability of collaborating institutions. The TSMM achieved its objectives by arranging four international workshops attended by 350 participants from over 40 countries, sponsoring three international seminars attended by 580 participants from

49 countries, establishing collaborative experiments in Jordan, Niger, Morocco, the Dominican Republic, Haiti, and India, and developing automated databases and information systems for Niger, Mali, Cameroon, Benin, Syria, and Jordan.

3.2. Relevance

In general, the soil management CRSP projects have been relevant to the need to understand soil resources and their potential and constraints, in providing training opportunities, and in developing decision support systems. Several programs were also relevant to USAID and its priorities on the environment. Periodic shifts in objectives by soil management CRSP reflect vision and the ability to address changing priorities and needs.

Some programs could have done more to address relevant problems of the participating institutions. For example, while accelerated soil erosion and water runoff are serious problems in Mali, soil management CRSP is conducting on-station fertility management experiments. Similarly, soil management CRSP in Sumatra placed heavy emphasis on the management of upland soils while the host-country Crop Research Institute felt that emphasis was also needed on management of wetlands. The relevance of the USLE-type plots in Niger and on steeplands in Honduras is also questionable. While quantifying soil loss on 63 percent slopes in Honduras is useful, it would be more relevant if the conservation-effectiveness of alternative land uses were also demonstrated using permanent crops. Policy issues should be identified that can reduce pressure on these marginal lands.

Relevance of some training and graduate thesis research is also questionable in view of the problem-oriented approach required of the participants on their return to their home institutions. Because a large proportion of soil management CRSP research was based on student thesis research, it also gives the impression of a lack of continuity. Originally implemented on an ecosystem basis, there was no global program with common objectives and treatment variables. The programs developed at four universities apparently lacked coordination. These issues were, however, addressed in the 1994–99 program proposal and global plan.

Relevance and effectiveness of the CRSP can be enhanced by

- developing programs with sharply focused objectives, identifiable products, and quantifiable impact;
- formulating a coherent program that is global in nature with common objectives among participating institutions;
- providing technical guidance through periodic peer reviews by an independent panel not involved in the CRSP;
- conducting on-farm validations of research with farmer participation as part of the

project plan; and

- developing strong linkages with IBSRAM, IFDC, and other relevant international agricultural research centers.

Relevance of the training activities can be improved by

- conducting short-term in-country training courses on modern procedures, data analysis, and program formulation;
- choosing thesis topics of practical importance to the farming community;
- providing back-up support to the trainees on their return to the home institution through mentor programs;
- identifying the gaps in professional expertise of the host institution and providing training opportunities to fulfill those gaps. Suggestions include soil and water conservation and soil physics in Mali and Niger.

3.3. Effectiveness

The soil management CRSP has been extremely effective in conducting some basic and applied research. Among other programs, NifTAL and SMSS have done a good job in transferring technology and in developing linkages with nongovernmental organizations, private, volunteer organizations, and the private sector. Cost-effectiveness of the soil management CRSP is high because faculty salaries are paid by the participating institutions and research facilities are shared among collaborating institutions.

The soil management CRSP successfully achieved parts of its original objectives, especially

- conducting collaborative soil management research to contribute to sustainable agriculture, improve natural resources, and minimize risks of environmental degradation;
- translating new technology into usable knowledge and techniques for diverse user groups; and
- providing training in the principles and practices of soil management.

The external evaluation panel has tried to be objective and professional in providing technical support. The external evaluation panel, however, is not entirely independent. Although overall the board of directors has been very constructive, in recent years, however, it has been ineffective and nonfunctional. This problem also has been exaggerated by the lack of definite guidelines for channels of communication between the director and the host institution. The effectiveness of the board has been undermined by proprietary attitudes and issues of entitlement on

behalf of their institutions. In general, the technical committee has been effective and professional in developing scientific programs although there have been several instances of lack of coordination among programs developed by participating institutions.

The soil management CRSP scientists realize that soil management research should be used for farmer-oriented technology transfer, and technology transfer has to be done in collaboration with scientists from other disciplines. Four principal constraints to the adoption of improved technologies identified by the soil management CRSP are (a) the number and diversity of potential users, (b) the site-specificity of soil management practices, (c) the deficiencies in local expertise and communications, and (d) the gap between new information and usable knowledge (Smith and Smyth, 1994). The soil management CRSP principal investigators have addressed these constraints, especially in terms of making research information available to other researchers and extension agents. The information has also been extended through newsletters, networks, training sessions, workshops, and conferences. Over 76 countries requested and received the TropSoils publications and several private, volunteer organizations and nongovernmental organizations are enthusiastic users.

3.4. Efficiency

The soil management CRSP successfully leveraged additional sources and kinds of non-CRSP funding. Specific examples of programs that include outside funding follow:

- A collaborative program initiated by North Carolina State University and involving USDA/FRS, CATIE, and INIAA Peru) evaluated the agronomic, economic, and social impacts of tropical production systems in the humid tropics. This program yielded seven years of production data comparing five management systems in Yurimaguas, Peru.

- A program in Bolivia involving North Carolina State University, USDA-SCS, and IBTA Bolivia is aimed at determining the absolute soil-mineral supplying potential of major soils in Peruvian ecosystems.

- All four universities are involved in collaborative programs on rejuvenating degraded land in Latin America, Africa, and Asia. Research on steep acid infertile soil, at Claveria and Mindanao in the Philippines is an important example of such collaboration.

- Texas A&M University is supporting a USAID-funded steepland management project (LUPE) in Honduras. It is funded by non-CRSP sources with technical support from soil management CRSP.

- In the Chapare region of Bolivia, North Carolina State University is leading

research on the synchrony between soil nutrient availability from organic inputs and plant nutrient uptake.

- Cornell University is collaborating with the University of Costa Rica in evaluating a slash-mulch system of bean production for improving the availability of phosphorus and the efficiency of managed legume fallows.

- North Carolina State University is coordinating technical support for research networks in the humid tropics of Latin America through the RISTROP network.

- The University of Hawaii developed a network involving two international agricultural research centers, IITA and IBSRAM, and 75 scientists from national institutions. This network is validating and adapting decision support systems.

- NifTAL, SMSS, and TSMM leveraged external funding for many of their activities.

- Programs in Peru and Indonesia have been efficient and successful because of long-term continuity. These prime sites also had long-term resident scientists who served as country program leaders and were responsible for developing collaborative plans with host-country institutions. Although programs in Brazil were very successful, their efficiency and effectiveness may have been curtailed by their termination for political reasons.

Program efficiency also depends on collaboratively set goals having the assent and full participation of host-country institutions and in-country USAID missions. The IMAW program in Niger and the LUPE project in Honduras are examples of efficiently organized collaborative projects. In contrast, the soil management CRSP program in Mali is not efficient in part because it does not have support from the USAID mission. Program efficiency is greatly influenced by networking, and linkages have helped narrow the knowledge gap in the area of soil/water/nutrient relations for tropical ecosystems. Nevertheless, there is a need for closer collaboration among CRSPs and the other international organizations involved in similar activities.

The soil management CRSP has attempted to reform research that will complement the on-going research of several international agricultural research centers and national agricultural research institutes. Examples of successful collaboration include the IMAW project in Niger in collaboration with ICRISAT, the NifTAL programs in the Philippines with IRRI and in Nigeria with IITA, and the steepland and acid soil networks developed by IBSRAM with support from SMSS. The USAID office in Washington has helped increase efficiency, as has been the case with the backup support provided by the program office to NiFTAL over the past two to three years. There are several examples, however, where the universities considered USAID involvement unnecessary and counterproductive interference.

3.5. Impacts

The soil management CRSP has advanced scientific knowledge on properties, processes, and management options for representative soils of the experimental sites. Major technological contributions with potential to make significant economic impact in different ecoregions are outlined in table E.3.5.1. The soil management CRSP developed technologies for natural resource management, sustainable agricultural production, and technology transfer (table E.3.5.1). Both NifTAL and SMSS made quantifiable impacts because both are development and service oriented. The economic impact of a research program organized by four American universities is difficult to quantify because few projects were extension-oriented. It is also too early to evaluate the economic impact of projects like IMAW because they have not yet been adopted outside the experimental area. Furthermore, most projects were implemented in collaboration with host-country institutions and international agricultural research centers. Also, it is difficult to attribute the impact of technology such as that being used in the Cerrado region solely to the soil management CRSP. Training personnel from participating national agricultural research institutes is an extremely important contribution by soil management CRSP.

The institutional impact of the soil management CRSP is commendable and relatively easy to quantify. There were 105 graduate students trained, some of whom now occupy leadership positions in their respective institutions.

3.6. Sustainability

Sustainability implies the ability of the host-country institutions to continue the program on their own when external support is withdrawn. Sustainability of the soil management CRSP depends to a large extent on its alumni and developing a collaborative program with them on their return to their home institutions. This human resource development has created a long-lasting pool of talent in collaborating institutions. These alumni are important to developing truly sustainable institutions because they provide a high level of in-country expertise in soil and water management and are available to develop interdisciplinary and multi-institutional teams to respond to the needs of the farming community. These trainees not only provided immediate solutions to short-term problems through sharply focused thesis projects, but also increased the technical capabilities of the host-country institutions to identify problems and constraints and develop relevant technical solutions.

Table E.3.5.1. Technological contributions made by CRSP with the potential to impact significantly the economy of different ecoregions

Program thrust	*Technological Innovations*
Natural resource management	· Improved soil resource inventory · Ecologically compatible land clearing methods · Integrated watershed management to alleviate landform restrictions · Alleviation of drought stress in semiarid regions by water conservation and water harvesting measures · Integrated nutrient management to minimize loses
Sustainable agricultural production	· Managing acid soils using crop selection and soil amendments · Computer-based decision support systems for recommendations on liming and crop selections · Rejuvenating degraded soils by quantifying nutrient requirements · Quantification of processes of soil physical degradation, and use of legume fallows and green manures for soil restoration · Alleviation of root restriction in acid subsoil by deep lime placement
Technology transfer	· Use of soil taxonomy or fertility capability classification as basis for technology transfer · Training 105 scientists for MS and Ph.D. degrees to strengthen institutions · Publications of 300 articles · Development of decision support systems ADSS and PDSS · Adoption of GIS to integrate new with indigenous technologies · Identification of policy issues to facilitate technology transfer

The soil management CRSP established several long-lasting networks among U.S. institutions and scientists and between the United States and host-country research institutions and scientists. Examples of such relationships go back to the early days of soil management CRSP. Several networks are funded by external donors, including the European Union, which lends support to the RISTROP network in Latin America.

The soil management CRSP also attempted to develop close linkages with USAID

missions in Niger and Honduras. Because each mission has its own program and there is frequent staff turnover, the soil management CRSP has not developed close ties with missions in Mali and Indonesia.

The attitude of expatriate resident scientists is a significant factor in international sustainability. Professional contributions by a resident scientist depend on the level of host-country expertise. A resident scientist is not a substitute for local expertise, however, and should not be the cause of hindering the development of local expertise. Although unintentional, such may have been the case in Niger.

Because women farmers play a major role in many if not most agricultural economies, the soil management CRSP influenced sustainability by addressing the gender issue. The gender issue has been studied in Indonesia, Mali, and Bolivia. Most technology developed by soil management CRSP is gender neutral.

Taking the above factors into consideration, it can be said that some soil management CRSP projects are sustainable while others are not. Examples of sustainable programs include the Cerrado Center of EMBRAPA in Brazil and the Soil Research Institute in Bogor. In contrast, the programs in Niamey, Mali, and Peru are not sustainable. Lack of sustainability may be due to several factors including social and political conditions in the host country and lack of direction by the soil management CRSP in developing appropriate programs and research support facilities.

Restructuring soil management CRSP is deemed necessary and may be accomplished by

- Taking NifTAL and SMSS out of the CRSP structure and funding both of these through direct contracts with USAID.
- Establishing field sites only in countries where the USAID mission supports the soil management CRSP program(s) and provides additional funds through buy-ins.
- Eliminating numerous small trials and establishing focused programs of a global nature with interdisciplinary and multi-institutional teams.

3.7. Future plans

It is important that the knowledge gained and the technologies developed by soil management CRSP are synthesized into useable products and techniques, then applied to solve location-specific problems. Technical accomplishments and human resource development by the soil management CRSP provide the foundation for a science-based program to transfer the technology developed. Adoption of these technologies will have a significant economic impact on the productivity of the participating host countries and will benefit U.S. institutions and the private sector. It is important that knowledge accumulated is synthesized into usable products for technology transfer.

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Annex F

Peanut Collaborative Research Support Program

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1. Introduction

1.1. Purpose

The peanut Collaborative Research Support Program was initiated in 1982 with "the modest purpose of enhancing peanut production and utilization in the United States and less-developed countries as a means of improving human nutrition and stock feed" (BIFAD/USAID grant agreement, 1 July 1982).

This long-term research effort between scientists in the United States and specific host countries was designed to resolve the most serious constraints to production and utilization of this very important oil and protein crop. One of the first CRSP's (Project Number 936-4048), this project had an authorized funding level of $22,423,000 supported by the USAID grant DAN-4048-G-SS-2065-00. The four collaborating U.S. institutions were the University of Georgia, North Carolina State University, Texas A&M University, and Alabama A&M University. The coordinating institution, the University of Georgia, was also designated the management entity. The established advisory and supervisory systems used by the earlier CRSPs (a Board of Directors, a technical committee, and an external evaluation panel) were instituted. Considering the global importance of the peanut, it is surprising to note how little research on this valuable crop had been carried out before 1980 except in the United States, India, and South America. It was not until 1981 that the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) adopted peanut as a target crop, so it was quite natural that the Peanut CRSP develop strong research ties by collaborating with ICRISAT.

Among the four collaborating U.S. institutions are found approximately 87 percent of all U.S. peanut research professionals. They were gathered to share, plan, train, and conduct research jointly with fourteen host-country research institutions on a full partnership basis and as a participating linkage with more than a dozen other developing countries. Of the fourteen collaborating countries, six were in Africa, six in Southeast Asia, and two in the Caribbean.

1.2. Duration

The Peanut CRSP was originally conceived to span the years 1982 through 1995. The first grant covered the years 1982 to 1987, the three-year extension took the program from 1987 to 1990, and the second (and possibly final) extension runs from 1990 to 1995.

1.3. Objectives

In the Five-Year Program Plan, 1985–89, the major goals and thrusts of the peanut CRSP were stated as follows:

- Improve the research capability for peanuts in the United States and developing host and nonhost countries.
- Develop improved, environmentally sound production systems for peanuts in the United States and host countries.
- Develop improved cultivars of peanuts with greater resistance to diseases, insects, nematodes, and environmental hazards in the United States and host countries.
- Develop methods to reduce loss of the peanut crop due to pests and post-harvest deterioration that could lead to decreased dependence on chemical control practices worldwide.
- Develop new and expanded uses of peanuts for the betterment of human nutrition generally.

A positive and congenial attitude among peanut CRSP researchers in the United States was noted. It was interesting that as soon as budget reductions were announced in 1992–93, this group initiated a very effective method to set priorities and immediately began a search for alternative support in the event USAID support diminished further or ceased.

Soon after constraints were identified, the peanut scientists in the U.S. universities divided up research responsibilities. Most of the subdivisions of labor were based on existing expertise, experience, and relative agroclimatic relationships. The Texas A&M group took leadership in development of disease-resistant peanut varieties for semi-arid regions, and because of its strengths in mycotoxin management became heavily involved in aflatoxin monitoring and prevention. North Carolina State University emphasized varietal improvement for Southeast Asia as well as bringing a strong background to arthropod management in the humid tropics. The University of Georgia group addressed insect management strategies in semi-arid Africa, and because it was most knowledgeable on peanut virus behavior, led in this area of research.

Utilization research, led by the University of Georgia and Alabama A&M groups, identified new products, more appropriate storage technology, and post-harvest handling.

2. Findings

2.1. Scientific outputs or achievements

2.1.1. Research

The peanut CRSP was designed around a set of constraints to sustainable production and utilization identified during the 1980–82 planning process. Based on the numerous advancements achieved by the peanut CRSP during the 1982–89 period, in 1989 the external evaluation panel evaluated the following constraints and found them still to be valid as a basic framework for the peanut CRSP for the near future.

- Low yields because of unadapted cultivars and lack of cultivar resistance to diseases, insects, and drought;
- Yield losses due to infestations of weeds, insects, nematodes, and diseases;

  Diseases: fungal 41; bacterial 5; viral 25.
  Insects: soil-borne 12; foliage 22; storage 7.
  Nematodes: total soil and foliar 16.

- Health hazards and economic losses due to mycotoxin contamination;
- Food supplies inadequate; lack of appropriate food technologies to exploit a relatively well adapted peanut crop that is not generally considered a primary food source;
- Physiological and soil microbiological barriers to higher yields;
- Resource management including agronomic, engineering, economic, and sociological situations prevent efficient production and utilization;
- Inadequate numbers of trained researchers and support personnel;
- Lack of adequate equipment to conduct research;
- Information not available to potential beneficiaries for support of production and utilization efforts.

2.1.1.1. Constraint-driven research

The constraint-driven research program started with the following projects in 1982 and continued these until 1987 (CRSP Project Review, 1990).

Food technology

- An interdisciplinary approach to optimum food utility of the peanut in semi-arid tropical Africa (Alabama A&M, Sudan)

- Appropriate technology for storage and utilization of peanut (Georgia, Thailand, Philippines)

- Peanut utilization in food systems in developing countries (Alabama A&M, Florida, Caribbean)

Soil microbiology

- Influence of soil microbiology on nitrogen fixation and growth of peanut in Thailand and the Philippines: rhizobia considerations (North Carolina, Thailand, Philippines)

- Influence of soil microbiology on nitrogen fixation and growth of peanut in Thailand and the Philippines: mycorrhizal considerations (Texas A&M, Thailand, Philippines)

Germ plasm improvement

- Disease-resistant peanut varieties for semi-arid environments (Texas A&M, Senegal, Burkina Faso, Niger)

- Peanut varietal improvement for Thailand and the Philippines (North Carolina State University, Thailand, Philippines)

- Breeding and cultural practices for the Caribbean (University of Georgia, Jamaica)

Pest and disease management

- Mycotoxin management in peanut by monitoring and prevention of contamination (Texas A&M, Senegal)

- Peanut viruses: etiology, epidemiology, and nature of resistance (Georgia, Nigeria)

- Integrated pest management strategies for peanut insects in semi-arid tropical Africa (Georgia, Burkina Faso)

Due to budget restrictions revisions in research projects were recorded as follows for the period 1990–95:

Food and post-harvest technology

- An interdisciplinary approach to optimum food utility of the peanut in semi-arid tropical Africa (Alabama A&M, Burkina Faso, Ghana)

- Appropriate technology for storage and utilization of peanut (Georgia, Thailand, Philippines)

- Post-harvest handling systems for the small peanut producer (Georgia, Jamaica Thailand)

Germ plasm improvement

- Disease-resistant peanut varieties for semi-arid environments (Texas A&M, Senegal, Burkina Faso, Niger, Mali)

- Peanut varietal improvement for Thailand and the Philippines (North Carolina, Thailand, Philippines)

Pest and disease management

- Mycotoxin management in peanut by monitoring and prevention of contamination (Texas A&M, Senegal, Ghana)

- Peanut viruses: etiology, epidemiology, and nature of resistance (Georgia, Nigeria, Thailand)

- Management of arthropods on peanut in Southeast Asia (North Carolina, Thailand, Philippines)

- Integrated pest management strategies for peanut insects in semi-arid tropical Africa (Georgia, Burkina Faso)

2.1.1.2. Genetic resistance and tolerance

The search for resistance and tolerance in the genetic resource pool has been global, thorough, and highly cooperative among all interested institutions. This sharing has been so open that it is often difficult to assign primary credit for some of the thirteen improved cultivars and forty of the more advanced experimental lines generated. Some of the new cultivars serve U.S. farmers more than developing countries, others serve particular needs of limited international areas. For example, the black rot–resistant Virginia market type NC 9 serves North Carolina farmers well, and the Texas A&M releases including the Spanish (market type) Langley and Tamrum 88 (runner type) have become important in arid areas from Texas to West Africa and in other areas of rain-dependent production where drought resistance is important.

The following list reflects the relative state of available parental lines that have been accumulated during the past decade from various sources and are now ready to

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be used to generate improved peanut cultivars in the future:

High-yielding dry season	Drought tolerance
High-yielding wet season	Agronomic adaptation
Leaf spot resistance	Shade tolerance lines
Early maturity	Acid soil tolerance
Short growth duration	*Aspergillus crown* rot resistance
Peanut rust resistance	Leaf miner resistance
Stem rot resistance	Leaf hopper resistance
Moderately high nitrogen fixing ability	Thrips resistance
High fatty acid lines	Root rot resistance
Low fatty acid lines	Rosette virus resistance

The following five viruses that affect peanuts represent a serious challenge because very little or very low genetic tolerance has been assembled thus far: peanut stunt virus, peanut mottle virus, groundnut mosaic virus, tomato spotted wilt virus, and tomato yellow spot virus on peanut. The main hope for control of these viruses (or virus complexes) may lie in genetic transformation isolating viral genes and rendering them less transmissible.

Peanut researchers, including those at the peanut CRSP, National Agricultural Research Services (NARS), the international agricultural research centers, and elsewhere, together have generated a wide range of highly repeatable procedures (referred to as protocols) to reduce the time to screen for diseases, drought, or insect resistance to analyze chemical compositions, to assess yield loss, to purify viruses, to perform serology of viruses and procedures to characterize more fully the peanut genome and isolate viral capsid genes, screen transgenic plant responses for tomato spotted wilt, and carry out protocols to assess seed storage proteins.

Wild species of *Arachis* contain valuable resistance to various nematodes and viruses. Although the chromosome number of the wild species is 2N=40 and cultivated peanut is 2N=20, manipulative techniques have allowed effective interspecific crosses. As most of the genetic characters are not of simple inheritance and there are many genes linked in "block form," a widening series of approaches is being used. These include biolistic bombardment of desirable genes in resistant germ plasm and the use of various transformation procedures. The full use of more traditional biotechnological procedures such as embryo rescue, anther culture, and others allows current researchers to utilize resistance factors from specific as well as interspecific manipulation.

Great progress has been made in the past decade in mapping the genome of peanut and protocols for the genetic manipulation of peanut have made rapid advances. Procedures for shortcutting the time for varietal development (protocols) include screening for disease and pest resistance, drought tolerance and mycotoxin development.

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Marked advancement has been made in the understanding of viral and fungal biology, the nature of resistance, and interrelationships between host and pathogen. These developments provide a basis for future crop improvement and the prospect of custom design of peanut cultivars to fit specific environments.

The following list of released cultivars represent significant improvements in yield or diseases resistance or both for specific areas:

Texas: TANSPAM, TAMRUN 88, LANGLEY.
North Carolina: NC 9, NC 10, NC-11
Thailand: Konkean 60-1, (KK 60-1); KK 60-2, KK 60-3.
Burkina Faso: Fleur 11
Philippines: UPL PN6
Caribbean: Cardi-Payne

2.2. Publications

The peanut CRSP has registered 348 refereed scientific journal articles and 910 other scientific papers.

2.3. Training output

This CRSP has trained 105 M.S. and Ph.D. graduate students representing 32 countries, 95 percent of whom were from developing nations.

From management entity's Training Report, 1993:

	1982-90	1990–94
Degree program students from host countries	26	14
Degree program students from nonhost countries	24	30
Degree program students in host countries	17	40
Degree program students from the United States	35	9
Postdoctoral/sabbatical of host-country researchers at U.S. institutions	21	
Short-term training of host-country scientists at U.S. institutions	74	
U.S. principal investigators and co-principal investigators making collaborative visits to host countries	46	

The peanut CRSP sponsored thirty-five workshops to plan research and disseminate technology during its short period of existence. Short-term, nondegree training supported 160 individuals in specialized aspects of research operations.

2.4. Technology generated

The technology generated by the peanut CRSP was of three types: agronomic, post-harvest and utilization, and scientific methodology.

Agronomic

- Production of peanuts in partial shade as part of the peanut-coconut system.
- Production enhanced by the use of wood ash as a soil amendment in acid soils.

Post-harvest and utilization

- Improved harvesting, drying, and storage of peanut.
- Detection and removal of aflatoxin in peanut oil using clay absorption detoxification method.
- Development of new and expanded uses of peanut as enriched convenience foods.

Scientific methodology

- Development of laboratory methods for virus assay.
- Development of methods for molecular marking of the peanut genome through RAPD and RFLP techniques.
- Development of methods to reduce barriers inhibiting effective molecular engineering procedures in peanut.
- Training of host-country scientists in methods to procure funds for research through effective writing of project proposals.

2.5. Management

The scientific staff of the peanut CRSP felt they could operate easily within the guidelines of their project and most of the investigators felt that they were well represented and had an active input into their governance. The management of the peanut CRSP consists of a program director, a Board of Directors, a technical committee, and frequent inputs from an external evaluation panel.

The USAID grant for the peanut CRSP was made to the University of Georgia Agricultural Research Foundation, Inc. The management staff, situated in Griffin, is comprised of a program director, an assistant director, and an administrative secretary. The program director reports to the director of the Georgia Agricultural Experiment Station on the main campus of the University of Georgia in Athens.

The Board of Directors is made up of administrative representatives from the four subgrantee institutions (Alabama A&M University, North Carolina State University, Texas A&M University, and the University of Georgia). An outside representative such as an eminent scientist or an administrator from and international agricultural research center like ICRISAT or and international researcher working on peanut peanut is usually included at board meetings. This board meets annually and provides an effective policy interface between the CRSP and principal U.S. institutions.

The technical committee has one or two scientists from each of the four U.S. institutions. This group, whose members serve on a rotating basis, addresses project work plans, progress reports, and responses to program reviews. It also recommends ways in which meaningful adjustments to budget cuts can be made.

Program reviews and reviews of the CRSP management process were made in 1985 and 1989. These review teams engaged the expertise of external leaders from U.S. and foreign institutions. The CRSP responses to review team suggestions were well thought out and appropriate actions taken.

2.6. Linkages

The peanut CRSP maintains a wide range of strong linkages with numerous research institutions in the United States and internationally, as shown below:

2.6.1. Participating institutions

United States
- Alabama A&M University
- University of Georgia
- North Carolina State University
- Texas A&M University

West Africa
- Senegalese Institute for Agricultural Research (ISRA)
- Senegalese Institute of Food Technology (ITA)
- Institut Superior Polytechnique (ISP), University of Ouagadougou, Burkina Faso
- National Institute for Agricultural Research of Niger (INRAN)
- Institute of Agricultural Research, Amadou Bello University, Nigeria

Institute of Economic Research (IER), Mall

Southeast Asia

Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development (PCARRD), Los Banos

Thailand Department of Agriculture, Kasetsart University, and Khon Kaen University

Caribbean

Caribbean Agricultural Research and Development Institute (CARDI) headquartered on the campus of the University of the West Indies, St. Augustine, Trinidad

International Centers

International Center for Research in Semi-Arid Tropics (ICRISAT), India

ICRISAT Sahelian Center (ISC), Niger

International Development Research Centre (IDRC), Canada

Australian Centre of International Agricultural Research (ACAIR), Australia

French Institute for Oilseeds Research (IRHO), France

Conference des Responsables Africains et Francais de la Recherche Agronomique (CORAF), France

The linkages observed were mutually beneficial in many ways. With ICRISAT there was a very active sharing of germ plasm, research methodology training, disease survey and identification, and publications. With the other institutions the benefits varied from support of workshops and assistance in producing publications to serving in advisory capacities intermittently. In the USAID missions in which peanut production is important (and the CRSP's purpose properly translated to the mission) fairly strong support was evident. Financial support has shown promise where positive interest was noted in some African and Asian USAID missions.

3. Conclusions

3.1. Fulfillment of objectives

The peanut CRSP formulated its original objectives based on global constraints. Strategies to resolve these constraints included the developing of improved cultivars and better management practices plus improved and more effective utilization of research capacity in the United States and host countries. In all these areas significant accomplishments have been made, but perhaps the most outstanding output from a global standpoint has been in the area of enhanced research capability. An effective multicountry network of peanut researchers now exists that did not exist before the inception of the peanut CRSP. Many important cultivars have been developed, the fronters of knowledge regarding pest biology and management have been advanced, and new ways of using peanuts are being commercially developed.

3.2. Relevance

The peanut CRSP had a very effective mechanism for frequent examination of its programs to see how well objectives were being addressed. Issues, targets, and progress in resolving global constraints were reviewed each year; these self-tests were conducted in the U.S. universities and through visits by U.S. scientists to hostcountries plus visits by host-country scientists to U.S. institutions. Both planning and reporting meetings reinforced these assessments of constraints, and research was kept to this constraint-oriented approach.

Some of the restrictions on improved production and utilization including drought, acid soils, or type of peanut preferred can be site specific, but many were global in nature such as crop reduction or failure due to viruses, fungi, nematodes, or environmental degradation.

Since its inception, the peanut CRSP has redirected its emphasis to include not only the small farmer but commercial-level production as well. The overall goals and nearly all of the CRSP's activities give importance to ecologically friendly crop production methodology, food safety, and reducing the use of chemicals in pest management.

In stored peanuts, maize, sweet potatoes, rice, and other starchy foods and feeds, the presence of mycotoxin, the result of fungal contamination, is a highly dangerous global problem that this CRSP addressed. A three-pronged approach that spanned the entire sequence from field to finished product was used. This approach included the search for crop varieties that had either chemical or physical resistance to invasion by the ubiquitous fungus *Aspergillus flavus,* improved harvesting, drying, and storage practices to reduce infection and mycotoxin development, and detection of the mycotoxin and its removal from food. The whole program was implemented with effectiveness and efficiency.

When an improved variety is released in the United States, producers are usually already familiar with its performance through extension programs, field days, and research publications. The seed may then enter commercial channels in which increase, distribution, and marketing ensure availability of the improved variety to small as well as large farmers.

In developing countries the seed industry may be weak or almost nonexistent, thus impeding or precluding access by the farmer to the improved variety. In some countries the propagation of local, unimproved varieties remains the responsibility of government seed programs and only the higher-profit hybrid cultivars get very much commercial attention. This is a serious detriment to development. Even the super-improved variety may never reach wide adoption because of this lack of commercial or governmental attention. This problem is more than just a policy decision. It even threatens the justification for many avenues of research and their support because the results may never be usefully applied.

Relevance becomes a moot question if research results cannot be made available to the producer, processor, and consumer. Perhaps countries that lack facilities to increase and distribute improved varieties should not be selected as sites for variety development unless policymakers can be persuaded to make efforts to encourage more enterprise to further the availability of these improved cultivars to peanut growers.

3.3. Effectiveness

In interviews with U.S. scientists, most felt that they were adequately or over-reviewed and that much of the monitoring process could be simplified by eliminating the duplication in reporting. All in all, there was an appreciation for the research freedom in programs and, because each scientist had an opportunity to serve in rotation on advisory committees for the degree of self-governance

As an interface with university administration, the Board of Directors was considered vital. Opinion varied on the worth of review panels as advisory bodies, but nearly all felt that the technical advisory committee quite effectively served as a primary peer review.

The cost effectiveness of the research as well as training reflected an exceptional multiplier effect both at U.S. universities and in host countries. Outside funds exceeded the 25 percent stipulated, ranging from 27 to 41 percent. The project also benefited from the input from the faculty advisors (whose salaries, paid by the universities, were almost never derived from CRSP support except for some partial salary support in rare instances in the United States and seldom in host countries).

Interviews with U.S. faculty showed a real interest in the host country and their foreign students. This interest was made manifest in the follow-up after the trainee returned. Most major professors made strong efforts to keep their previous trainees

current in the field of interest through publications, photocopied reprints, and concerned advisory letters.

The trainees were provided with a wide range of supplementary benefits through team efforts by the CRSP research project, associations with other research activities, stimulating discussions with senior scientists, the opportunities to participate in the U.S. land-grant research, teaching, and extension experience, and to be part of high-tech science directly and indirectly through the trainees' research. Although some of the students said that if much of the high-tech science would not be available to their home country, still they felt that they were more complete scientists because of the experience. Trainees said another benefit of their graduate work was that they got a feel for the agricultural system in the United States, in which the production, supply, regulatory and marketing functions were related to and in some cases derived from the inputs from the land-grant institutions. This was important to some students because many will return to take policy-level positions and could influence and perhaps improve their national agricultural system.

Research subprojects fit well into the master plan of overcoming the constraint. Students research related to the overall problem-solving for which CRSP support was provided. Target adherence was very good, and the team approach was a vital part of the training program as well as the problem-solving process.

Evaluation of research progress must necessarily be relative and related to the whole because scientific progress is based on a series of interlocking building blocks. The development of a protocol at one research site may allow other researchers to move much faster in their programs. The collection, characterization, and preservation of germ plasm and fungal and insect collections are time-consuming but very necessary and highly valuable when shared. Strong evidence of progress in the peanut CRSP is reflected in the development of improved varieties and methodologies as well as publications and presentations of findings at research conferences. Because technology development for extension delivery was never meant to be a priority of this CRSP, few applications other than those listed in the section "Findings" were generated.

3.4. Impacts

3.4.1. International impacts

- In Senegal, the new peanut variety Fleur 11, which yields 25 percent more than varieties presently in use, was released for farmer use as the result of a joint collaboration between ISRA-Senegal, CIRAD-France, and the peanut CRSP. If successful in-country seed multiplication programs can be implemented to provide farmers with this new cultivar, it is estimated that Fleur 11 can increase the gross value of peanuts produced in Senegal by $18 million per year.

- In Jamaica, the new peanut cultivar CARDI-Payne developed by CRSP researchers

is presently being grown on about 10 percent of the total peanut area of 5,000 acres. This cultivar is estimated to yield 42 percent more than the traditional peanut variety and is acceptable to consumers, especially when used in peanut butter production. If this cultivar were adopted on the entire peanut area, it has the potential to add $600,000 annually in revenues to producers, which would represent a tenfold return on the research investment made to develop it.

- As a result of collaboration with the peanut CRSP, in 1992 the Bureau of Food and Drugs of the Ministry of Health in the Philippines set allowable levels of the mycotoxin called "aflatoxin" in food at 20 parts per billion. This action was taken because of evidence linking the accumulation of aflatoxin in the body to liver cancer. Subsequent government testing for aflatoxin levels in domestic food products at nine processing firms led to the condemnation of existing stocks of peanut products. The firms in question were suspended from marketing their products until they met the required standards and until the firms submitted detailed descriptions of their quality control procedures, sanitation processes, raw material standards of acceptance, and their rejection and recall systems plus written commitments to maintain quality standards and voluntarily recall products in the case of contamination.

- CRSP microbiologists have demonstrated the effectiveness of a technique using kaolinite clay to remove aflatoxin from contaminated peanut oil and peanut meal. The value of this simple cost-effective technology now in widespread use in Africa is estimated to be in the millions of dollars.

- Research has yielded a considerable body of work on processing and utilizing peanuts to develop such products as peanut noodles, peanut soft curd, peanut white cheese, peanut yogurt, peanut sauces, peanut candy, peanut cakes and breads, peanut butters, and peanut-based cheese and meat-flavored spreads among others. In some cases the CRSP has involved private firms in the production and market-testing of these new products. At this point, as far as can be determined by the evaluation team, many of these products are still in the development stage, and there has not yet been any widespread commercial adoption of any of these products or techniques. Modest efforts to promote artisanal production of peanut products for local sale were initiated in Huay-Bong-Tua Village in Thailand and with the University of Visca on Leyte in the Philippines. With the termination of CRSP support the women's group in the Philippines has managed to continue its operations, whereas the women's group in Thailand apparently was discontinued.

3.4.2. Domestic impact

- CRSP researchers in North Carolina developed a pest management strategy to control the southern corn rootworm, which causes extensive damage to peanuts in North Carolina and Virginia, an area that represents 15 percent of the 1.7 million acres planted to peanuts in the United States. This strategy has eliminated the need

to use an estimated 42,000 tons of chemicals on the area's peanut crop. Under current production practices, the financial savings from CRSP technology in North Carolina and Virginia are expected to total $1.5 million annually.

- In North Carolina, CRSP research led to the release of the new peanut cultivar NC10c, which is the only *Cylindrocladium* black rot–resistant cultivar available to local farmers. In 1992 and 1993 this cultivar occupied about 20 percent of the North Carolina peanut acreage, and the net value of the crop losses prevented was estimated to be $4.5 million.

- In Texas the new peanut cultivar Tamspan 90 was released. It yields 11 percent more than Starr, the previously most popular cultivar, and it has partial resistance to important soil-borne diseases, including *Sclerotinia* blight and *Pythium* pod rot. In 1992 and 1993 Tamspan 90 was grown on about 28 percent of the total peanut area in Texas and Oklahoma, an area that produces peanuts with a potential gross value of about $25 million annually.

- CRSP researchers developed procedures to control the lethal and highly contagious seed-borne peanut stripe virus, introduced into the United States from China. These procedures prevented a potential epidemic that could have been spread by infected peanut seed throughout the southern peanut-growing states. According to CRSP scientists, if the infected seed had spread to all peanut production areas, crop losses could have amounted to several hundred million dollars.

- A new integrated pest management technique developed by CRSP researchers in North Carolina uses pheromone traps to monitor populations of southern corn rootworm in peanuts. By applying pesticides only when pest populations reach economic-damage thresholds, growers can now reduce their pesticide use by an estimated 42 tons per year. Once this management technique is in widespread use, it is estimated that it will reduce peanut production costs in Virginia and North Carolina by approximately $840,000 annually–in addition to benefiting the environment by reduced pesticide use.

- In Georgia the application of genetically engineered *Pseudomonas aeruginsosa* containing the delta endotoxin gene from *Bacillus thuringensis* using Sunspray oil as the carrier was demonstrated to be as effective as the chemical Lannate in controlling both corn earworm and the velvetbean caterpillar on peanuts. When this new technology is in widespread use, it will reduce the need for the potentially polluting agricultural chemicals presently used to control these damaging insects.

3.6 Sustainability

Sustainability requires a number of supporting services and technologies if it is to be permanent and profitable. Without a functioning, efficient seed industry, new cultivars

can stay on the shelf and do no one any good. Without conscientious and vigilant regulatory and enforcement bodies to keep diseased material from entry, even the best pest control program would be almost useless. Without an effective system to supply materials and technology, farmers may have difficulty getting needed inputs. If there are artificial market forces controlling prices, they may pay too much, thus reducing their profits. They also need an effective research and extension segment to help them solve their problems, effective training institutions to educate their children in improved agriculture, and an effective technology transfer system to bring them news of improved practices and improved varieties. Otherwise, they will not be able to remain competitive.

The other dimension to sustainability is related to graduate student training. Excellent candidates have been selected from the National Agricultural Research Service for Ph.D.- or M.S.-level study and have returned to their home countries to fill vital research positions. To sustain this research, means must be found to keep training students to replace the researchers who retire.

By training scientists based in universities in their own countries, it is likely that they in turn will provide training to others, thus ensuring a special form of sustainability. If a university develops sufficiently well-trained researchers and teachers, a center of excellence for research and graduate training will emerge, making for even greater sustainability.

The African peanut network associated with the peanut CRSP has been very effective but is highly dependent on USAID funding. Some researchers feel that this network will be seriously damaged if CRSP support is withdrawn.

Annex G

Pond Dynamics and Aquaculture Collaborative Research Support Program

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1. Introduction

THE pond dynamics and aquaculture CRSP is an international scientific cooperative effort to develop aquacultural technologies and facilitate adoption approaches to effectively address food security problems in developing countries. The pond dynamics and aquaculture CRSP was developed as a long-term, multi-institutional project to provide information about those factors that constrain or regulate pond productivity worldwide. Projects are supported presently in four Host Countries and at several U.S. institutions. They are conducted and coordinated by teams of U.S. and host-country scientists and students.

The research program consists of three elements: a global experiment in pond dynamics; host-country special topic research projects; and research projects at U.S. institutions. The program is supported under the authority of and addresses the principal objective of the Title XII Amendment to the International Development and Food Assistance Act of 1975, which is to provide for substantial expansion of U.S. agricultural college and university involvement in helping to solve food, nutritional, and agricultural problems in developing countries.

In recommending the pond dynamics and aquaculture CRSP, the Joint Research Council (JRC) of the Board for International Food and Agricultural Development (BIFAD) recognized that the potential for producing animal protein in pond culture systems had not been fully realized in developing countries. Replication of efficient production systems did not occur in other developing countries because of a limited understanding of the principles and mechanisms of pond culture systems.

Over the years, the pond dynamics and aquaculture CRSP has adjusted to budget fluctuations, political events, priority shifts, and scientific amendments that have influenced the location and number of host-country project sites and research agendas. The program fosters creation of a unique international network that extends well beyond the CRSP participating institutions. Many CRSP project sites utilize host-country institutional linkages and facilities supported by previous AID Mission funding. The pond dynamics and aquaculture CRSP is different from other agricultural CRSPs because of its lower funding level and focus on a global concept that involves participation by all host-country and U.S. institutions.

The pond dynamics and aquaculture CRSP provides a rare and crucial opportunity for U.S. and host-country universities and institutions to collaborate on long-term strategic research and development for mutual benefit in an era dominated by global trade and competition, natural resources conservation, the quest for rural economic sustainability, and food security.

1.1. History

The CRSPs were envisioned as 15–25 year collaborative research initiatives with annual funding levels of $4–$5 million. They were intended to be global programs addressing complex global problems with widespread application and impact.

In 1977, USAID Washington at the request of the Joint Research Council (JRC) and the Board for International Food and Agriculture Development (BIFAD) contracted with Resources Development Associates to conduct a planning study for a fisheries and aquaculture CRSP. In response to recommendations in the planning study, in 1980 AID through BIFAD selected Auburn University (AU), the Consortium for Fisheries and Aquaculture Development (CIFAD), and the University of California-Davis (UC-D) to participate in the design of the pond dynamics and aquaculture CRSP. Oregon State University (OSU) was designated as the lead institution and management entity.

In June 1980, the first pond dynamics and aquaculture CRSP preliminary design proposal was approved by the JRC. Twenty-one AID missions indicated a positive response from an AID request for indications of interest in the pond dynamics and aquaculture CRSP. Brazil, Colombia, Honduras, Indonesia, Jamaica, Panama, Philippines, Rwanda, Sierra Leone, and Thailand were selected for site visits by the CRSP technical advisory committee because they represented the best prospects for mutually beneficial collaborative research.

The approach for designing this CRSP included a review and synthesis of the state-of-the-art for pond aquaculture, overseas site visits to determine research needs in LDCs and negotiation of provisional administrative agreements with collaborating institutions. The findings from these surveys were translated into planning guidelines. The two important aspects identified for improving the efficiency of pond culture systems were (1) technological advances to improve the reliability of pond production, and (2) economic optimization based on local conditions. The common link to both aspects was to improve the understanding of pond dynamics.

The original U.S. participating institutions were Auburn University, the University of California–Davis, and the CIFAD institutions, namely, University of Arkansas–Pine Bluff (UA-PB), University of Hawaii (UH), University of Michigan (UM), Michigan State University (MSU), and Ohio State University. In 1993, Michigan State University ceased formal participation. The continuation proposal presently being prepared will offer opportunities for participation by new institutions.

Jamaica and Sierra Leone were selected initially as host countries, and both were included in the program budget in the original pond dynamics and aquaculture CRSP grant for funding from 1 September 1984 to 31 August 1987. Formalized pond dynamics and aquaculture CRSP activities were never initiated because of budget constraints.

The original selected CRSP host countries and corresponding U.S. and host-country lead institutions were the following:

Host Country/U.S. Lead Institutions	*Host Country Lead Institution*
Honduras Auburn University	Directorate of Renewable Natural Resources, Ministry of Natural Resources
Indonesia Michigan State U.	Institute Pertanian Bogor
Panama Auburn University	National Directorate of Aquaculture
Philippines University of Hawaii	University of the Philippines–Visayas
Rwanda Oregon State U.	National University of Rwanda
Thailand University of Michigan	Thai Department of Fisheries Ministry of Agriculture and Cooperatives
Jamaica Auburn University	Inland Fisheries Unit Ministry of Agriculture
Sierra Leone Oregon State U. University of Arkansas–Pine Bluff	Ministry of Natural Resources

1.2. Duration of projects

The pond dynamics and aquaculture CRSP has been supported in part by USAID Washington since 1982 under a Collaborative Research Support Grant and contributions by U.S. and host-country universities and institutions.

From 1982 to 1987, participating host countries were Honduras, Indonesia, Panama, the Philippines, Rwanda, and Thailand. CRSP experiments were conducted at seven locations in six host countries in the first five-year grant proposal. Research sites were reconsidered during the fourth work plan and annually thereafter because of level funding linked to increasing project operational costs. Greater emphasis on data synthesis and computer modelling also pulled funds away from host-country research.

After budget cuts in 1986 and 1987, the program downsized to three host countries, one in each of USAID's three regions and geographical areas as suggested by USAID/BIFAD criterion Panama (two sites) for Latin America, Rwanda for Africa,

and Thailand for Near East/Asia. The Thailand project was regionalized in 1990 in collaboration with Central Luzon State University (CLSU) to include a subproject site in the Philippines. Initial CRSP research studies in Thailand were conducted at Thailand Department of Fisheries (DOF) facilities. Primary CRSP experiments in Thailand were transferred later to the Asian Institute of Technology (AIT) because of a political coup and AID policy.

Former CRSP sites included both brackish water (Aquadulce) and freshwater (Gualaca) sites in Panama, a brackish-water site in the Philippines and a freshwater site in Indonesia. The CRSP project at the Brackish Water Aquaculture Center at Leganes, Philippines, was terminated in March 1987. The Indonesia project ended in August 1987 and finally the CRSP project in Panama was suspended by AID in November 1987 because of U.S. policies. In 1988 the Latin America site was relocated to Honduras.

In 1993, the primary project site in Honduras was transferred from the original freshwater site at Comayagua to a new brackish-water location at Choluteca. New host-country collaborators are the National Association of Honduran Aquaculturists (ANDAH), the Federation of Agricultural and Agroindustrial Producers and Exporters (FPX), and the Escuela Agricola Panamericana (EAP). Comayagua still operates as a secondary project site.

In May 1994, AID suspended all project activities in Rwanda because of violent political instability.

1.3. Original objectives

The grant objective in the original (1982–1987) pond dynamics and aquaculture CRSP proposal was to develop fish cultural technology by studying the physical, chemical, and biological mechanisms that regulate the productivity of pond culture systems in developing countries.

The research program objectives in the first grant proposal were:

Objectives (year one)

- to compile a quantitative baseline of chemical, physical, and biological parameters for each work location;
- to observe quantitative physical, chemical, and biological responses to various levels of inorganic fertilizer application to pond culture systems, and test for significant correlations within and between work locations;
- to observe and document technical constraints limiting fry availability in each participating host country;
- to compile a baseline of information in locally available nutrient inputs and local

geography, hydrology, and water quality in each participating country, utilizing available host-country resources.

Objectives (years two to five)

- To expand the quantitative baselines compiled in year one to reflect seasonal and annual variations;
- To observe quantitative physical, chemical, and biological responses to other treatments (e.g., pond preparation, use of locally available inputs as fertilizers, supplemental feeding) and test for significant correlations between and within treatments and between and within work stations;
- To test alternative fry production methods where appropriate;
- To develop productive models describing the principles of pond culture systems.

Research was planned to quantify the dynamic responses of four categories of systems to various treatments. The systems were the following with designated participating country in parentheses.

- Small, low intensity tropical ponds characterized by limited external inputs of feed or fertilizers. (Panama, Sierra Leone, Thailand)
- Cooler water (15–25 degrees C) tropical ponds at medium to high elevations. (Honduras, Indonesia, Rwanda)
- Brackish water and hypersaline ponds, including those in tropical mangrove zones. (Panama, Philippines)
- Higher intensity tropical ponds systems, characterized by high external inputs of feed or fertilizers. (Jamaica)

1.4. Modifications in objectives

The pond dynamics and aquaculture CRSP was revised in 1986 because of both technical requirements and financial considerations. A new data synthesis component was added to the pond dynamics and aquaculture CRSP with the following objectives:

- to statistically analyze data from the field experiments;
- to synthesize these data and develop descriptive models of the physical, chemical, and biological processes that regulate the productivity of pond culture systems;
- to develop conceptual frameworks for one or more pond management models and develop operating instructions consistent with each conceptual framework;
- to compile a manual of operating instructions describing pond management pro-

cedures for optimizing yields, increasing the reliability, and improving the efficiency of pond culture systems.

The 1987–90 continuation grant contained a revised scope that addressed the most important objectives rather than all the objectives included in the original plan. The approach to continue the global experiment was to synthesize the results of the first three work plans as a staged progression into a conceptual model of pond aquaculture systems. This model was used to identify research needs that were prioritized and translated into objectives for field research projects specific for each host country.

In the 1990–95 continuation plan the long-range goal was stated, "to increase the availability of animal protein in developing countries through pond aquaculture." The overall purpose was stated: "to improve the efficiency of pond systems by bringing together the resources of developing countries and U.S. institutions into a long-term comprehensive research program in pond aquaculture."

The specific pond dynamics and aquaculture CRSP programmatic and operational objectives in the 1990–95 continuation plan were:

- to continue to develop technology, through research, to overcome major problems and constraints affecting the efficiency of pond aquaculture in developing countries;
- to maintain or improve national resource quality through proper management of aquacultural systems;
- to stimulate and facilitate the processing and flow of new technologies and related information to researchers, to extension workers, and, ultimately, to fish farmers in developing countries;
- to promote activities that encourage faculty and researchers to build and maintain linkages;
- to create opportunities for greater multidisciplinary research in aquaculture and to enhance the socioeconomic and ecological aspects of the CRSP;
- to encourage information and data exchange among international agricultural research centers, universities, the nongovernment research community, and AID centrally funded and mission funded projects;
- to expand results derived from the site-specific research to regional recommendations through a global analysis of the data, and
- to use an ecosystem approach to arrange the research agenda and integrate technologies.

1.5. Funding

The pond dynamics and aquaculture CRSP has no specified termination date and has been funded since 1 September 1982 through continuing research proposals approved by USAID Washington. Three research support grants have been funded for (grant 1) 1 September 1982 to 31 August 1987 (DAN 4023-G00-2074-00); (grant 2) 1 September 1987 to 31 August 1990 (DAN 4023-G-00-7066-00); and currently (grant 3) 1 September 1990 to 31 August 1995 (DAN 4023-G-00-0031-00). The authorized funding levels for each grant and the actual amount allocated by AID are listed in the following table.

Grant Number	*Time Period*	*Authorized Amount*	*Allocated Amount*
1.	1982-1987	$4,750,000	$4,683,000
2.	1987-1990	$2,850,000	$2,812,000
3.	1990-1994	$4,600,000	$4,624,000

A new, revised continuation proposal for 1 September 1995 to 31 August 2000 is being prepared for submission to AID/W in 1994. The pond dynamics and aquaculture CRSP will redefine and refine its goals and objectives to reflect changes in aquaculture development worldwide and global priorities.

Year	*AID Funds ($)*	*U.S. Cost Share ($)*	*% AID*	*H.C. Contribution ($)*	*% AID*
1982–83	650,000	138,097	23.0	43,000	7.2
1983–84	600,000	274,190	39.2	605,790	86.5
1984–85	700,000	440,015	33.8	829,420	63.8
1985–86	1,300,000	640,051	61.5	1,288,602	123.9
1986–87	1,040,000	218,801	22.5	316,768	32.6
1987–88	973,000	167,297	18.2	134,980	14.7
1988–89	920,000	234,402	25.5	133,500	14.5
1989–90	919,000	217,887	23.7	135,000	14.7
1990–91	920,000	175,104	15.9	121,093	11.0
1991–92	1,104,000	226,039	22.4	116,451	11.6
1992–93	1,007,000	228,823	22.9	103,977	10.4
1993–94	1,000,000	-	-	-	-
1994–95	900,000	-	-	-	-
Total to date	12,033,000	2,960,706		3,828,581	

Although a multiyear research grant proposal is approved by AID/W, funds are authorized annually. The total amounts funded to date per annum are presented below. Contributions from U.S. and host-country institutions in dollar equivalents and percentages of annual total AID funds are included.

The average percent of cost sharing by U.S. institutions was 28.1 percent from 1982 to 1993. For this same period, the average percent in-kind contribution from host-country institutions was 35.5 percent. Values for 1993 and 1994 were not available.

2. Findings

2.1. Scientific outputs and achievements

Over the past several years, the core of the pond dynamics and aquaculture CRSP has included three major components: (1) the global experiment, (2) special topics research in host countries, and (3) data analysis and synthesis. Each area has made scientific contributions to enhancing the understanding of pond aquaculture systems and developing new technologies and/or products.

The global experiment initially involved common treatments replicated during dry and wet seasons at each host country using standardized experimental protocols to compare results between different sites. Later, amendments were made whereby different studies were conducted at host countries, but similar data were monitored and filed into the central database to retain the global nature and interrelationships for comparisons of host-country results and global applications.

The following are highlights of specific scientific outputs by country project sites.

2.1.1. United States

Most of the U.S. research effort involves the analysis and synthesis of global experiment field data filed into the central database. The Central Data Base is the heart of the global experiment and is the world's largest standardized database on tropical aquaculture with over 1.5 million observations on 96 variables.

The Data Analysis and Synthesis Team (DAST) at the UC-D and OSU has developed computer decision-support tools with predictive models based on the principles of pond culture systems, pond management guidelines, and field data. UM was involved in data synthesis and modeling activities during the first grant period.

The first OSU data synthesis product was the expert system PONDCLASS version 1.1 designed to provide practical guidelines for fertilizing fish ponds to improve the efficiency and reliability of fish production. The expert system PONDCLASS version 1.2 is being used to design experiments at host-country field sites to validate the reliability of the predictive model in Rwanda, Thailand, and the Philippines. It has been used to determine fish stocking and fertilization rates. Because not all of the CRSP data have been verified, PONDCLASS includes considerable data from the scientific literature.

The OSU DAST released POND 2.0 in 1994 as a Windows-driven computer decision-support tool. The POND program provides researchers, extension agents, pond managers, and educators a tool for rapidly exploring, via computer simulation,

the dynamics of warm-water aquaculture systems under various configurations and management regimes and to assist in developing optimal management strategies. Plans are to include an economic analysis component next year.

The UC-D DAST has developed simulation models from the analyses and syntheses of CRSP field data, including dissolved oxygen concentrations in stratified ponds, water temperature in stratified ponds, and primary productivity models in addition to others.

The data synthesizers have not kept pace with the accumulation and incoming flow of field data. Improvements are expected with the 1993 transfer of the central database management from OSU to UH-Hilo. Although originally designed for use by data managers, it is now being reconfigured for use by field staff and others. Database management, in the past an administrative task, is now a research responsibility, including statistical analyses and summaries for each experiment completed.

2.1.2. Thailand

Studies have focused on developing alternative fertilizer and supplementary feed inputs at various levels to enhance fish productivity. The goal is to provide fish farmers with options for pond inputs that are appropriate technologies for resource-limited to more intensive production systems. Each option includes an economic analysis and an approach to mitigate potential environmental impacts.

Specific scientific research achievements include the following:

- determined the most efficient levels of nutrient inputs so farmers can manage fertilizer applications and ensure optimal fish production without pollution;
- developed economically efficient fertilizer strategies utilizing organic and inorganic fertilizers that can produce yields of 18,000 kg/ha/per year - highest tilapia production yet reported without supplemental feeds;
- conducted supplemental feeding studies in fertilized ponds that can save farmers 50 percent of feed costs;
- determined the relationships of pond size to fish yield, management practices and system efficiency;
- developed algal bioassay method for use in determining fertilization rates in production ponds;
- determined the relationships between primary productivity and net fish yield with frequency of fertilization applications;
- determined the effects of stocking density on pond carrying capacity in fertilized ponds with supplemental feeding;

- developed hatchery techniques for Asian catfish fry production;

- determined that diking ponds instead of excavation minimizes the deleterious effects of acid-sulfate soils on fish production;

- the nitrogen:phosphorus ratio model for fertilization developed by the Thailand team received widespread attention and been used successfully in several locations; and

- economics study resulted in selection of profit-making fish culture enterprises in impoverished NE region.

2.1.3. Honduras

Research studies have been conducted at a freshwater project site since 1982 and were initiated recently at a brackish-water site in 1993. The major species included tilapia and other exotic species and marine shrimp.

Notable accomplishments include the following:

- developed five fish production systems and evaluated each for economic optimization and biological efficiency. The systems are, (1) compost, (2) chemical fertilization, (3) organic fertilization, (4) fertilization followed by feed, and (5) feed only;

- quantified the effects of supplemental nitrogen and phosphorus fertilization on tilapia yield and economics;

- determined the potential of tambaqui in polyculture with tilapia;

- determined the effect of water exchange frequency on tilapia yield, water quality and primary productivity;

- determined more optimal and cost-effective protein level of shrimp feed for use during different seasons for shrimp grow-out;

- determined that lower shrimp stocking rates should be used in the dry season to increase final average weight for export markets;

- on-farm studies indicated that higher yields result when juvenile shrimp are stocked during March and June compared to stocking between November and February;

- developed monosex tilapia production technology using hormones and guapote tigre to control unwanted tilapia reproduction;

- conducted 41 different production system experiments to determine which pond

management systems are appropriate for various intensities of production and determined economic returns and performance from enterprise budget analyses.

2.1.4. Rwanda

Experimental studies were conducted at the Rwasave Station in addition to on-farm yield trials. Aquaria studies to support Rwandan research have been conducted at AU and UA-PB. Research concentrated on selecting and evaluating local materials as suitable inputs for pond fish production. Other work was directed at optimizing stocking densities at different elevations and determining temperature effects on tilapia growth. Economic evaluations of applying CRSP experimental results and risk analysis studies were also conducted.

Some research achievements include the following:

- determined the maximum levels of primary production and fish production (3,850 kg/ha/per year) possible when nitrogen, phosphorus, and carbon were not limiting;
- determined that relatively low water temperatures in ponds affect fish growth directly, rather than through a reduction of phytoplankton productivity;
- studies suggested that supplemental provision of energy with cassava is unnecessary in ponds enriched with fresh grass and chemical fertilizers;
- on-farm studies of monosex tilapia growth at different elevations indicated that reduced yields occurring above 1,700 meters may result from reduced food consumption rather than decreased primary productivity;
- determined the effects of temperature and treatment duration on production of monosex tilapia with hormones based on local conditions;
- conducted a survey to determine the socioeconomic factors that affect the transfer and sustainability of aquaculture technology;
- initiated a gender study of women in fish farming used to improve the design of CRSP research by incorporating sociocultural variables;
- an economics study indicated that fish were the best cash-generating crop among traditional crops studied;
- quantified the influence of elevation on tilapia production relating to temperature and water quality;
- determined the inorganic nitrogen input rate required for maximizing primary and fish production.

2.1.5. Philippines

Experiments have been conducted at CLSU pond facilities since 1991. Recent experiments tested the PONDCLASS program against pond trials and developed fertilizer input recommendations for tilapia production. Newly developed improved tilapia strains are being tested under CRSP fertilization guidelines in cooperation with another bilateral donor program.

A summary of achievements include the following:

- Preliminary conclusions indicate that tilapia can be produced at more than 4,000 kg/ha/per year by fertilization alone at recommended nitrogen input rates;

- Studies revealed that using only organic fertilizers can increase the risk of fish mortalities because of poor water quality;

- Developed improved chicken manure/inorganic fertilizer guidelines;

2.1.6. Former host countries

Although pond dynamics and aquaculture CRSP research activities were short-lived in Indonesia and Panama, some scientific achievements were made.

Research accomplishments at Bogor Agricultural University, Indonesia included:

- Improved hatchery management techniques were developed for seed production of Asian catfish;

- Developed fertilization programs using chicken manure and determined how to avoid nitrate and ammonia depletion in ponds.

Research accomplishments at Aquadulce brackish-water site, Panama were:

- developed practical water quality management through periodic water exchanges in shrimp ponds;

- evaluated the effects of liming acidic pond soils and developed practical recommendations;

- determined the most appropriate species of marine shrimp to stock in commercial shrimp ponds. From these studies, *Penaeus vannamei* was selected as the best candidate species.

Research accomplishments at Brackish Water Aquaculture Center, Philippines were:

- evaluated the effects on pond depth on water quality in shrimp ponds and comparisons of available "lablab" with "lumut" as food for mullet fish growth;

- established baseline water quality data on brackish-water ponds;

- determined the effects of water exchange rates on nutrient levels and productivity of brackish-water ponds;

- developed the use of teaseed cake for selective control of finfishes in shrimp ponds;

- examined water quality dynamics in brackish-water shrimp ponds with artificial aeration and circulation.

2.1.7. Contributing factors

The strength of the CRSP has been the multidisciplinary approach to problem solving and the melding of diverse scientific backgrounds from multi-institutions. Participating scientists represent various disciplines including limnology, aquaculture, sociology, resource economics, agricultural engineering, computer science, statistics, and others. This mix of expertise creates a synergy that has enabled the CRSP to accomplish more than could be possible from a single institution or single discipline-focused research team. The worldwide network of scientists enhances the research capability and extends accomplishments and impacts.

The pond dynamics and aquaculture CRSP has pursued a strategic research plan addressing both the understanding of the principles influencing pond aquaculture systems and development of appropriate practices and technologies that can be adopted by farmers and end-users.

Recently the CRSP has expanded into new target areas including economics research, gender studies, on-farm study trials, and outreach programs. U.S. economists have been involved with the CRSP for eight years, but their involvement has been limited because of budget constraints. Current efforts integrate natural resources activities with sociocultural and economic studies. This approach is critical for developing successful technology adoption strategies.

The pond dynamics and aquaculture CRSP has attracted quality research faculty to serve as principal investigators at host-country project sites and in the United States who are highly regarded by the scientific community for their domestic research and international contributions. Host-country expatriates are oriented to both scientific rigor in the design and implementation of experiments and extending promising research results to potential population beneficiaries. The program also has recruited talented graduate students who have been motivated about scientific research through exposure to CRSP activities both in the United States and abroad. The availability of adequate facilities at research sites developed collaboratively by pond dynamics and aquaculture CRSP and host-country institutions also have enabled the program to make important scientific contributions.

2.2. Training outputs

2.2.1. Background

The pond dynamics and aquaculture CRSP recognized that development of human resources is the critical element to sustainable development in aquaculture, however, the first external evaluation panel triennial review in 1985 recommended that peripheral activities (extension, demonstration, training) be restricted and unauthorized deviations from core research plans be prevented to safeguard the central research objectives of the program. This position has changed dramatically since then.

The 1989 external evaluation panel triennial review stressed that consideration be given to the potential for more effectively extending information and technologies in host countries without diminishing the primary goals and research activities. There was also a recognized need for a review of opportunities for nonmainline activities in light of interaction with the farmers via extension needs.

In the pond dynamics and aquaculture CRSP 1994 request for proposals, technology transfer, extension training, and outreach were specifically listed as possible new research areas. In the past several years, the program has expended more resources to outreach and movement of CRSP research results from project sites to on-station (Thailand) and on-farm (Thailand, Rwanda, Honduras, and the Philippines) field verification trials.

Each CRSP project site has invested in the training and education of diverse audiences and participants. The program has not directly funded graduate level or informal nondegree training, yet has been instrumental and extremely effective in attracting funds from other sources to benefit pond dynamics and aquaculture CRSP-associated professional staff and students.

2.2.2. Formal degree training

Host country and U.S. persons associated with the pond dynamics and aquaculture CRSP as professionals and students have received 58 B.S., 48 M.S. and 15 Ph.D. degrees. These scientists now work in many countries as teachers, researchers, administrators, and policy-makers. Some specific examples follow.

- In Thailand, CRSP expatriate scientists are faculty members at the Asian Institute of Technology (AIT), which has an aquaculture program. In 1993 the total number of AIT aquaculture program M.S. degree graduates reached 115. CRSP researchers teach one graduate-level course per year and serve as faculty advisors to M.S. and Ph.D. students. Since 1989, 16 M.S. graduate students have supported CRSP-related research. Students originate from many countries, including Thailand (4), Bangladesh (2), China (4), India (2), Nepal (2), Canada (1), and Sweden (1). AIT M.S. graduates are serving as CRSP research associates and a former research associate works in the AIT Aquaculture Outreach Program. These research associate positions provide opportunities to enhance field research skills.

- In Honduras, the CRSP expatriate is an adjunct associate professor of the Escuela

Agricola Panamericana (Zamorano) and supervises the thesis work of students on CRSP-related topics. A similar arrangement exists with the National Autonomous University of Honduras. Four students have completed their B.S. degrees with CRSP-directed research and seven are currently completing their studies.

- In the Philippines, the host-country CRSP principal investigator is a faculty member and professor at the Freshwater Aquaculture Center of CLSU and supervises M.S. graduate students in CRSP-related research and teaching.

- The Rwanda CRSP expatriates collaborated with the National University of Rwanda and engaged in providing support for B.S.-level formalized education. One CRSP expatriate scientist was awarded faculty status that enabled her to teach various short courses to university students. Since 1984, 21 Rwandan students successfully completed B.S. degree requirements through their association with the CRSP. The CRSP facilities also have supported field research for nine Belgium M.S. students.

- In Panama during 1985 to 1987, CRSP researchers provided supervision and materials to support 11 B.S. students and one M.S. student at the Aquadulce and Gualaca project sites. One U.S. student completed a Master of Aquaculture degree from Auburn University from work completed at the Aquadulce field location.

- From 1985 to 1987, 12 Indonesian students completed requirements for B.S. degrees with assistance provided by the CRSP project through the Institute Pertanian Bogor. One Indonesian received a Ph.D. at a U.S. CRSP institution.

- Since 1987, CRSP principal investigators in the United States have been directing research studies of both M.S. and Ph.D. students who utilize the data and information developed by the CRSP field sites. U.S. student linkages with the CRSP resulted in two Ph.D. degrees and ten M.S. degrees. Presently, seven Ph.D. and one M.S. candidate students are involved in research associated with the CRSP. Several CRSP expatriates used their host-country research to fulfill requirements for Ph.D. degrees in aquaculture.

2.2.3. Informal nondegree training

The pond dynamics and aquaculture CRSP at all host-country locations has trained host-country research associates to manage and operate scientific water quality laboratories and perform analyses using acceptable standardized protocols and methods. Other notable training accomplishments are:

- CRSP principal investigators in Thailand conducted special topic workshops and short-courses that attracted students from countries outside the Indochina region. CRSP staff also conducted training programs for fisheries extension agents of the Thai Department of Fisheries (DOF) in addition to agricultural extension agents

working with the Department of Agriculture. An extension of CRSP results was channeled through PVOs, such as the Northeast Research Foundation, which conducts field verification trials of CRSP research and trains a cadre of village-level extension workers. The transfer of CRSP technologies through on-station and on-farm field trials offers invaluable hands-on training experiences. The CRSP linkage with the AIT's Aquaculture Outreach Program for northeast Thailand, Laos, Cambodia, and Viet Nam has provided many opportunities to extend CRSP results via AIT training initiatives.

- In Honduras, CRSP scientists have directed training programs for 35 Peace Corps fish culture volunteers since 1991 and many Land Use and Productivity Enhancement (LUPE) project extensionists who are involved with extension outreach programs throughout the country.

- A former Honduran CRSP host-country principal investigator is currently working with an agrarian reform project funded by Holland that includes a fish culture training component for nongovernmental organizations extension leaders who train farmers. Practical hands-on activities are conducted at the former principal investigator's private fish farm.

- In Honduras, on-farm testing of four CRSP research technologies involved 31 small and medium sized farms and served as a teaching tool for extensionists and farmers. The collaboration involved U.S. Peace Corps volunteers and the Ministry of Natural Resources LUPE extensionists. The host-country principal investigator also developed a program linking producers in northern and central Honduras to the El Carao National Fish Culture Research Station. Farmers participated in field trials using production systems developed by CRSP in Honduras and Thailand. Over 100 technicians and farmers have benefited from CRSP aquaculture training activities in Honduras.

- Work with shrimp farmers has involved on-farm research studies and FPX/ANDAH sponsorship of two shrimp symposia in Honduras to present CRSP research results to several hundred people throughout Central America.

- Rwanda has made substantial commitments to training of National University of Rwanda staff as well as extension agents and farmers. Special efforts have been directed to women who are actively involved in fish farming. A "Colloquium on Rwanda Women in Aquaculture" was organized to recognize the important role played by women in fish culture activities in Rwanda. The training targeted researchers, planners and extension agents. A goal was to improve communications and the transfer of fish production technologies to private farms.

- A conference on high altitude tilapia culture was held in Rwanda at the Rwasave Station in 1991 and attracted participants from Burundi and Zaire. Others involved were university professors and students, FAO staff, Peace Corps volunteers,

farmers, extension and training specialists, and government personnel.

- Significant gains in on-farm production in Rwanda have been realized through two-way communication between researchers and farmers. The increase in fish pond construction activity and demands for training caused some delays in the analysis and publication of results. Recent efforts included on-farm yield trials at five different elevations involving five farmer ponds at each elevation.

- In the Philippines plans include the training of agriculture extension agents who will be assisting the host-country researcher to implement on-farm yield trials. CRSP staff also participate in training programs organized by other agencies that are targeted to farmers and extension agents.

- While the CRSP was active in Panama, training of host-country staff was a priority. Many CRSP-trained staff became integrated into the rapidly expanding aquaculture private-sector.

2.3. Technology generated

The pond dynamics and aquaculture CRSP has generated numerous technology packages that have had direct application to aquaculturists in developing countries. With a greater emphasis on development and outreach, more farmers should be reached and benefited from these technology outputs. Because of the progressive nature of some research studies more new technologies are anticipated in the near future from on-going experiments. The following describes the most notable technologies developed at each research project site.

2.3.1. United States

The United States effort has been directed at development of computer-based software technologies that can be used for experimental designs, educational activities, and guidelines for management practices.

- PONDCLASS versions 1.1 and 1.2 and POND version 2.0 based in part on CRSP results provide decision-support tools and expert system guidelines for managing aquaculture ponds and to simulate pond production strategies.

- The CRSP database is available on diskettes, customized data requests are processed and future online access provides an opportunity for others to synthesize and analyze a wealth of data.

2.3.2. Thailand

- Fertilization and supplemental feeding methods have been developed that are economically viable for small to medium operations.

- New methods of pond construction in areas of acid-sulfate soils render thousands of hectares more suitable for aquaculture.

- Technologies to produce monosex sex-reversed tilapia have been developed and adopted by the private-sector.

- Methods have been developed to propagate sand gobies.

- In-pond cage culture technologies have been developed for Asian catfish and grow-out of tilapia.

2.3.3. Honduras

- Fertilization and supplemental feeding practices for tilapia production have been demonstrated to generate farm income and improve production over traditional methods.

- Polyculture systems, including native and nonnative species, have been developed for local conditions.

- Improved technologies for mass production of sex-reversed tilapia have been developed and applied on private farms and other countries in Central America.

- Propagation technologies have been successfully developed for exotic species, including grass carp, silver carp, and tambaqui.

- Alternative methods of feeding shrimp have been developed to reduce production costs.

2.3.4. Rwanda

- Developed production packages for tilapia at different elevations using locally available materials and inputs.

- Developed improved methods of sex-reversing tilapia based on local temperature conditions.

- Determined various combinations of fertilizer and feed inputs that optimize fish production.

2.3.5. Philippines

- Manure inputs practices were developed that determine the limits that are detrimental to efficient tilapia production.

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- Combination pond inputs of inorganic and organic fertilizers have been determined that can reliably produce tilapia yields in excess of 4,500 kg/ha/per year.

- Cost-effective feeds for tilapia and carp polyculture systems have been developed.

2.3.6. Indonesia

- Fertilizer experiments without supplemental feeds nearly quadrupled production over baseline yields and tripled average production for farm ponds in the region.

2.4. Management and administration

2.4.1. Program management

The pond dynamics and aquaculture CRSP operates under a tripartite agreement between AU, UC-D and CIFAD. OSU is the lead institution and management entity and is responsible to AID for research and fiscal administration. Program organization and management follow the "Guidelines for Collaborative Research Support Program under Title XII" prepared for JCARD as recommended by BIFAD and AID.

The program management office at OSU consists of a director (1.0 FTE), assistant director (0.5 FTE), and secretary (0.5 FTE). The PMO is fully integrated into and collocated with the Office of International Research and Development (OIRD) at OSU and benefits from this institutional linkage. The presence of the program management office at OSU resulted in increased involvement of OSU faculty in CRSP-related activities. A recent AID/Egypt buy-in of $1,382,377 expanded pond dynamics and aquaculture CRSP expertise through new OSU faculty participation and collaborative linkage with AU expatriate and principal investigators.

The program management office reacted positively to feasible recommendations from the external evaluation panel and AID management reviews.

Some issues have been difficult to reconcile because of budget constraints, for example, more interactions between field project sites and increased involvement of host-country participants.

The program management office provides an important function of publishing and distributing CRSP reports and updates to reach interested audiences worldwide.

Management entity costs are not subject to the 25 percent cost-sharing required by AID. Indirect costs from the CRSP help support OSU's operation. The average management entity costs as a percentage of AID funds are summarized for different periods.

Grant Number	*Time Period*	*Average Management Entity Costs as Percent AID Funds*
1.	1982-1987	15 percent
2.	1987-1990	19 percent
3.	1990-1994	n/a

The management entity costs includes activities not related to management and administration, such as CRSP data management (until 1993), external evaluation panel reviews, publications, annual meetings, and training. OIRD covers incidental CRSP costs when needed.

OSU provides cost-sharing to support management entity operations. The Egypt buy-in provides some additional funding to cover administration costs. The level of management entity funding for grant 3 is anticipated to be closer to 23 to 25 percent of the total AID contribution and will likely be above the 20 percent or lower figure associated with management entity costs of other CRSPs. The management entity budget as a percentage of total AID funds increased recently because of pond dynamics and aquaculture CRSP budget cuts. A potential problem is a further extension of management entity support resources from any additional CRSP buy-ins.

There are usually no funds earmarked for management of contracts. Overhead funds are sometimes transferred back to the project.

A fiscal audit occurs yearly because the CRSP is considered a component project of OSU programs. This audit is conducted by the state authorities. OSU has waived all overhead costs for subcontracts associated with pond dynamics and aquaculture CRSP because of rising internal costs. U.S. universities charge off-campus overhead rates based on updated OMB regulations. OSU's overhead rate for grant 3 is 26 percent.

The PMO and project director appear to be providing the guidance and supervision needed to comply with AID reporting requirements and oversight over U.S. and host-country research activities. The PMO appears to be effective in planning, coordinating, documenting, and managing the program. The fiscal administration is efficient within the university grants and contracts office. Most delays are associated with the grant processing and fiscal disbursements by AID/W. The project director is experienced and well versed in her duties. There is a good distinction and separation of technical and administrative responsibilities and an understanding of the roles of the technical committee, Board of Directors, and management entity. Regular communication between the director and Board of Directors occurs via telephone conference calls as needed. Most communication is with the Board of Directors chair.

2.4.2. Board of directors

The board consists of one administrative member from each AU, CIFAD and UC-D.

The Board of Directors provides an advisory and review function. Board members are primarily senior-level administrators who can exert considerable influence over the CRSP. The board has asserted its will on several occasions over the technical committee to recommend support for specific CRSP component activities. Initially there were some serious differences among Board of Directors members about the direction and staff capabilities associated with the CRSP. With changes in members and advances in accomplishments over time, the Board of Directors is now a more effective and consensus building group.

Their function is to keep the CRSP on a progressive track that includes some latitude for adjustments. One real challenge is to employ a credible means of prioritizing CRSP activities without institutional bias. With an anticipated 10 percent budget reduction, the Board of Directors will be challenged to recommend actions that at least do not impair the functions of the CRSP. A critical review of assessing what activities can be completed and terminated is inevitable. There are no host-country representatives on the Board of Directors because of budget constraints and the original tripartite administration agreement.

2.4.3. Technical committee

The technical committee develops the technical plans and advises the Board of Directors and director on the technical aspects of planning and performance. Principal investigator (principal investigator) members represent U.S. and host-country institutions and different research disciplines to foster multidisciplinary problem-solving approaches. The technical committee meets annually to report research and development activities and present future research work plans.

In the early years, the annual technical committee meetings were associated with tension, science vs. politics and turf protection. Today, the technical committee functions better under four standing subcommittees: work plans, materials and methods, budgets, and technical progress.

At the technical committee level, decisions are made by voting. The tenth annual CRSP report indicated twelve voting members of which four represented host-country institutions. In addition to voting members, the CRSP director and AID project officer serve as ex-officio members of the technical committee. Voting results tend to follow institutional participation, in particular projects or activities. The impartiality issue is critical in regard to making recommendations based on the importance and anticipated benefits of a project vs. an institutional affiliation, particularly in respect to programmatic options for budget cuts. These are tough decisions that are ultimately resolved by the management entity in consultation with the board and external evaluation panel.

Other U.S. and host-country researchers also participate in the annual meetings. Each

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project budget covers travel costs to the annual meeting. The availability of funds often determine who and how many individuals attend. Continuity within the technical committee had been disrupted when new persons become temporary ad-hoc substitutes for designated principal investigators.

The technical committee attempts to reconcile any differences among projects based on needs of the integrated global experiment and recommends subproject budgets to the Board of Directors.

All U.S. technical committee members with the exception of expatriates are active in non-CRSP activities. In some cases other priorities dominate because U.S. principal investigator supporting roles may not be recognized as professional career building activities at some U.S. institutions. Each component of the CRSP, the global experiment, special host-country research topics and data analysis and synthesis contributed to the goal and purpose of the CRSP. The technical committee has recognized the need for the integration of socioeconomic studies and support for outreach activities intended to reach and benefit end-users. The widespread use of electronic communication technology (e-mail) by CRSP members has facilitated information exchanges and formation of international networks.

2.4.4. Research Staff Roles and Organization

Within each subproject of the CRSP, staff consists of a host-country principal investigator, a U.S. principal investigator, and supporting United States and/or host-country research associates. The co-principal investigators are responsible for the design and conduct of research at the project site and for analysis of data and timely reporting of results.

The following host-country expatriate staffing patterns have been used over the life of the pond dynamics and aquaculture CRSP:

Country	*PD/A Funded Expatriate FTEs*
Thailand	1.0/1.3
Honduras	1.0
Rwanda	1.0
Philippines	0
Panama	1.0/2.0
Indonesia	0

Host-country research associates and/or principal investigators assist with the design and conduct of experiments, however, the relationships between host-country principal investigators and expatriate principal investigators is a weak link in Thailand and Honduras. The research associates play a more active and supportive role. In the

Philippines, the UH expatriate in Thailand and at UH-Hilo provide research planning and analysis support to the host-country principal investigator through biennial site visits. U.S. principal investigators assist with technical and logistical backstopping and in reporting research results both to the management entity and in the scientific literature.

The presence of the expatriate is most critical when host-country scientists are lacking who can design and implement scientific experiments and statistically analyze data and develop scientific inferences from the results. In the case of Honduras, the expatriate is the only person in-country with a Ph.D. in aquaculture. The interactions of the U.S. and host-country research teams are adequate with the exception of strong participation by host-country research counterparts in Thailand and Honduras. The need and justification for an expatriate is country-specific; however, at each host-country site, the expatriate's contributions have been significant through leadership, program development, and institution capacity building.

2.4.5. Program evaluation methods

An ad-hoc program evaluation occurs annually, however, an in-depth review is conducted triennially or at least every five years by a three-member external evaluation panel that is responsible directly to AID and BIFAD. External evaluation panel candidates are nominated by the management entity in consultation with the board and AID Program Officer. Members are impartial senior scientists selected on a worldwide basis by the board and approved by BIFAD. The external evaluation panel reviews and assesses the merits of projects and technical and administrative accomplishments and provides guidance for continuing the CRSP. Similarly, an AID administrative management review is conducted prior to each continuation grant proposal. The review team consists of one representative each from BIFAD and AID/W.

An AID/W-funded evaluation of the CRSP by Hogan, et. al. (1986) did not include a review of the pond dynamics and aquaculture CRSP.

2.4.6. External evaluation panel

The external evaluation panel plays an important role by providing recommendations based on interactions with AID and BIFAD and other stakeholders through their triennial reviews. The external evaluation panel should provide strategic guidance for long-term sustainability of the CRSP based on input from various CRSP stakeholders. The management entity would like to have more specific guidance and recommendations from the external evaluation panel. Membership requires a dedicated commitment to conduct a complete evaluation review and to report findings. Considerable pond dynamics and aquaculture CRSP expense and effort are expended

for the external evaluation panel reviews. Some external evaluation panel members have had problems completing all activities associated with a full triennial CRSP review which have been reported in 1985, 1989, and 1993.

Some external evaluation panel members have had close previous association with the pond dynamics and aquaculture CRSP and this potential bias has been noted with some skepticism by some staff within AID. The issue of objectivity is valid because some external evaluation panel members include a previous AID program officer and a representative from an IARC with cross-cutting and potentially biased interests.

The management entity provides external evaluation panel members copies of all pertinent CRSP documents and at least one member attends the annual technical committee meeting. Panel members serve without compensation but receive reimbursements for travel expenses and an honorarium for the triennial review.

AID does not provide additional funds for the required triennial external evaluation panel review. This has created management entity budget squeezes and incomplete team participation in site visits to economize expenses. Some concern exists about equitable external evaluation panel evaluations across host-country sites because each external evaluation panel member did not visit all sites.

2.4.7. AID Administrative Management Review

Only two Administrative Management Reviews (AMR) have been conducted – in 1985 and 1989. A third review is planned for 1994 before the new, revised pond dynamics and aquaculture CRSP continuation proposal is submitted to AID.

The first review included no visits to participating U.S. institutions because of satisfactory progress made by the pond dynamics and aquaculture CRSP. Concern was directed mostly toward developing a U.S. research component and keeping clearly focused on the global experiment. There was a sense that the CRSP needed to better communicate the goal and purpose of the global experiment to AID to dispel potential confusion because of its unique approach.

During the second review there was concern expressed about the lack of focus on the global research plan and that host-country special projects were becoming too dominating in CRSP work plans. The delays associated with the DAST also were highlighted in addition to noting that considerable progress had been made to address this concern.

The AMR has provided a useful accounting of CRSP accomplishments and a means to strengthen the management, administration operations and functions, and provide strategic internal AID support.

2.5. Linkages and collaboration

The CRSP is associated with a multitude of linkages that are critical for its support, function, and subsequent impact on targeted end-users. The CRSP serves as an important U.S. focal point for international aquaculture activities and this creates opportunities to further extend its linkages and program benefits.

The 1989 external evaluation panel triennial report recognized the trend of decreasing resources and the need to seek buy-in opportunities from non-CRSP sources that can relate to or integrate into the pond dynamics and aquaculture CRSP.

2.5.1. U.S. university linkages

The U.S. CRSP institutions co-managing the research at a host-country project site appear to work cooperatively, provide an adequate support role, and communicate freely. AU, OSU, and UA-PB collaborated in Rwanda while UH, UM and formerly MSU cooperate in research planning and reporting in Thailand. The DAST involves OSU and UC-D. All institutions support the global experiment. Linkages are weaker between institutions that do not co-manage a project; however, host-country principal investigators have sought U.S. technical support from the best source rather than only through their institutional affiliation. This bodes well for an efficient CRSP network. Linkages with UA-PB need some strengthening, but this should improve if the institution becomes more actively involved in the next grant.

Linkages between the CRSP participating universities have improved because of the long-term working relationships over the past twelve years. The CRSP has enhanced scientific exchanges between CRSP participating institutions that strengthen all programs.

At most U.S. institutions visited, there is administration support and interest in international programs. OSU provided more that $65,000 for partial support of salaries and travel of management entity staff and publication of data reports. Most envision mutual benefits and linkages that may result in trade and scientific exchange opportunities. The presence of foreign students on campus is deemed positive and reflective of a global society. The university linkages provide opportunities for extending CRSP activities to students and faculty and foster broader university-wide participation.
The U.S. principal investigators provide critical back-stopping support to CRSP activities, yet receive no CRSP funds. The original concept was to post U.S. research associates at host-country sites who would conduct research studies designed by U.S. principal investigators. Over time, this relationship has changed because of experience and training. Now U.S. and host-country staff work as co-principal investigators.

The U.S. principal investigators review all host-country short-term studies and assist in developing joint publications to report information. Host-country principal investigators often need this type of back-stopping or delays can occur in reporting results.

University programs have provided buy-in support to the CRSP. UA-PB conducted an economics study involving 250 farmers in Rwanda through a $99,000 two-year project funded by AID's Historic Black Colleges and Universities (HBCU) program. Many students from developing countries have been trained at CRSP participating institutions. These informal linkages have enhanced CRSP activities and extended benefits.

Presently, UA-PB receives a small budget that marginally covers limited U.S. research studies and travel to the annual technical committee meeting. UA-PB staff are involved in preparing the new continuation proposal. The current level of funding does not warrant active UA-PB participation in the pond dynamics and aquaculture CRSP.

2.5.2. Host country linkages

The commitment and level of collaboration between U.S. and host-country institutions are quite varied and a subject of concern.

2.5.2.1. Thailand

The U.S. expatriate's host-country principal investigator is a Thai Department of Fisheries administrator, not a trained fisheries scientist. The host-country CRSP research associate is more actively involved in the CRSP activities. There appears to be limited collaboration with the National Inland Fisheries Institute at Kasetsart University. Because of research staff shortages and differences in research agendas, it has been difficult to obtain a host-country research counterpart who can actively plan, design, and support CRSP experiments. The host country provides research associates and technicians who are partially funded by CRSP to provide technical assistance, primarily in water quality sampling and testing.

The CRSP can provide a strategic research contribution to the Thai fisheries program, but the CRSP benefits from a strong buy-in of support from the DOF. Initially, CRSP research was conducted at a DOF facility. Last year, four DOF stations participated in CRSP field verification trials each dedicating eight to twelve ponds. Two additional DOF stations will perform similar field trials this year.

The primary CRSP project site is now at AIT where the CRSP is integrated into the Aquaculture Department and Aquaculture Outreach Program. The linkage with AIT offers tremendous leveraging opportunities through other bilaterally funded programs supported by IDRC (Canada), ODA (United Kingdom), SIDA (Sweden), and DANIDA (Denmark).

One CRSP expatriate serves on DOF Committee on Development of Commercial Freshwater Aquaculture.

2.5.2.2. Honduras

The situation with host-country principal investigators has been unstable because of frequent staff changes every four years. The Honduran Director of Fisheries changes often. Maintaining continuity in host-country staffing has been difficult when the collaborative linkage involves a government agency. There is no functional research counterpart at El Carao or Choluteca project sites. The CRSP does not have funds to train counterparts at Ph.D. or M.S. levels.

More staff support stability exists with linkages to host-country universities and/or private-sector organizations than with the host-country government. The Honduran government no longer supports an agricultural extension program in the country. U.S. Peace Corps plans to suspend their fish culture extension program next year because of the lack of host-country counterparts.

The sorghum and millet CRSP through EAP has assisted the pond dynamics and aquaculture CRSP obtain PL-480 funds to support PD/A activities. New policy change requires host-country to provide some matching funds to be eligible for PL-480 funds. This new matching requirement may end this source of critical supplemental funding for PD/A freshwater projects.

The CRSP is also linked with the EAP's Department of Aquaculture, which has research and training facilities. The two programs are developing an aquaculture curriculum for a vocational technical degree program at a high school near Choluteca to train students for technical positions on shrimp farms. ANDAH pays the instructor's salary. The U.S. Peace Corps will also provide a volunteer to assist with program.

EAP is also expected to participate more strongly in the shrimp research studies with pesticide analyses and possibly become a stronger host-country institutional linkage. FPX is collaborating with the CRSP in developing intensive production systems for tilapia. FPX is a nonprofit private association cofunded by AID (49 percent) and private sector (51 percent) for purposes of developing and promoting competitive, nontraditional exports. FPX is a collaborator with pond dynamics and aquaculture CRSP and Ministry of Natural Resources in supporting shrimp research studies.

FPX provides funds for a U.S. consultant to assist the pond dynamics and aquaculture CRSP by contributing needed expertise in oceanography and marine estuarine ecology at the Choluteca site. FPX also sponsored study tours to Jamaica and Colombia to expose producers to new production technologies. A former CRSP research associate is the present manager of a new FPX model, demonstration tilapia farm that applies CRSP research and collaborates on advancing more intensive production technologies to produce tilapia for export fillet markets.

In 1991, formal collaboration with pond dynamics and aquaculture CRSP was pursued

involving ANDAH, FPX, and the Government of Honduras. Each contributed to establish and operate the water quality lab at Choluteca in 1993. Currently the Honduran Ministry of Environment Protection has included funding support for the lab as a component in a World Bank project. Two EAP students will do thesis work at the lab.

ANDAH members provide pond water samples from sixteen sites for water quality testing and have sponsored three symposia attended by representatives from Nicaragua and El Salvador for sharing CRSP research results to all stakeholders in the region. Three shrimp farms provide ponds for research studies designed by the CRSP which also interprets findings and reports results to ANDAH. Many techniques used are scientifically unproven. A "check-off" system provides a source of private-sector funds to supplement pond dynamics and aquaculture research. Present host-country counterparts at Choluteca are the technical staff at lab and private shrimp farmers.

2.5.2.3. Rwanda

A four-year AID-funded project directed to extension with two CRSP institution expatriates began about the same time the pond dynamics and aquaculture CRSP project began. The CRSP benefited from the AID bilateral project and eventually the research associate switched to the pond dynamics and aquaculture project when the former terminated in 1988. Many of the trained Rwandan extension agents became CRSP participants.

The CRSP was linked to faculty of the National University of Rwanda through the Ministry of Higher Education and Research. The host-country principal investigator was a soils scientist. The CRSP expatriate worked with the National University with funding from the European Economic Community to develop twenty research ponds of excellent quality in 1985. In the Second external evaluation panel Triennial Review Report, the dean of the College of Agronomy at the National University of Rwanda rated the pond dynamics and aquaculture CRSP the most successful of many collaborative projects.

The Ministry of Agriculture was not officially linked to the CRSP but collaboration occurred because of friendships and previous linkages through the AID-funded extension project. Recently the extension program had become dysfunctional and the World Bank had offered assistance to revamp and reorganize it.

Other research study collaborators include Germany, the Netherlands, and Belgium.

2.5.2.4.1. Philippines

The Philippines has no U.S. expatriate associated with the CRSP. The host-country principal investigator collaborates with UH staff at UH and in Thailand to plan and

implement research studies. UH staff visit the host-country project site usually twice yearly to plan studies and coordinate activities.

The U.S. co-principal investigators provide technical and logistical backstopping to the host-country project participants. This arrangement appears to be working well. This linkage also involves the co-authorship of CRSP reports and scientific papers. One weak link is the dependency of host-country researcher on data analysis and synthesis by U.S. principal investigator. This linkage needs strengthening to expedite the flow of information and complete the reporting of results.

There is need for a memorandum of understanding between ICLARM and the CRSP to foster stronger collaboration of activities in the Philippines. The Genetic Improvement of Farmed Tilapias (GIFT) project funded by ADB and UNDP/DGIP has not yet fully collaborated with pond dynamics and aquaculture CRSP in yield trials combining GIFT fish and CRSP pond management as cited in the seventh work plan. This joint effort offers considerable benefit to the many tilapia farmers in the Philippines and Asian region.

The Freshwater Aquaculture Center of CLSU in collaboration with the University College of Swansea, Wales, United Kingdom is implementing the Genetic Manipulations for Improved Tilapia (GMIT) project funded by the British Overseas Development Administration. This project is now identifying cooperating fish farmers for its new Technology Adaptation and Development (TAD) project, which aims to mass produce Genetically Male Tilapia (GMT) fish for testing under on-farm conditions. The pond dynamics and aquaculture CRSP research team is using GMT fish in yield trials using global CRSP fertilization recommendations.

The pond dynamics and aquaculture CRSP project site is also collocated near the National Freshwater Fisheries Technology Research Center of the Philippine Bureau of Fisheries and Aquatic Resources. This program offers training courses for farmers and extension workers and initiates cooperative programming activities with the pond dynamics and aquaculture CRSP.

The Philippine Council for Aquatic and Marine Research and Development (PCAMRD) coordinates and monitors a National Aquatic Resources R&D System of which CLSU is a member. This coordinating structure provides an opportunity to link different research initiatives, including CRSP activities, to effectively develop and deliver improved aquaculture systems to farmers.

Extension services for fish farmers are now very limited. PCMARD, BIFAR, and other programs are directing training efforts to strengthen extension outreach capabilities for fish farmers.

2.5.3. AID mission linkages

AID mission support has been positive in most countries where the pond dynamics and aquaculture CRSP interacts regularly with AID mission staff and the host-country institutions communicate the relevancy and importance of project activities. The enthusiasm for AID Mission support increases as the host-country coalition of support broadens, and especially when the program clearly benefits end-users and the private sector. CRSP staff usually follow courtesy protocols to brief and debrief AID Mission staff when requested.

In September 1989, the pond dynamics and aquaculture CRSP was awarded a Basic Ordering Agreement (BOA) to facilitate the placement of delivery orders by AID Missions for specific requirements related to the basic CRSP research grant. This provided a mechanism to respond quickly and directly to Mission needs.

There are cases when the AID staff support was enthusiastic when the pond dynamics and aquaculture CRSP began, yet this support waned over the years because of the continuous turnover of AID staff with increasingly larger portfolios and decline in direct-hire staff. This institutional instability is not conducive to sustainable support for long-term CRSP research, unless the program is well understood and held more accountable to AID Missions. This revolving door of AID staff requires that CRSP representatives continually keep abreast of staff changes and provide briefings and updates to maintain CRSP visibility and support.

In global studies, pond dynamics and aquaculture CRSP may be on target in several countries but not in all because of differences in country needs and conditions. This created problems in some countries between 1982 and 1987, when similar standardized experiments were repeated at each host-country site for the global experiment. For example, Rwanda did not have easy access to chemical fertilizers and substituted compost materials as more appropriate inputs. In Indonesia AID staff did not support pond dynamics and aquaculture CRSP because activities were considered irrelevant to AID Mission priorities. Later adjustments to host-country Special Research Topics have become more relevant to AID Mission and host-country needs.

In Honduras the pond dynamics and aquaculture CRSP initiated the interest to supplement a Natural Resources Management Project with an aquaculture component. AID Mission in Honduras has supported FPX efforts to export farm-raised marine shrimp since 1986. FPX also provides technical assistance to the shrimp industry through their technical advisors. AID Mission also funded two studies related to commercial shrimp production and studies on mangrove ecosystems in the Gulf of Fonseca that could be impacted by the fast growing shrimp industry. AID Mission also provided discount loans and lines of credit through FPX via the Central Bank for shrimp farms in 1987–88. Early shrimp development problems were technical and the AID Mission contracted two technical consultants to assist the industry.

As the shrimp industry became more concerned about water quality degradation and mangrove destruction, the AID Mission supported CRSP involvement with

marine shrimp development. The AID Mission also wants to sustain and protect its long-term investment in this industry. AID Mission and the private sector cosponsored the Central American Symposium on Aquaculture, which attracted 150 participants from twenty countries. Being one of the first to develop a natural resourses management program, the issues of sustainability and environmental protection are high priorities for the AID Mission.

The El Carao National Fish Culture Research Station in Honduras was constructed and equipped with USAID/Honduras Mission funding in 1979 before the CRSP initiated project activities in 1983. During 1987 when the Latin America CRSP program was moved from Honduras to Panama, AID/Honduras Mission at the request of MNR contracted with Auburn University to provide aquacultural technical assistance for fifteen months after the termination of the pond dynamics and aquaculture CRSP in Honduras. The CRSP was later reestablished in Honduras in 1988.

In the Philippines, only $20,000 is budgeted for PD/A activities. This amount does not attract much attention at the mission-level. However, in past years the AID mission had funded several long-term aquaculture development projects through Auburn University and Texas A&M University.

The CRSP research ponds at AIT were constructed with a $30,000 buy-in from the AID/Thailand Mission. The Mission has also been supportive of training and extension activities for fisheries biologists and farmers. AID also provided funds for studies on the use of legumes as fish pond inputs. The U.S. expatriates have good rapport and liaison with AID Mission staff who acknowledged significant contributions to the knowledge of pond dynamics in Thailand. However, now is a time of uncertainty because of the change in mission director and a planned switch in the Mission's role to an East Asia regional bureau office. With AIT being an Indochina regional institution, the pond dynamics and aquaculture CRSP is linked with a regional rather than country institution.

The AID/Mission/Rwanda has been highly supportive of CRSP activities and viewed the program as being worthwhile and politically important, concerning land use policies and natural resource issues. AID/Rwanda provided four years of funding to the National Fish Culture Project through the Ministry of Agriculture about same the time the pond dynamics and aquaculture CRSP was initiated. The former project focused on extension, nutrition, and the importance of fish as a source of protein. AID Mission through a block grant supported four sociology studies related to the fish culture conducted by staff from pond dynamics and aquaculture CRSP institutions. And, AID's Office of Women in Development and AID/Rwanda Mission supported studies on women's participation in fish culture in Rwanda.

An AID/Rwanda Mission Natural Resources project provided scholarships for graduate-level training of host-country CRSP staff. The CRSP project benefited from

these Mission-funded projects as U.S. expatriate staff moved to the CRSP project after the termination of the National Fish Culture Development Project.

While active in Panama, the pond dynamics and aquaculture CRSP experienced good AID Mission support. The Mission had also funded previous aquaculture projects involving a CRSP institution.

The new Egypt CRSP project site was funded in October 1992 through a separate grant from AID/Egypt. This informal buy-in of more than $1 million broadens the scope of CRSP activities to include polyculture, bioconversion, and biotechnology. New U.S. (University of Oklahoma) and host-country (Egyptian National Aquaculture Research Center) collaborators now participate in the pond dynamics and aquaculture CRSP. The Egypt project is administered in association with the CRSP PMO. The Abassa research project site was constructed with AID/Egypt Mission funding.

The CRSP projects have had varying degrees of interaction with AID missions. Overall, the relationship has been positive as evidenced by mission buy-ins and previous AID mission support for aquaculture development projects. There have been some problems, however, caused by protocol oversights and sometimes inconsistent communication. The PMO provides AID missions with copies of quarterly CRSP newsletters.

Several U.S. principal investigators felt that the CRSP could function in a country without an AID Mission through MOUs with host-country institutions or other organizations. The AID Mission provides a legitimate, "legal U.S. presence" and facilitates logistical and project support functions that are deemed critical by most PD/A participants. This assistance avoids many potential hardships. Most persons contacted believed the CRSP should only operate in countries where there is an AID presence, whether Mission or regional.

2.5.4. International and regional linkages

As noted in the third external evaluation panel review, considerable efforts have been made to develop strategic research plans including priorities for aquaculture research in a global and regional perspective. These initiatives were supported by the World Bank in 1992 and by ICLARM in 1992 and 1993. There are also numerous regional initiatives and programs that interact with and can benefit from linkages with the pond dynamics and aquaculture CRSP. The global orientation of the CRSP necessitates an extensive regional and international network.

2.5.5. International Agricultural Research Centers

In May 1992, it was admitted to the Consultative Group in International Agriculture

Research that ICLARM is the only international agricultural research center associated with pond dynamics and aquaculture CRSP.

ICLARM has interests in production systems that include trophic dynamics, integrated resources management, water management systems, ecological modeling, and social science studies. Although, ICLARM is proposing collaborative research on the trophic dynamics of fishponds, formalized collaborative linkages with the pond dynamics and aquaculture CRSP still have not been established. These interests fit well with the pond dynamics and aquaculture CRSP and provide mutually beneficial resource leveraging opportunities. ICLARM participates in an aquaculture project in Malawi that serves as a regional training site and provides access to national programs. AID also funds a project in Bangladesh that involves fish production in irrigation ditches for landless families. AID provided $220,000 of unrestricted core funds last year to support ICLARM.

NAGA, the ICLARM quarterly newsletter, provides CRSP results to an international network. There are good opportunities to complement and strengthen both networks through sharing strategic planning documents and seeking options for joint programming and leveraging resources. Opportunities exist for joint proposal development integrating ICLARM and CRSP common interests and expertise.

The pond dynamics and aquaculture CRSP project in the Philippines provides a collaborative opportunity to develop a technology package for fish farmers that incorporates ICLARM's GIFT fish and CRSP's global fertilization results.

ICLARM is supportive of incorporating some of the CRSP central database into ICLARM's database on fisheries resources (FishBase) program, although implementation has been delayed. This biological database on marine and freshwater fishes contains information on many topics, including aquaculture. A CRSP U.S. principal investigator is planning sabbatical leave with ICLARM and this linkage and tenure are expected to expedite completing several mutual interest tasks.

ICLARM researchers also have interest in a data logger system developed by CRSP scientists. The POND decision-support tool will also be applied to ICLARM projects. ICLARM also wants to target the common CRSP interest resource-limited agricultural sector. Another common CRSP/ICLARM issue is socioeconomic studies related to fish farming. CRSP initiated one, including the Philippines, in January 1994. ICLARM also initiated a related study this year in the Philippines funded by the Asian Development Bank. The CRSP has proposed a collaboration with ICLARM to develop a handbook of aquaculture research techniques.

2.5.6. Regional linkages

Regional aquaculture research planning also occurs with AIT, the Network of

Aquaculture Centres in the Asia-Pacific (NACA), and the Southeast Asian Fisheries Development Center (SEAFDEC). UNDP-FAO also funds an aquaculture research support program, Aquaculture for Local Community Development (ALCOM) in Zimbabwe. The CRSP association with AIT facilitates the extension of research results throughout the Indochina region where AIT has become a center for graduate level training and outreach.

One promising linkage facilitated by pond dynamics and aquaculture CRSP is between AIT and Auburn University's International Center for Aquaculture and Aquatic Environment to develop collaborative strategies for aquaculture development in Indochina.

In Rwanda, the pond dynamics and aquaculture CRSP presence led to expansion of the research facilities with construction of additional ponds funded by the European Economic Community and Belgium. Belgium researchers also worked at the CRSP site to develop methods for propagating the African catfish.

2.5.7. Private-sector linkages

A strong private-sector linkage exists in Honduras where ANDAH provides partial funding and in-kind support to operate the pond dynamics and aquaculture CRSP water quality lab that involves active on-farm water sampling and delivery of samples to the lab. This initiative is also associated with a recently passed government environmental protection law that requires environmental impact statements for the development of new shrimp farms or expansion of ponds on existing farms. The permitting license requires water quality monitoring and reporting. The CRSP is also developing environmentally sustainable semi-intensive shrimp production technologies for the sensitive coastal estuaries. Shrimp farmers have provided ponds for CRSP adaptive research use under commercial conditions. The sustainable development approach being pursued in Honduras has application in the Gulf of Fonseca region, including Nicaragua, El Salvador, and the world. It is the only known project generating and analyzing quantifiable data that defines the relationship between commercial shrimp production and water quality conservation.

In the United States, CRSP research is supporting field trials using an androgen hormone approved for sex-reversal of tilapia by the U.S. Food and Drug Administration under an investigational exemption. pond dynamics and aquaculture CRSP project sites are collaborating with the American Tilapia Association, Ziegler Brothers Feed Company, and Auburn University to generate data required for final FDA approval of this drug.

Much of the CRSP research involves fertilizers as primary inputs to pond systems. In the U.S. commercial aquaculture, growers primarily use formulated feeds. However, bait fish and tropical ornamental fish growers and State Fish and Game

agencies often use inorganic fertilizers and liming materials to stimulate pond productivity and increase fish production.

2.5.8. Inter-CRSP Linkages

Inter-CRSP opportunities exist in Honduras between the TropSoils CRSP and pond dynamics and aquaculture CRSP relating to soil erosion impacting coastal estuaries important for commercial shrimp farming and ecosystem stability. Also, in Honduras the INTSORMIL CRSP assisted the pond dynamics and aquaculture CRSP to obtain PL-480 funds through their association with EAP. Other possibilities are likely, but budget constraints have limited joint projects at host country. The CRSP council consisting of directors of each CRSP provide a forum to assess inter-CRSP opportunities.

2.6. Reporting and disseminating information

Technical and program reports are distributed to approximately 300 people in forty-two countries. Two technical series distributed regularly are the "Collaborative Research Data Reports" and the "CRSP Research Reports." CRSP researchers and the management entity are very active in presenting and providing information on CRSP-funded research and activities. Over 350 reports and theses resulted from CRSP-related research worldwide. To provide nontechnical information and updates on CRSP activities, OSU periodically distributes the PD/A newsletter, "Aquanews." It provides information on CRSP projects, staff, meetings, and milestones. Similarly, UC-D produces a DAST newsletter to inform CRSP researchers of data syntheses results, updates on DAST projects, and the newly developed products.

Most research is communicated in scientific peer-reviewed publications. The reporting through scientific literature makes information accessible to a diverse worldwide audience.These publications reflect the high standards and scientific merit of research. CRSP researchers participate actively in international, regional, and U.S. professional meetings.

As an example of the volume of reporting, 27 scientific journal articles and 36 technical papers have been published based on Thailand research alone. The PMO also produced a "List of Publications, 1982-1991," and recent May 1994 publications list of available research reports, data reports, and administrative reports.

The PONDCLASS manual is now available in French and work is underway for a Spanish version. The Rwandan team translated the manual in a cooperative effort with the DAST. PONDCLASS has been distributed to eighty people worldwide, about half in the United States. User feedback has not been solicited yet to determine its utility and ease of use.

The central database is a resource of global importance and since 1992 there have been increased efforts to market the availability of this database. The CRSP data are now available on computer diskettes upon request. The PD/A collaborative research data reports provide specific information and data recorded for each experiment associated with the global experiment, including interpretations of results.

CRSP is planning to incorporate much of the CRSP global database into ICLARM's FishBase, which will extend access of the CRSP data to others.

The CRSP developed a "Handbook of Analytical Methods" that serves as a guide for acceptable analytical methods, procedures, and instrumentation for analyses associated with the global experiment and central database. These standardized, scientific procedures cover fish/shrimp sampling, pond characteristics, soils/sediments, water quality, and weather data.

A noteworthy project planned for completion in 1995 is the comprehensive book *Dynamics of Pond Aquaculture* authored by pond dynamics and aquaculture CRSP scientists. The book will include summaries and inferences from CRSP research and serve as a valuable reference to persons interested in tropical pond aquaculture. It will update the previous CRSP book, *Principles and Practices on Pond Aquaculture*. Other publications in preparation include, *A Ten-Year Summary of Activities in Honduras* and *The Proceedings of the Third High Altitude Tilapia Conference in Rwanda*.

Pertinent CRSP results are packaged into educational materials and translated into host-country languages for use by extension educators and farmers. In Thailand, CRSP research concepts were communicated in Thai language posters, and guidelines for fertilization were developed in Thai language extension publications. Information is also communicated through local TV and radio broadcasts. After field verification trials at DOF stations, CRSP results are incorporated into extension materials in the Thai language.

In Honduras, Spanish language CRSP pond management recommendations are distributed to farmers when they pick-up their fish fingerlings at the National Fish Culture Station at El Carao. ANDAH in Honduras sponsored three symposia on shrimp farming that highlight the presentation of CRSP research findings to farmers and others from Honduras, El Salvador, and Nicaragua. Attendance reaches 200 people and management practices are already influenced by CRSP short-term on-farm research results.

CRSP researchers in Rwanda wrote a biometry textbook in French and developed numerous other educational products for country use.

Indonesian researchers developed a water quality analysis manual that was translated into Bahasa Indonesian.

3. Conclusions

3.1. Fulfillment of objectives

The pond dynamics and aquaculture CRSP effectively addressed the objective in the original grant. New fish culture technologies have been developed through the application of scientific approaches to problem-solving. The CRSP has generated a wealth of information pertaining to the further understanding of mechanisms that regulate the productivity of pond culture systems. The CRSP central database and DAST efforts provided a unique opportunity to develop descriptive models and conceptual frameworks for pond management models. The testing of correlations within locations has been adequate, however, comparisons between host-country sites have not kept pace with the data generated.

There has been significant progress made in identifying and addressing constraints limiting fry availability with tilapia, sand goby, Chinese carp, Asian catfish, tambaqui, guapote tigre, and others. The increased availability of fish seed stock has been instrumental in the expansion of private-sector fish farming. The seed stock technologies have been transferred to private firms in Thailand and Honduras.

The computer program outputs, PONDCLASS and POND and textbook, *Principles and Practices on Pond Aquaculture*, scientific papers, technical reports, and newsletters are examples of pond dynamics and aquaculture CRSP outputs.

The original grant addressed four different systems and environments. Because of budget constraints, the brackish-water research lasted only a few years and become reestablished in 1993 in Honduras. With the fast growth of shrimp farming in the environmentally sensitive estuaries of many developing countries, the return to a brackish-water site is important. Because of budget restraints, the higher intensity tropical pond systems were never addressed as proposed in Jamaica.

More recent program objectives are being addressed on schedule in the seventh work plan with some studies being completed from the sixth work plan. With few exceptions, the research studies have been completed. In spite of continuing political hostilities near the CRSP project site in Rwanda, research progressed close to schedule until the AID pullout in May 1994. The suspension of project activities occurred at a critical time for the beginning and completion of studies to develop different pond management strategies based on elevations, an economic analysis of pond systems, and on-farm yield trials.

One problem has been the occasional delay in analyzing data and reporting results. This is associated with heavy workloads and the need for technical and reporting

backstopping. The DAST has experienced delays in analyzing field data, however, with recent changes improvements are anticipated.

The planned comparisons of results and differences between host-country sites have not progressed as anticipated as only one study between Panama and Honduras was reported. The global experiment enabled a first-ever opportunity to understand differences in results between sites so that appropriate, custom-tailored technologies can be developed.

The integration of social science research has been sporadic and somewhat weak. However, numerous socioeconomic studies have been conducted that address nontechnical constraints and opportunities for developing baseline socioeconomic data for future impact assessments.

The objectives in the first two grants did not address technology transfer and support for program activities directed to impact targeted beneficiary populations through host-country outreach programs. However, in recent years more activity has been directed to on-farm yield trials and development of extension materials and curriculum. With no funds allocated for training, the pond dynamics and aquaculture CRSP has been extremely effective in training many persons associated with the program.

Host-country special topic research projects have been well designed and implemented and in most cases are addressing grant objectives effectively. These projects developed numerous technology packages that reached farmers.

The mechanism of expanding results from site-specific research to regional recommendations has not been firmly established, although results do flow across host countries. The broader flow of information across AID missions and other international organizations is accomplished through information dissemination, but the adoption of CRSP practices outside of host countries is undocumented with few exceptions.

3.2. Relevance

The pond dynamics and aquaculture CRSP is addressing major constraints to aquaculture development in a global context. The centerpiece of the pond dynamics and aquaculture CRSP has been the global experiment. This effort generated volumes of raw quantifiable data, much of which has not yet been synthesized. The full value and benefit of this uniquely designed initiative have not been fully realized, yet it provides a wealth of information that can further the scientific understanding of the complexities associated with pond aquaculture systems.

There is no ownership of the pond dynamics and aquaculture CRSP data once it

becomes accessible by the public. Until recently, the central database was not being used principally for scientific analyses but, rather, being maintained as a management function. Open access and integration into ICLARM's FishBase database should extend the benefit of CRSP data worldwide.

The development of computer decision-support systems has applications to designing experiments and evaluating outcomes from different levels of inputs and management intensities. The computer simulation technology provides new approaches to education, management, and policy development. These tools have limited use by farmers to facilitate periodic management decisions to optimize production efficiencies and lack of personal access to computers will constrain their use in many developing countries. The utility and benefit of these computer programs will not be significantly realized until more persons have access, learn, and apply their capabilities for decision-support or evaluate comparisons.

The DAST and central database are relevant components of the pond dynamics and aquaculture CRSP and this should become more evident as more emphasis is directed to the utilization and synthesis of existing data. Wise decisions have been made to limit data generation and add new variables related to pond sediments that is a critical component of a pond ecosystem and nutrient cycles.

The pond dynamics and aquaculture CRSP provides a critical scientific foundation that has addressed land-use policies in Rwanda and shrimp farming development regulations in Honduras. Also, in Rwanda, CRSP field scientists cooperated with host-country administrators to reorganize the national plan for aquaculture development. Public-sector funds are needed to address the development of sustainable aquaculture production systems that are efficient and competitive in global markets and compatible as components in integrated farming systems in rural sectors. The pond dynamics and aquaculture CRSP is addressing the harmonization of aquaculture development with environmental and natural resource conservation and protection unlike most public- or private-sector programs in developing countries.

The global nature of the pond dynamics and aquaculture CRSP enables interactions between project sites, yet also supports more country-specific original research designed jointly by American and host-country principal investigators that is both relevant and linked to shorter-term developmental impacts. The combination of the central data base, global experiment design and country-specific special research topics provide a unique opportunity to impact the development of tropical aquaculture in a global context. The network synergy and commitment of PD/A staff to scientific excellence applied to addressing priority aquaculture constraints make this CRSP a relevant initiative.

A global social sciences project was initiated in 1994 involving economists and sociologists collaborating with researchers in Honduras, Thailand, and the Philippines to examine factors relating to adoption and diffusion of aquaculture technology,

including CRSP results. This effort is expected to improve the diffusion process of CRSP results to targeted audiences.

3.3. Effectiveness

The PD/CRSP has been active since 1982 and, with a modest level of funding and strong staff commitment to science and development, the program has contributed to the recognition of aquaculture as viable agricultural practice in many countries. The program has attracted a multidisciplinary research team that appear to work independently, but collaborate in an increasingly effective manner. The inclusion of socioeconomic components in projects that serve to identify development constraints other than technical barriers enhances the overall effectiveness of the program.

The goal of research is the generation of new knowledge translated into outcomes and applied by end-users to achieve impacts. The latter requires strategic planning and effective partnerships and coalitions. The pond dynamics and aquaculture CRSP have been an effective mechanism to conduct strategic research and extend results through collaborators to reach and benefit end-users.

The partnerships and collaborators both in the United States and host countries indicate the strength and credibility of the pond dynamics and aquaculture CRSP. While host-country government institutions are obvious collaborators, project staff have broadened their coalitions, recruited, and attracted many other stakeholders impacted by or supporting aquaculture development programs. This multiplier and leveraging approach has resulted in significant impacts and accomplishments using the pond dynamics and aquaculture CRSP as the initiator and scientific and technical foundation in many cases.

The U.S. and host-country linkages and global network associated with the pond dynamics and aquaculture CRSP have been instrumental in promoting and advancing education and training to support human resource development and longer-term sustainable aquaculture programs and private-sector initiatives. The pond dynamics and aquaculture CRSP continues to mature and expand its expertise to effectively address new objectives and priorities. Multidisciplinary research is critical for solving complex problems, yet difficult in practice and function. The pond dynamics and aquaculture CRSP is making better use of the expertise in the land-grant university system and is effectively directing limited resources to problem-solving efforts. The transferability of CRSP results across regions is critical to expand impacts and benefits. The global pond dynamics and aquaculture CRSP network facilitates this extension of results.

The program addressed its project objectives adequately with the exception of data syntheses delays associated with the central database. Most research studies were completed on schedule and project results reported in a timely manner with some

exceptions. Host-country expatriates are often over-extended with research studies, data generation for the global experiment, management entity reporting, and training and education activities. This heavy workload has affected the timely analyses of research studies and reporting of results. U.S. principal investigators have provided critical support roles in assisting with reporting and publishing results.

The role and importance of U.S. expatriate involvement in host-country projects has been critical in the initial years. As more host-country scientists are trained the relative cost-benefit of maintaining U.S. expatriates needs to be carefully assessed on a per country basis. There is no doubt that the presence of U.S. expatriates is essential where host-country expertise is lacking for designing and implementing "scientific" studies and interpreting results to develop scientific inferences. However, options exist for various levels of host-country support. The commitment to research and PD/A objectives, such as quantifying the optimal fertilizer and feed inputs for efficient and sustainable aquaculture production, are other important considerations.

The pond dynamics and aquaculture CRSP has been effective in bridging research and development to benefit farmers and consumers through extension and commercialization linkages, especially in Honduras, Thailand, and Rwanda.

The pond dynamics and aquaculture CRSP activities could improve communications to persons outside the international aquaculture networks. This is especially true in the United States where several U.S. agencies fund aquaculture research, development and extension programs and projects, yet are not well informed about pond dynamics and aquaculture CRSP activities.

The commercial catfish, trout, and salmon industries would likely benefit from the application of CRSP decision-support computer models. This requires a closer interaction and collaboration between the modelers and U.S. aquaculturists and private-sector participation in the CRSP planning and programming processes.

Some external evaluation panel members are or have been closely associated with the pond dynamics and aquaculture CRSP and this has raised concern. An effective external evaluation panel triennial review requires an adequate budget to enable all members to visit all relevant project sites, but this has not been the case. Some external evaluation panel members have not dedicated adequate time for this important responsibility. The external evaluation panel members should be carefully selected and fully committed to their challenging tasks.

The external evaluation panel triennial reviews could (1) be more specific in their recommendations; (2) engage in more controversial issues that persist regarding the relative importance of various project components; (3) recommend criteria for determining when a project should be terminated; (4) suggest priorities of broadest application and impact; (5) stress the linkage of scientific technology output to development impacts; (6) encourage new CRSP partnerships through international

development programs and the private commercial sector; (7) recommend that impacts are monitored and measured for all relevant project activities to address accountability issues; and (8) include a statement of anticipated benefits and impacts for each CRSP project activity reviewed.

The management entity and PMO appear to function well. The responsibilities are many and with such a diverse group of participants, strong and respected leadership is essential to effectively address controversial issues. The pond dynamics and aquaculture CRSP established an operational and organizational structure that works, although overdominance by technical committee biologists has made it difficult at times for social scientists and computer scientists to become fully integrated into the program. The interaction has improved over the years, yet can be strengthen to the benefit of all.

Budget constraints caused the program to contract over time rather than expand as needed. Because the CRSP is a grant and not a cooperative agreement, the AID program manager can only serve in an ex-officio advisory role. The means of "approving" the grant for technical merit, progress, impacts, and anticipated benefits are delegated to JCORD through BIFAD, which makes recommendations for AID approval. BIFAD and JRCORD consist of university administrators who may be constrained in their ability to critically and thoroughly review all CRSP grants. This process is layered in bureaucracy and over-management.

The AID reporting and administrative requirements demand considerable effort and could be streamlined. The role of JCORD and BIFADEC has been minimal recently and their role and association with the CRSP needs to be reevaluated.

3.4. Efficiency

In 1994, twelve years after the first grant was awarded, the pond dynamics and aquaculture CRSP has become an efficiently performing program highly leveraged and effective with a limited budget. U.S. regional research programs operate at comparable funding levels yet do not have the global scope of this program. The participating universities charge reduced off-campus overhead rates. U.S. principal investigators provide time and resources to support PD/A activities, yet receive little or no funding compensation. The management entity is integrated into the international program at OSU and functions well.

Annual administration costs have varied over the years at usually less than 20 percent of total AID contributions. The management entity budget includes costs not associated with normal management functions. Participating U.S. institutions have contributed an average of 28.1 percent of total AID funds from 1982 to 1993. For this same period, host-country in-kind contributions exceeded 35 percent.

Participating U.S. institutions are fulfilling AID matching contribution

requirements. Host country institutions continue to support activities, although host-country cost-sharing is not required by AID.

Although the pond dynamics and aquaculture CRSP has not directly funded training, many persons associated with the program have obtained Ph.D., M.S., and B.S. degrees at CRSP participating institutions. The "value" of training for 206 individuals leveraged by the pond dynamics and aquaculture CRSP is estimated at more than $3 million.

AID Mission support has been substantial over the years at all host-country primary project sites. This has included funding for facility construction and development, training, program support through PL-480 funds, and contractual services. In the case of Egypt, a "new" PD/A project site was initiated with more than $1 million in funds. Most present and former host-country project sites are associated with facilities that were established in part with AID funds.

The land-grant universities provide considerable undocumented cost-sharing through the sharing of resources, staff and equipment. Universities often cover costs to keep projects on schedule rather than delay activities until AID funds are received. Without this type of fiscal assistance, many projects could not be conducted as planned and critical growing season schedules would be missed.

The land-grant partnership provides an opportunity for sustainable collaboration through their established international and domestic programs and faculty.

The global nature of the pond dynamics and aquaculture CRSP provides an opportunity to complement and enhance the on-going and planned efforts of other international and regional programs directed at aquaculture research and development worldwide. Functional and purposeful linkages need to be formalized and mechanisms developed to leverage resources and talents. There is sometimes a sense of competition and exclusivity which negates the strengths and benefits from interdisciplinary approaches to solving complex situations found in many regions. With the linkage to international and regional organizations there is a stronger likelihood to associate research agendas and priorities to country policies that include land development and environmental protection. The adoption of science-based information to formulate country policies can have long-lasting impacts regarding sustainable agricultural systems.

The pond dynamics and aquaculture CRSP adjusted well to changes in objectives and balancing global experiments with country-specific priorities that have regional and global relevance. The program also addressed development problems and issues through scientific research and on-farm yield trials that have proven to be effective in changing farming practices and human behaviors.

The guidelines for the CRSP were originally developed in 1977 and amended in

1979 and 1985. A revisit and reevaluation of these guidelines to reflect current AID and congressional policies and priorities matched with the strengths and capabilities of U.S. universities in partnership with host-country institutions and private-sector groups could forge new opportunities for confronting and solving global problems.

3.5. Linkages

The pond dynamics and aquaculture CRSP has effective linkages in all host countries to move and deliver research findings to end-users. These linkages include government agencies, nongovernmental organizations, private-voluntary organizations, educational and research institutions, bilateral and multinational donor organizations, and private-sector organizations. Linkages with and support by the AID missions has varied over the years. Most AID missions have been highly supportive of pond dynamics and aquaculture CRSP project activities because of their relevance to host-country and AID mission priorities and support by host-country institutions. The pond dynamics and aquaculture CRSP and participating U.S. universities serve as focal points and contacts for international aquaculture programs in the United States and because of this recognition are continuously establishing new partners and potential collaborators worldwide.

ICLARM has established a network of tropical aquaculture scientists that could be expanded with a more complete inclusion of CRSP researchers. CRSP and ICLARM can integrate their networks to make each more complete and beneficial for contacts and informational exchanges.

3.6. Impacts

3.6.1 Economic impacts

3.6.1.1 International Impacts

- In Honduras, commercial shrimp farming has grown to 11,000 hectares of ponds since 1979 and is now the country's fourth most valuable export with a 1992 raw product value of $40.2 million.

  In collaboration with the Asociación Nacional de Acuicultores de Honduras and local shrimp producers, CRSP researchers determined in on-farm trials that 20 percent protein feed used in rearing ponds produced weights of marketable shrimp equal to those produced in ponds where 40 percent protein feed was used. This research finding has convinced local producers to use the lower protein feed and has reduced their feed costs by approximately one-third for the same levels of marketable output.

  Another study determined that young shrimp do not feed until four weeks after hatching. This single finding saved shrimp farmers one month of feed costs per growing cycle, generating a savings of $975,000 in the first year the delayed feeding strategy was recommended.

Additional savings came from recommendations in a third study to decrease direct feeding of shrimp by using chicken litter fertilizer (250 kilograms per hectare per week) to enrich the shrimp pond environment and thereby indirectly feeding the shrimp. This practice can substitute for processed shrimp feed during the first four to eight weeks of cultivation.

These innovations could result in even greater savings over time in developing shrimp industries in Honduras and neighboring countries.

- Equally important in Honduras is the pond dynamics and aquaculture CRSP research link with government coastal environmental conservation regulations and the development of sustainable shrimp production systems. These related initiatives will determine the sustainable level of expansion appropriate for the Honduran industry. The project activities are also expected to influence commercial development activities in Nicaragua and El Salvador, which also have suitable shrimp farming sites on the Gulf of Fonseca.

- Over a ten-year period, the PA/A CRSP developed and tested technologies on limited-resource farms with production efficiencies of more than 100 percent over traditional tilapia raising methods. Partial enterprise budgets have been developed to compare the financial costs and returns for forty-one production technologies. Several indicate profit potential and are being practiced by farmers with limited resources. Net returns to land, labor, and management ranged from $174 to $542 per hectare.

  In experiments since 1983 in Comayagua, Honduras, stocking male Nile tilapia at more than one fish per square meter in organically fertilized ponds resulted in smaller fish, but not greater fish yields. Increasing the stocking rate to two fish per square meter resulted in greater yield when organic fertilizer was supplemented with urea. The combination of organic fertilization and supplemental feeds increased feed use efficiency if feed was combined with low amounts of fertilizer, or if no supplemental feed was provided until the third or fourth month of fish grow-out. However, economic returns from ponds that received organic fertilizer combined with supplemental feed were no greater than returns from ponds that received organic fertilizer supplemented with urea. Tilapia yields of 3,500 kilograms per hectare were obtained from natural pond productivity alone. Yields increased to 5,300 kilograms per hectare in 150 days when supplemental feed was used, but high feed cost reduced net returns to less than those for fertilizers alone.

  In the absence of a sales price differential based on individual fish size, semi-intensive tilapia culture was clearly profitable for management systems that rely on enhanced natural pond productivity. Production of large tilapia, i.e., > 400 grams, necessitates the use of supplementary feed, but a higher market price for large tilapia is required for this management system to be profitable. Large tilapia generally are produced for export markets. Tilapia harvested from semi-intensively managed ponds can supply domestic markets in Central America. Combined use of organic and chemical fertilizers as nutrient inputs for tilapia ponds requires less capital expenditure then if supplemental feeds are used, and therefore are

appropriate for small- to medium-scale commercial producers who supply domestic markets. (Green, Teichert-Coddington and Hanson, 1994).

Finally, ten years ago in Comayagua, there were few fresh fish available in local markets. Now there are 600 fish farms in the region that provide a stable domestic supply. As a result, the demand for tilapia fingerlings has increased by at least 600 percent from 1986.

The pond dynamics and aquaculture CRSP activities in Honduras have provided the scientific and training foundation that has resulted in the development of large-scale commercial tilapia farms producing export products for the U.S. and European markets. Several large commercial farms are already operating and more are in the planning stage or under construction.

- In Rwanda, pond dynamics and aquaculture CRSP research demonstrated that fish was the best cash-generating crop among traditional crops studied. In 1983, there were no extension recommendations for Rwandan fish farmers. These farmers raise fish for cash income, not home food consumption, and 65 percent of farmed fish are sold in high demand markets. pond dynamics and aquaculture CRSP research developed appropriate production technologies based on local inputs and for fish ponds at various elevations. Within a five-year period, average rural pond fish production increased from 260 pounds per acre to more than 1,300 per acre per year using techniques developed by the CRSP. Some private farms have reached production levels of 5,670 pounds per acre annually. Surveys indicated that participation in fish farming can increase family incomes by 14 percent or more.

- Scientists from the CRSP in Thailand have developed economically efficient fertilizer strategies, i.e., using a combination of organic and inorganic fertilizers, which can produce up to 18,000 kilograms of Tilapia per hectare per year. The new strategies are currently being adopted by 500 small-scale fish pond operators in the Udon Thani Province. In the Nong Khai Province, adoption of the fertilizer techniques by the 100 small to medium operations there could result in increased net income of approximately $2,500 per hectare.

  Supported by the pond dynamics and aquaculture CRSP and the Asian Institute of Technology Outreach Program, the annual production of tilapia in Thailand has increased from 20,000 to 80,000 metric tons in the last five years. Tilapia is now the largest tonnage fresh water fish produced in Thailand. The demand for private sector-produced, sex-reversed tilapia fingerlings has exceeded the current supply, creating new opportunities for fish hatchery entrepreneurs.

  Ten years ago, fish farming failures caused banks in Thailand to withdraw loans. Recent advances in technology have made fish farming a profitable enterprise and the banks are again loaning money for aquaculture. Asian Development Bank loans are also available through Thai institutions and the Thai government is presently subsidizing the construction of thousands of ponds for water conservation purposes. Many of these ponds have potential for fish production, particularly in northeast Thailand.

3.6.1. Domestic impacts

No impacts were reported by CRSP scientists.

3.6.2 Social

The pond dynamics and aquaculture CRSP had an overall goal of increasing food security and nutrition by increasing animal protein through aquaculture in LDCs. One of its specific program objectives included promoting the adoption of CRSP-developed technologies to fish farm families and rural residents. The pond dynamics and aquaculture CRSP has worked in Honduras, Thailand, Philippines, Rwanda, Indonesia, and Panama. The work in Indonesia and Panama terminated early in the life of the CRSP and no documented social impacts have been reported there. This section reports on the social impacts in the other four countries.

Recent socioeconomic studies in Rwanda and Thailand revealed that fish farming has grown rapidly in recent years, though most aquaculturists are small-scale or subsistence producers. Fish culture contributes to nutrition, income and employment opportunities for those adopting fish farming practices, and results from studies show that farming systems are diversified and that fish culture is considered primarily as a cash crop. Aquaculture is considered as an important and often vital production strategy capable of making to positive social impacts.

In Rwanda, more than 25 percent of the fish farmers were women. A socioeconomic study revealed that women in groups had most effectively realized the benefits of fish culture for their families, including children. Land tenure for certain types of land is legally based on land uses approved by the government. The pond dynamics and aquaculture CRSP effectively addressed social policy issues in Rwanda where fish farming is now an accepted land-use practice in the fertile lowlands and marias controlled by the government. There were early revolts against this land-use policy because no information existed. Through CRSP research, fish farming was demonstrated to be a profitable enterprise and an acceptable land-use practice. The CRSP had been so successful in encouraging women to adopt fish farming that a research project was conducted to document the program's success and seek opportunities to structure similar extension programs for women in the region. Unfortunately, the political and military unrest in Rwanda has subsequently caused huge population dislocations and social disruption that threaten all social institutions in the country. The eventual impact on fish farming practices is unknown.

In Thailand, the cooperation between AIT and the DOF resulted in completion of pond fertilization studies, development of extension materials, and plans for more materials and outreach activities. The AIT aquaculture outreach program identified the needs of small-scale farmers and constraints to development of aquaculture as components in farming systems. AIT, which works through DOF extension, took six years

to determine how to develop effective outreach programs to rural farmers. In the first phase (1988–1992) of the outreach program, recommendations for fertilizer use and fry nurseries reached 700 farmers in northeast Thailand and were included in training to 840 people from eighteen government agencies and nongovernmental organizations. Of the farmers known to have received AIT Aquaculture Outreach Program recommendations, 38 percent adopted recommendations during the first year and 55 percent adopted the recommendations during the second year.

AIT Aquaculture Outreach Phase II (1993–1997) has involved collaboration with DOF extension programs that cover six districts in three provinces in northeast Thailand. This technology transfer effort incorporates CRSP results from chemical fertilizer, the combination fertilizer and feed on-station and on-farm, trials with extension materials. This geographical area includes at least 30,000 farms.

In addition, AIT conducted the study "Women in Aquaculture in Thailand," funded by the IDRC. In Honduras, the CRSP has conducted baseline water quality studies to assist in regulatory decisions on the expansion of shrimp farming in the sensitive coastal zone. The Honduran shrimp farming industry provides 8,000 direct jobs and 20,000 indirect jobs, involving 40 percent of the people from depressed economic areas—including employment opportunities to hundreds of women.

In the Philippines, although some research experiments have been completed on developing appropriate fertilization technologies, little outreach to farmers has occurred. Plans are underway to initiate ten on-farm yield trials in collaboration with local agricultural extension agents. This CRSP project has plans to develop extension publications on fertilization recommendations.

A current PD/A project is preparing a comparative framework to provide a socioeconomic database to complement the experimental and biological information generated by this project. One objective is to develop a global integrated framework for considering socioeconomic factors affecting the implementation and sustained development of aquaculture. Data has been gathered from Honduras, Thailand, and the Philippines.

Social scientists in the pond dynamics and aquaculture CRSP have provided baseline information and follow-up impact studies addressing socioeconomic issues and factors in the adoption and sustainability of CRSP developed technologies.

Women have had key roles in all phases of pond dynamics and aquaculture CRSP activities. They include the pond dynamics and aquaculture CRSP director and associate director, U.S. principal investigators and research associates, host-country research associates and students, despite the fact that aquaculture as an academic profession does not attract many women. However, numerous women have been attracted to aquaculture through experiences as former U.S. Peace Corps volunteers. The percentage of women students for different pond dynamics and aquaculture CRSP

training categories are 34 percent, B.S degree; 20 percent, M.S. degree; 26 percent Ph.D degree; and 26 percent nondegree training.

3.6.2. Institutional

The pond dynamics and aquaculture CRSP presence has made significant impacts on national institutions and programs and has contributed to the formation of a global network that facilitates further strengthening of participating institutions. The program has established human resource and research capacities that form the core for sustainable development. The high calibre and dedication of pond dynamics and aquaculture CRSP staff have been the driving force behind a successful record of institutional building. The impacts in the United States cannot be overlooked as universities have strengthened their capacities to contribute to the worldwide advancement of aquaculture through their faculty and students.

CRSP funds have been used to renovate the freshwater El Carao National Fish Culture Center in Honduras and establish two functional water quality laboratories at freshwater and brackish-water sites. Honduras now has the institutional capability to conduct scientific aquaculture research. What is presently lacking are trained Ph.D. scientists associated with the PD/A project, though the training at the technician and M.S. levels has been adequate. El Carao host-country staff now do all spawning and seed production without expatriate supervision. The Honduran project strengthened institutional linkages with national universities and codeveloped curriculum.

The Honduran pond dynamics and aquaculture CRSP brackish-water laboratory is referenced in recently passed environmental conservation legislation as a supporting resource for required water quality monitoring. The linkage with private-sector associations has brought science into the policy-making process.

In Honduras it has been difficult to institutionalize the CRSP within government programs because of limited resources and commitments. Long-term sustainability is more uncertain with government institutions because of the high turnover of staff, low pay, and constant changes in administration. Institutionalization has been more sustainable with private-sector organizations and national universities.

In Thailand the CRSP is fully integrated into AIT, where PD/A scientists are faculty members. The pond dynamics and aquaculture CRSP with AID mission funding constructed a research pond complex at AIT to support the conduct of scientific research studies. AIT is recognized internationally as an excellent center for aquaculture teaching and research. One CRSP principal investigator is 70 percent supported by AIT. The AIT Aquaculture Outreach Program extends CRSP results into Northeast Thailand, Viet Nam, Cambodia and Laos through a network of Indochina institutions.

The pond dynamics and aquaculture CRSP has not been readily integrated into the Thai Department of Fisheries, however, collaboration is improving through on-station field trials and training activities. The CRSP also recently completed construction of ten deep-water rain-fed ponds in the northeast for experimental studies. Additional research ponds were established at the Chaiyaphum and Phayao DOF Fisheries Stations.

In Rwanda, pond dynamics and aquaculture CRSP was associated with the National University of Rwanda through the Ministry of Higher Education. Expatriates became fully integrated into the university and had a tremendous impact on other national institutions. CRSP researchers introduced fish culture and statistics courses in the university curriculum. The Rwasave Fish Culture Station and pond dynamics and aquaculture CRSP marked their ten year anniversary. The government institutions were unstable and opportunities for institution building were more limited. The water quality laboratory is one of the best in East Africa and also serves the needs of other programs. The pond dynamics and aquaculture CRSP presence attracted funds from the European Economic Community to construct 51 additional ponds for research.

In the Philippines, the pond dynamics and aquaculture CRSP is integrated into CLSU's Freshwater Aquaculture Center, which has 93 undergraduate and 16 graduate students. The field research program depends on support from donor funds. Although the CRSP funding is limited it enables faculty to apply scientific research to teach students and benefit farmers.

In Indonesia, CRSP researchers played a major role in curriculum development at the Institute Pertania Bogor.

3.6.3. Anticipated impacts

After a twelve-year investment of funding support, the benefits of pond dynamics and aquaculture CRSP research are becoming more evident as linkages strengthen between researchers, development specialists, and the private-sector. With the beginning of on-farm and off-site yield trials, the field demonstration of CRSP results is expected to have considerable impact as new knowledge and practices reach more farmers.

The conduct of scientific field research, verification of promising results in commercial conditions, and translation of results for diffusion to targeted audience takes years because of the progressive nature of research, periodic delays, and adjustments to often changing circumstances. However, numerous pond dynamics and aquaculture CRSP projects have had fast-adoption rates by the private-sector when they are directly involved in developing and testing the technology.

The access to the CRSP central database and release of the computer software

programs should have broader use as more persons become aware of these decision-support tools.

The stronger integration of socioeconomic aspects in addressing development constraints are expected to accelerate the adoption and diffusion of CRSP technologies. The active expansion into networks with the private-sector and other international organizations should facilitate the broader global application of pond dynamics and aquaculture CRSP research findings.

The development of the revised continuation proposal is expected to strengthen the multidisciplinary approach to problem-solving with greater emphasis on socioeconomic issues, environmental and natural resource conservation issues, and sustainable production systems.

3.6.4. Sustainability in the future

The pond dynamics and aquaculture CRSP provides its greatest impact through the generation of new scientific knowledge that can be translated and delivered to intended beneficiaries worldwide via educational programs and various types of communication methods. The conduct of scientific research whether applied, adaptive, or basic requires facilities, supplies, and scientific knowledge. This implies institution building aimed at facilities, adequate operating budgets, and trained scientists who are directed to problem-solving approaches that are effective in terms of scientific results and positive developmental impacts on society.

The pond dynamics and aquaculture CRSP has accomplished much to ensure or strengthen the opportunities for sustainability. The weakest links are the long-term, sustainable commitment of host-country government agencies and the lack of trained scientists who are engaged in applied field research and on-farm demonstrations. The sustainability of PD/A accomplishments and continued progress will depend partly on the role of aquaculture in country planning and development strategies and its contributions to addressing national priorities.

3.6.5. Thailand

The pond dynamics and aquaculture CRSP funding is small compared to funds from other bilateral donor programs at AIT. Without CRSP funds, the research focus on pond dynamics and production systems will likely continue because of the research interests of the longest residing expatriate principal investigator, who is also committed 70 percent to AIT activities. This research focus is important because no

other in-country program is involved in this type of research. The facilities and training are excellent. The Thailand site is important because of its association with the regional institution AIT.

3.6.6. Honduras

This program is poised to have tremendous impact in establishing commercial development strategies for marine shrimp farming. There is a critical need for an expatriate scientist to direct this effort that involves on-farm research studies, interpretation, and reporting research results. Presently, the expatriate is planning to return to the United States next year after spending ten years with PD/A projects. The shrimp farming private-sector and government can likely support the operation of the water quality laboratory and salaries for lab technicians at Choluteca. This joint private and public-sector support for the freshwater research facility is currently lacking. pond dynamics and aquaculture CRSP or other donor funds will be required to continue its research function or find other donors.

3.6.7. Rwanda

This highly successful program has been suspended because of the recent violent uprising. Any opinions concerning future sustainability cannot be made presently. Reportedly, PD/A project staff in country were directly affected by recent events and several Rwandans are currently pursuing graduate studies in aquaculture at U.S. universities. Their immediate plans are unknown. The pond research facilities were excellent and the pond dynamics and aquaculture CRSP water quality laboratory was a premier facility. The program has had extensive impacts on private fish farming development and government policies.

3.6.8. The Philippines

Research supporting pond dynamics and aquaculture CRSP objectives will not likely be continued without funding for this cooperative research program. The research facilities are excellent and the absence of a resident expatriate appears to be working well, with the exception of delays in data analyses. The Freshwater Aquaculture Center does not have core research funding from host-country sources and depends heavily on soft funds. Funding to support research usually originates from bilateral donor programs or is available through a competitive research grants program administered by PCAMARD. There were plans to include GIFT fish in yield trials using CRSP fertilization guidelines at the Central Luzon State University project site, however, they were not implemented.

Annex H

Fisheries Stock Assesment Collaborative Research Support Program

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1. Introduction

1.1. History

The fisheries stock assessment Collaborative Research Support Program (FSA CRSP) was established under United States Agency for International Development (USAID) Grant No. DAN-4146-G-SS-5071-003 and signed on August 23, 1985; it ended on June 30, 1994. It included a core initial five-year program, a three-year extension and a one-year no-cost extension. The program was an amalgam of two proposals from two university consortia. The proposals were based on a Request for Proposal (RFP) developed by Dr. Brian Rothschild of the University of Maryland Center for Environmental and Estuarine Studies (UMCEES), with funding from USAID. This request for proposal in turn had antecedents to some extent in an earlier workshop in Rome convened by Dr. Rothschild and an extensive survey of fisheries needs of developing countries made by RDA International, Inc., with USAID funding.

Four bodies were required to be established, under USAID guidelines, for the overall functioning of the CRSP:

A Board of Directors composed of institutional representatives was established. It was made up of four members, one from each of the three principal U.S. research institutions (the University of Rhode Island, the University of Washington, and the University of Maryland Center for Environmental and Estuarine Studies) and a fourth member selected from the scientific community at large to represent the management entity. The board dealt with policy issues, reviewed and passed on plans and proposed budgets, assessed progress, and advised the management entity on these and other matters.

The management entity was responsible for administering the grant from USAID and for managing the total fisheries stock assessment CRSP research. It controlled and accounted for funds, coordinated the development of annual budgets and work plans, and reported on progress through annual reports, newsletters, and attendance and presentations at appropriate meetings. Two different management entity directors served during the CRSP term.

A five-person technical committee was also established, with one person each representing the three principal U.S. research institutions, one person representing the University of Costa Rica'a Centro de Investigaciones en Ciencias del Mar y Limnología (UCR-CIMAR), and the fifth representing the University of the Philippines (with representation alternating between the Marine Sciences Institute and the University of the Philippines in the Visayas College of Fisheries). The technical committee met as necessary to develop work plans and budgets, review the progress of the entire program, propose any needed modifications, and recommend fund allocations.

An external evaluation panel was established as the fourth body. Its responsibility was to evaluate the status, funding, and progress of the research program and to make recommendations on modifications to the program. Two highly respected fisheries scientists were appointed to the external evaluation panel at the end of the second year of the fisheries stock assessment CRSP; budget constraints did not permit the planned appointment of three experts at the beginning of the program. Two major evaluations were made, one at the end of the third year of the program, the other in 1993 at the end of the program. Two outside experts were added to the extenal evaluation panel for the 1988 review. One member of the panel resigned in 1990 for conflict of interest reasons and was replaced by an equally qualified fisheries scientist.

Overall evaluation and review, for USAID, of the program and particularly of the management entity's performance toward meeting the CRSP's objectives were provided by advice from the Board for International Food and Agricultural Development (BIFAD) and the Joint Committee on Agricultural Research and Development (JCARD). This advice was based on their participation in the various CRSP reviews, evaluations, workshops, and meetings. Liaison between the management entity and USAID was through the senior fisheries advisor, AID/Science and Technology (AID/S&T), who maintained a close and helpful relationship to the fisheries stock assessment CRSP.

1.2. Review process

This review is based on examination of documentation produced by the CRSP and on personal and telephone interviews with the principal investigators, the associated researchers, the mangement entity directors, USAID personnel, an external evaluation panel member, and two board members. Site visits were made to the University of Maryland Center for Environmental and Estuarine Studies, University of Washington, and University of the Philippines Marine Scineces Institute (Manila and Bolinao). Funding limitations precluded a site visit to Costa Rica.

Appreciation and thanks for their participation and courtesies is extended to all the persons interviewed.

1.3. Objectives

Fish products are an important source of protein for many developing countries. Fisheries in these countries are frequently overexploited and poorly managed. An adequate scientific basis for the rational use and management of fisheries resources is essential if long-term sustainable benefits are to be attained. A fundamental scientific need is a knowledge of the size of the stocks of fish. Most fisheries stock assessment techniques were developed for temperate, single-species, industrial fisheries and are not particularly useful for tropical marine fisheries, which are principally multispecies and artisanal. Most U.S. fisheries researchers have modest, if any, interest in tropical marine fisheries stock assessment.

This CRSP was designed to improve stock assessment methodologies for small-scale and multispecies tropical fisheries, to provide stock assessment advice to fishery managers, and to train U.S. and host-country fisheries scientists.

It should be noted that the fisheries stock assessment CRSP differs from other CRSPs in that it was discipline oriented. The outputs were to be contributions to fisheries science and subjective in many respects. The CRSP was designed to contribute to knowledge of and improvements in tropical fisheries stock assessment methodology and management rather than to make specific stock assessments or to lead to immediate increases in tropical fisheries productivity.

Specific objectives included

- Production of a stock assessment handbook (hereinafter called the "Manual") for fisheries managers in tropical countries—a manual that would provide a key for optimal fisheries stock assessment and management, given the problem and available resources.

- Testing and extension of existing methodologies for stock assessment as it applies to tropical fisheries.

- Development of new methodologies for fisheries stock assessment in tropical developing countries.

- Development and testing of multispecies fishery management models.

1.4. Participating agencies and program description

The fisheries stock assessment CRSP was able to attract several of the leading U.S. fisheries scientists in the field including principal investigators Vincent Gallucci (University of Washington), Brian Rothschild (University of Maryland Center for Environmental and Estuarine Studies), and Saul Saila (University of Rhode Island). In the early years of the program, Lee Anderson (resource economist, University of Delaware), William Fox (University of Miami), and Daniel Pauly (International Center for Living Aquatic Marine Resources Management) were collaborating researchers.

Technical research efforts in eight separate projects were planned. These were

- The University of Maryland Center for Environmental and Estuarine Studies (UM-CEES) and the University of Costa Rica, Centro de Investigaciones en Ciencias del Mar y Limnología (UCR-CIMAR).

  - Multiple species fisheries research
  - Economic and probabilistic extensions of standard fisheries models

- The University of Washington and University of Costa Rica–CIMAR.

  - Sampling catch and abundance
  - Age and size dependent/independent modeling
  - Age and size relationships and consequences of errors
  - Shallow water hydroacoustics

- The University of Rhode Island, the University of the Philippines Marine Sciences Institute (UPMSI) and the University of the Philippines in the Visayas, College of Fisheries (UPVCF).

  - Empirical analyses and modeling (with UPVCF)
  - Multiple field studies (with UPMSI)

The University of Maryland at College Park was selected as the management entity. The program office was located in the Office of International Programs of the College of Agriculture at the University of Maryland at College Park.

The College of Business and Management of the University of Maryland at College Park, the University of Delaware, the University of Miami, and the International Center for Living Aquatic Marine Resources Management (ICLARM) were also collaborators in the fisheries stock assessment CRSP.

Two principal approaches were taken to meet these objectives. The first involved development of theoretical considerations based on the use of in-country fisheries data previously collected in each of the host countries, particularly between the University of Maryland Center for Environmental and Estuarine Studies and University of Costa Rica–CIMAR and between the University of Rhode Island and the University of the Philippines in the Visayas College of Fisheries). The second approach involved fieldwork in the host countries, particularly between the Universit of Washington and the University of Costa Rica–CIMAR and between the University of Rhode Island and the University of the Philippines Marine Sciences Institute.

Interestingly, collaboration between the U.S. universities and the two host countries took quite diverse philosophical approaches. The University of Maryland– CEES and University of Washington investigators previously decided that the collaborative relationships with the Costa Rican researchers would consist of extensive foreign travel among the institutions, with lectures, workshops, and training sessions at the three locations, in addition to the local fieldwork in the Gulf of Nicoya, Costa Rica. The University of Rhode Island's investigators, contrarily, decided that their collaborative emphasis with the University of the Philippines' Marine Science Institute would be by locating an on-site U.S. researcher at the multiple field studies site area at Bolinao in the Philippines, although some amount of foreign travel for workshops and meetings would be included.

1.5. Funding

The fisheries stock assessment CRSP was planned as a five-year $6-million program ($1.2 million per year) and accepted as such by USAID. Even before the CRSP was officially underway, however, the funding was reduced to $1 million per year, and then further cut during the first year to $800,000 per year. Another funding reduction was made in 1988 to a $700,000 annual level, and yet another in 1991 to a $600,000 annual level (table H.1.5.1). When adjusted for inflation, the originally planned annual budget level in 1985 of $1.2 million had been reduced to slightly more than $400,000 by 1992.

Table H.1.5.1. Fisheries stock assessment CRSP budget allocations, 1985–1994

Date of Allocation	*Period Covered*	*Number of Months*	*Allocation (in $'000s)*	*Notes*
8/23/85	7/1/85-12/31/85	6	500	
1/1/86	1/1/86-7/31/86	8	600	
7/1/86	8/1/86-12/31/86	5	200	
1/1/87	1/1/87-4/30/88	16	895	
4/25/88	5/1/88-4/27/89	12	700	
1/5/88	-- -- -- --		15	For rev.
4/25/89	4/28/89-4/23/90	12	700	
4/25/90	4/23/90-4/23/91	12	704	
4/10/91	4/23/91-8/23/91	4	200	
7/22/91	8/24/91-4/23/92	8	400	
4/20/92	4/23/92-4/24/93	12	600	
{6/14/93	4/25/93-6/30/93	2	100}	
{6/14/93	7/1/93-12/31/93	6	---}	No cost
{2/15/94	1/1/94-6/30/94	6	---}	No cost

In addition to the continuing erosion of the fisheries stock assessment CRSP budget during its term, the allocations themselves to the U.S. universities were made erratically. Funding covered periods ranging from 4 to 12 months at a time and, sometimes, were made after the beginning of the period being funded (table H.1.5.2). The continued reductions in funding and persistent delays in authorizing and processing the allocations caused a considerable amount of time to be spent within the CRSP on replanning program activities and on revising interparticipant allocations. The budgetary disarray led to considerable discomfort and disillusionment within the CRSP.

Moreover, the inconsistency of the funding allocations required the CRSP to be tided over financially from time to time by an affected participating University. This

created serious problems twice at the University of Washington, with lesser disruptions at the University of Rhode Island and at University of Maryland–College Park and University of Maryland Center for Environmental and Estuarine Studies, where ad hoc "borrowing" mechanisms were more available than at University of Washington.

Table H.1.5.2. Annual Funding Rate

Planning basis	*$1,200,000*
7/85 - 2/86	1,000,000
2/86 - 4/88	800,000
5/88 - 4/91	704,000
4/91 - 6/93	600,000

2. Findings

2.1. Substantive achievements

- 105 working papers (titles and authors listed in Chapter H-4). Many of the program reports were converted into publications in referred journals. These are included among those listed in ii (below).

- Fisheries stock assessment CRSP related publications (titles and authors listed in Chapter H-5).

- The "Manual" as specified in the objective, with accompanying software.

- The "Advances in Stock Assessment of Artisanal Fisheries" ("Advances"). This is a more substantive and formal version of the manual. The book, now being prepared for a form of publication different from that originally planned, is still undergoing editorial and format revisions even though the CRSP has ended. It is one of the principal achievements of the fisheries stock assessment CRSP and represents a substantial effort on the part of the researchers involved. It is praiseworthy that a program with as many diverse components and participants as this and with such funding difficulties throughout its term should leave as solid a legacy as this book. "Advances" contains an excellent literature review on stock assessment methodologies for tropical and artisanal fisheries, and provides a good overall view of whole fields in the discipline. Although not exhaustively comprehensive, the contents of the book and the computer algorithms for stock assessment included in the software will provide a solid basis for teaching. As well, the material presented will be an excellent foundation for continued research and development of stock assessment methodologies for tropical marine fisheries.

  "Advances" contains 10 chapters—an introductory one, eight dealing with the CRSP research results and applicability, and a final chapter on systems approaches to fisheries management. They represent, in essence, the record of the substantial scientific and technological accomplishments of the fisheries stock assessment CRSP in the spheres of determining age in tropical fish, using fish size for tropical fisheries stock assessment, sampling coral reef fisheries, sampling tropical fisheries, using hydroacoustic methods for fish abundance estimates, developing models for the analysis of fisheries time series date, developing and applying empirical models for tropical multispecies stock assessment, and describing a system approach supporting fisheries management decisions. Brief abstracts of the latter nine chapters of the book are given in chapter H-6.

  Overall, the contents of "Advances" and the results of the researches have made useful and forward-looking contributions to the knowledge base for tropical marine fisheries assessment. However, the originally conceived wider scope of applicability of the results to a broad base of tropical marine fisheries was not attained

because of the research limitations imposed by the funding cuts made during the period of the CRSP.

2.2 Training outputs

Both training and information transfer were elements of the fisheries stock assessment CRSP in the practical development of the several objectives. Training outputs were limited initially because USAID and BIFAD instructed the CRSP not to use funds for their purpose (fisheries stock assessment CRSP Management Review, 1988, p. 4). After the Triennial Review and based on its recommendations, the joint CRSP Review Committee of JCARD and of the Agricultural Sector Subcommittee recommended that both training and information transfer activities be undertaken. The training, already well started, continued but at a later reduced level because of budget cuts. Information transfer to fisheries managers was scarcely begun, for lack of funding and time.

- A principal means of training, both informal and formal, is the exchange of research personnel among the participating countries and attendance at workshops and training sessions of varied lengths. Financial limitations, particularly after the 1991 reductions, limited these interchanges but those that did occur were useful and positive. Some examples are: one-on-one training in Costa Rica on fish aging techniques; small group training in the Philippines on fish species identification; and microcomputer software training at several locations. More formal, large-scale training programs included a two-month course at University of Washington on "Quantitative Management of Artisanal Fisheries" and three training programs at University of Rhode Island in 1987. Numerous smaller sessions were also held at the several CRSP sites on an array of topics pertinent to the research objectives. Many training sessions and workshops included participants from countries such as Brunei, Kuwait, Malaysia, and Indonesia, in addition to those involved in the CRSP.

  An important expanded technical committee meeting was held in Costa Rica in January 1990. The drafts of the CRSP stock assessment manual were reviewed and discussed in depth, as were other technical CRSP matters. Twelve CRSP investigators, a member of the EEP, the program manager and the USAID senior fisheries advisor attended the meeting.

  Further, throughout the term of the CRSP, there were opportunities to participate in professional society meetings, symposia and non-CRSP workshops, all of which contributed to broadening the perspectives of the CRSP participants. Of interest among these was a special symposium on "Fisheries Management in Developing Countries" which was held as an adjunct to the American Fisheries Society meeting in Toronto in 1988; the symposium was organized by CRSP participants, and CRSP research was a major element of the session.

  Two major final in-country workshops, based on the contents of the "Manual," were held as specified in the work plan, the first at the University of Costa Rica in March 1993 and the second, in June 1993, in the Philippines at the Bolinao Marine Laboratory. These consisted of formal presentations by invited researchers and by

the persons participating in the CRSP; hands-on work with the new software; and intensive working sessions with in-country data on practical in-country fisheries problems. Each workshop was attended by participants from the other host country's CRSP group. Lessons learned at the first workshop in Costa Rica served to improve the second workshop in the Philippines, in that the hands-on sessions were even more relevant to the participants' problems and level of training.

A third workshop, sponsored by UCR-CIMAR, was held in Costa Rica in May 1994 during the no-cost extension period of the CRSP. It was a follow-up of the 1993 Costa Rica workshop and aimed at providing additional hands-on training for regional fisheries researchers and managers. Representatives of five Central American countries (including Costa Rica) and Panama attended.

- Formal degree programs.

At least 56 persons received formal training directly with or were supported in part by the CRSP. A listing is given in chapter H-1, along with any additional data were available for each person. Eleven students were from Costa Rica, 16 from the Philippines, 17 from the United States and 12 in total from Ecuador (1), China (2), France (1), Japan (1), Morocco (2), Portugal (1), S. Korea (1) and Taiwan (3). Of those 42 students for whom gender data are available, 13 are female (nine from the Philippines) and 29 are male.

From the available records, seven Post-Doctoral students were supported; nine PH.D and 17 MS/MA degrees were granted; and four Ph.D. and two MS students are at the candidate stage. Theses titles are given in chapter H-7.

U.S. and Philippine students are well represented in the listing of students granted graduate degrees. Three of the Philippine graduates (one male and two females) are presently pursuing their Doctorates in Europe. A fourth Philippine graduate (male) is a Ph.D. candidate at USC, while on a leave of absence from his position as leader of the Coastal Living Resources Project (CLRP) AUS-ASEAN. A fifth Philippine graduate (female) has earned her Doctorate in France and is employed at ICLARM in Manila.

Although, of the eleven Costa Rican students, only one is listed as having been granted a CRSP-supported graduate degree, each spent a significant and meaningful period of time at the U.S. university campuses, particularly at the University of Washington. Personal interactions between these Costa Rican students and the U.S. researchers and other graduate students permitted a ready and productive transfer of technologies, processes, and research approaches.

- Informal.

On-the-job training was offered to students throughout the duration of the CRSP in both host countries. This generally provided support for them to continue their education. The principal mode, though, of informal training was through the variety of sources discussed in sections 2.1 and 2.2 above—workshops, interpersonal contacts, attendance at scientific meetings, observation, presentation of results, visits to foreign work sites, and the like.

2.3 Technologies

This CRSP, as noted, was an amalgam of two divergent proposals made to USAID and, at its core level, involved co-equal research teams (and their individual perspectives) from three U.S. universities. Further, the CRSP was managed by an entity which had no serious technical involvement in the program. A fundamental difference between the two proposals was of that whom to address the final written product (first targeted as a manual and then evolving into a book)—whether to fisheries managers or to fisheries researchers. The EEP, in its October 1988 report on the Triennial Review, noted the diversity of approaches within the fisheries stock assessment CRSP and acknowledged that there had never been sufficient funding to permit the extensive leadership and coordination efforts needed to deal with this issue. The panel went on to say that the diversity was, "on the other hand," also a strength of the CRSP and concluded that "merging these approaches into a single tightly coordinated program does not seem feasible, nor is it necessarily desirable."

Thus, the issue was never resolved. The components of the book ended up being approached from different viewpoints and assembled post hoc into a whole. "Advances" neither satisfies fully the developing country scientists nor the advanced stock assessment researchers in the developed countries. The fisheries scientists in the developing countries have been left with some chapters and methodologies which require a strong mathematical background to be understood and applied. The advanced fisheries researchers have in their hands a less than complete volume on tropical fisheries stock assessment, lacking important contemporary elements such as environmental effects and food web models, or new developments in production modeling.

Given this divergence in the audience being addressed, individually the array of new and improved technologies, analytical approaches and computer software produced by the fisheries stock assessment CRSP is well detailed in the forthcoming "Advances." The precis of each chapter of the book given in chapter H-6 provide a quick overview of the advances made in the sampling, coral reef surveys, fish aging, acoustics, and systems approaches fields, among others.

Some of the PC-based computer programs developed by the fisheries stock assessment CRSP investigators (and to be included with the "Advances") are:

- AGECOMP, for determining the optimal sampling for estimation of an age-length key.
- CANOFISH, which provides a prototype fisheries expert decision support system.
- CASA, which provides the means for a catch at size analysis; it is now being used in several places around the world for fisheries management.
- CORECS, which provides a tropical fishery system model for simulating continuous recruitment to the fishery.

- LCAN, which provides length cohort analysis, and is now used as a standard methodology for length based stock assessment.

- NETOPTIMUM, which provides a technique for estimating the optimal combination of fishing effort and gillnet sizes to maximize yield and minimize the risk of overfishing.

All represent useful and important advances in the continuum of the development of techniques for better understanding and managing tropical marine fisheries.

2.4. Intangibles

The intangible effects of this program should leave their mark on fisheries research in the two host countries for years to come. The CRSP has left a cadre of fisheries students, fisheries professionals and university faculty interested in fisheries research in both Costa Rica and the Philippines. They have become aware of fisheries problems, and have learned how to develop and undertake research to attack them. By example from the U.S. investigators and from other relationships developed during the CRSP, the host country participants have been reminded or become aware of the value of literature searches and reviews, and of the importance of the scientific method and its rigors. Collegial contacts and networking relationships have been established which can only serve to maintain and foster serious fisheries research. These host country investigators will contribute to fisheries management and to the continuing development of fisheries professionals in their countries and will undoubtedly contribute to the dissemination of tropical marine fisheries research and management capabilities within their broader geographic region (as, for example, with the May 1994 workshop in Costa Rica).

For the U.S. investigators, the fisheries stock assessment CRSP has provided an opportunity to broaden their research horizons beyond those of U.S. fisheries. Participation in the CRSP has given them an understanding of the fisheries problems and research difficulties in areas less developed than some may have been accustomed to. This awareness will provide a better understanding of the quality of fisheries data from developing countries, a sense of the urgency for developing methodologies to deal with tropical fisheries stock assessment and management issues and an understanding of the need to provide those methodologies in readily assimilable forms. All of this will lead, in the long term, to an improved ability of U.S. researchers to provide advice for managing both U.S. and tropical fisheries.

2.5 Linkages

Based on the close interactions developed during the CRSP through inter-personal relationships, workshops, foreign travel and training, strong formal and informal linkages continue between the host countries and the U.S. universities.

Further, an expanding series of linkages between host country researchers and national and international institutions has developed, based to a great extent on increased host country capabilities and awareness of needs.

Examples of organizations with whom these linkages have been made are:

- Food and Agricultural Organization.
- International Development Research Center (Canada).
- U.S. Peace Corps.
- Coastal Living Resources Project AUS-ASEAN.
- U.S. National Marine Fisheries Service.
- International Center for Living Aquatic Resources Management.
- Agency for International Development (several projects).
- World Bank.

Not readily quantifiable but obviously present are the internal in-country linkages which continue at the personal informal level among former CRSP participants and students now employed at university, government, and private-sector levels. These linkages are at both the research and policy levels. Employment locations for some students are given in Annex I, List of Contacts..

3. Conclusions

3.1. Fulfillment of goals and objectives

3.1.1. International impacts

No economic impacts reported to date.

3.1.2. Domestic impacts

No impacts were reported by CRSP scientists.

3.2. Relevance

The fisheries stock assessment CRSP researchers established self-imposed limits on their work, both to focus their research and to forestall duplication of the work of other researchers in the field. Thus, for instance, in Costa Rica work was by choice focused on the artisanal corvina fisheries rather than on the more valuable but industrialized shrimp fishery. The CRSP researchers also avoided duplicating the work of FAO, ICLARM and other non-CRSP researchers who were also working in the tropical fish stock assessment arena and preparing assessment training courses and associated software.

This fisheries stock assessment CRSP has provided theoretical advances in systems design for tropical marine fisheries management, delineated the information and data required to do so, exhibited the systems pathways and presented the possible alternative forms of the fisheries management arising from these system designs.

The CRSP research results have directly improved the capability to assess and manage tropical fisheries in the host countries and in other regions through

- improved fish catch sampling methodology in Costa Rica.
- the technical ability to provide recommendations on the appropriate mesh size of fish nets in the Philippines.
- the presentation to the researchers of both host countries of a range of software programs that can be used with a simple user interface to make basic stock assessment data analysis calculations.

The results of the coral reef studies in the Philippines have shown the specific negative effects of present reef-fishing methods. Solutions, now being pursued by Philippine authorities, have been offered for improved coral reef fisheries management and for amelioration of the fishery-associated problems.

In the long term, the fisheries stock assessment CRSP has been a useful and productive step in the continuing process of improving the ability to assess the stocks of tropical marine fishes, at both the theoretical and applied levels. Work within this CRSP has stimulated scientific discussion and research approaches to the stock assessment problem and has raised the general awareness of the research community to further information requirements.

However, it must be explicitly noted that the fisheries stock assessment CRSP outputs and results speak to and are directed at fisheries scientists and researchers. With some few exceptions, the results have not been translated for the ready use of fisheries policymakers and managers. Extension of the CRSP results to these users is a necessary and logical step of the Program which remains yet to be done. Although an extension phase was not included in the original planning, it might reasonably have been undertaken had the term of the CRSP been further extended.

3.3. Effectiveness

The fisheries stock assessment CRSP has maintained high standards in terms of self-criticism, internal workshops with invited experts, peer-reviewed publications, and two major reviews by the External Evaluation Panel. There has been excellent interchange on theoretical issues, particularly about the research design and approaches, at the 1988 Toronto and the 1990 Costa Rica workshops (where extensive in-depth methodological and programmatic discussions were held) and at the two final principal workshops in Costa Rica and the Philippines.

The quality and relevance of the manual to be produced by the CRSP became increasingly apparent in the later years of the CRSP. As a consequence, a decision was made to enhance its significance and effectiveness by presenting the material in a more permanent book form, along with the associated software.

The October 4, 1988, 'Corrected Version' of the EEP's Triennial Review recommended modifications in some of the research and procedural areas of the fisheries stock assessment CRSP. Based on the recommendations, the CRSP Continuation Proposal was revised and resubmitted in May 1989. To give an indication of the responsiveness with which the program reacted to the EEP's recommendations, some few of the revisions and changes made in the CRSP and in the continuation proposal in reply to the Triennial Review are given below:

Recommendation: That the CRSP develop a more specific research proposal.

Action: The CRSP technical committee substantially revised and extended the

work plans and objectives of the continuation proposal and incorporated them into the continuation proposal amendment. The technical committee also revised and extended its work plan for program coordination and integration.

Recommendation: That communications should be improved among CRSP researchers.

Action: Curtailed budgets limited researcher travel, but mail and telephone communications among the technical committee members were increased. Data sharing among the institutions was accelerated. Efforts were made to produce working papers in early versions for distribution. The suggestion that annual scientific meetings of the CRSP investigators be held led to the January 1990 expanded technical committee meeting in Costa Rica. These exchanges were limited during the later life of the CRSP (except for the two close-out workshops for which funds were put aside) again because of budget limitations. An increased percentage of funding requested in the continuation proposal amendment was earmarked for more travel within the CRSP, but this too fell by the wayside with the later decreased funding allocations.

Recommendation: That the details of the University of Maryland–Center for Environmental and Estuarine Studies/University of Costa Rica "Multiple Species Fisheries Research Project" be made more transparent.

Action: The CRSP reminded the EEP that the vague `black box' referenced in the Triennial review had been described both in a Ph.D. dissertation and in a draft outline of a User's Guide for CANOFISH II.

Recommendation: That the University of Washington/UCR program be restructured from four projects to two.

Action: The hydroacoustic and aging components of this program, having made substantial progress in the initial years, were scaled down substantially in the continuation proposal amendment. Suggestions by the EEP regarding the clarification and refocussing of the hydroacoustics project were accepted, although the project became a minor component during the latter years of the CRSP.

Recommendation: That the University of Rhode Island/UP program extend the empirical model, and provide documentation for its software programming.

Action: The team undertook to provide documentation for the initial empirical model and to provide documentation and software for additional empirical models. The team also proposed to address the problem of transferability of the results of the studies in sotheast Asia to other geographic areas.

However, some principal changes in the scope and activities of the program were occasioned less by serious scientific review than by a continuing diminution of the funds provided by USAID to the CRSP. As the budget reductions impacted the re-

search program, several key scientists (among those, Drs. Houde and Assad from UM, Dr. Anderson from Udel and Dr. Fox from Umiami) were dropped from the program. The reductions also impacted the CRSP heavily by making it impossible to expand the research program to the original planned level. The financial constraints also restricted graduate training of host-country students at U.S. universities, because of limited funds for graduate student assistantships. The consequences of this continuing reduction in funding, among others, were the reduced general applicability of the theoretical systems analyses, reduced scope of the planned field studies, decreased interinstitutional and interhost country travel and relationships, and limited equipment and supplies.

While the consequences of these budget reductions were serious, they were ameliorated to some extent by two factors. First, the U.S. universities and the host country institutions, throughout the term of the CRSP, provided more (28 percent) of the total USAID expenditures for research than the 25 percent level called for in the original budgets (table H.3.3.1).

The second factor was the dedication of the researchers themselves and of the senior fisheries adviser, AID/S&T to the completion of the program, so that often ways were found to continue activities in spite of reduced funding. For example, the decision to produce a book instead of the manual required major format and editorial changes in the materials already prepared for the manual. This work was undertaken by the program participants under a 1-year no-cost extension of the CRSP with final wrap-up and publication efforts continuing now beyond the June 30, 1994, termination of the fisheries stock assessment CRSP.

Table H.3.3.1. Research Expenditures to Date by University

	Actual		Budgeted	
University	USAID	Matching	USAID	Matching
Univ. of Washington	1,639,670	370,015	1,644,650	374,700
Univ. of Maryland–CEES	1,287,100	347,793	1,287,100	307,900
Univ. of Rhode Island				
Total	4,581,320	1,286,889	4,586,300	1,064,200
		M/A = 28%		M/A = 25%

(Does not include management entity expenditures.)

The management entity worked effectively, dealing with administrative activities; providing annual reports, documentation of CRSP activities, and an occasional newsletter (previously discontinued); and furnishing a continuing central focus for the program. The management entity's major problems were dealing with the reduced funding, and with the consequences of erratic and delayed transfer of funds from USAID. For example, the management entity twice intervened directly with University of Washington officials to obtain transition funding for the CRSP component there which was in danger of closing down for lack of funds. The management entity was also involved from time to time in arranging transition funding for

the UM components, but the situation was never as serious as tht of University of Washington. The capabilities of the management entity's office were also directly affected in that permanent staffing support was lost and travel was curtailed.

Although the EEP was designed to be a permanent three-person entity, it in fact did only two reviews, one in the third and one in the last year of the program, with a two-person permanent complement (two scientists were added to the panel for the Triennial Review). The input provided to the fisheries stock assessment CRSP by the EEP contributed at two equally important levels. The first was through the formal review report, which commented on the overall directions and prosecution of the research, and made specific recommendations to the Board and to the technical committee. The second important input of the EEP was through direct face-to-face intellectual interchange with the CRSP participants in the field, who considered them to be fresh, stimulating and constructive.

The technical committee acted in two roles, one resulting from budgetary necessities and the other, its true role, resulting from a deep commitment to the quality of the program's research. A goodly portion of the committee's time, on occasion, was spent revamping the program to deal with the budget cuts; this activity started in the first months of the CRSP and culminated in major budgetary and program changes which had to be agreed on during the development of the continuation proposal amendment. Allocation of the reduced funding was never easy, particularly when across-the-board cuts were no longer feasible and major program changes had to be made. (In response to the negative effects of the budget cuts—a diversion of the technical committee's role, exasperation, palliative cuts instead of programmatic ones—one principal investigator stopped attending the technical committee meetings after the second year and instead sent a delegate.) There were, however, also good technical committee working sessions where serious technical, programmatic and planning issues were dealt with, and the committee was able to provide constructive advice to the Board and to the individual projects. The technical committee was also particularly effective in preparing the continuation proposal and its subsequent reduced-budget amendment. The technical committee was also substantially involved in the decision to replace the planned "Manual" with "Advances," and in the development of guidelines and responsibilities for its preparation.

3.4 Efficiency

As noted above, all the organizations within the CRSP went beyond the norm in order to keep the program alive and moving. Advantage was taken of attendance at non-CRSP scientific meetings for CRSP participants to get together for scientific and programmatic discussions, as happened at the American Fisheries Society meeting in Toronto in 1988. Graduate students, always an inexpensive source of labor, were employed extensively throughout the several CRSP projects. Host country facilities - laboratories, existing fisheries data, university faculty - and existing U.S. university facilities - computers, other faculty, laboratory facilities - were used to good advantage in gaining cost efficiencies.

For a variety of reasons, active assistance from and cooperation with the USAID Missions in the host countries was not always available to the fisheries stock assessment CRSP. The USAID Mission in the Philippines started a new Coastal Research project—"Sustain." It is working with the environmental office of USAID with and virtually ignores the results of the fisheries stock assessment CRSP.

The single formal buy-in to the CRSP was the Oman Fisheries Stock Assessment Project, which was completed in July 1990, by University of Washington for approximately $50,000. Two small informal buy-ins by the Tinker Foundation and one by FAO for workshops in Central America were made to University of Washington.

3.5. Impacts

Inasmuch as this CRSP was discipline oriented, no immediate direct economic impacts are evident nor were any expected. In the longer term, however, as the fisheries management techniques are improved and translated for and used by the tropical marine fisheries policy-makers and managers, it can be anticipated that significant positive economic and social impacts will occur as these fisheries become more rationally managed.

A specific example of an imminent (three to five years away) such social and economic benefit is that of the reef fishery off Bolinao in the Philippines. The fisheries stock assessment CRSP results clearly showed overfishing, reduced numbers and sizes of fish, inappropriate and dangerous fishing methods (blasting and cyanide poisoning) and a failure to exploit alternative fishery resources in the area. In a book published in the Philippines on the results of the CRSP reef studies,[18] Dr. J, McManus, the on-site researcher and principal author of the book, presents recommendations for establishing a sanctuary area and for alternative fisheries (cultivated giant clams and cultivated sea grass) in the reef area. A Community Development proposal is now in draft form at UPMSI requesting funding from the Canadian International Development Research Center (IDRC) for a 3-year program to introduce Dr. McManus's recommendations at the grass roots level for community-based action. Prospects seem excellent for funding and for positive results.

Another example is the Catch at Size Analysis (CASA) methodology developed by the fisheries stock assessment CRSP, a sophisticated size-based stock assessment program based on stochastic optimization techniques. It can be tuned with other fisheries data that may be available, to enhance the solution. The methodology was successfully applied to the Gulf of Nicoya, Costa Rica corvina fishery, data from which were supported by CRSP-obtained hydroacoustic data from the same area. The analysis was used to specify an optimal mesh size and fishing effort combination for the corvina fishery, which results in optimal yield while accounting for the need to maintain an adequate spawning biomass. The use of CASA has clear implications for

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18. McManus, J., C. Nanola, R. Reyes, and K. Kesner, "Resource Ecology of the Boliano Coral Reef System," ICLARM, *Stud. Rev.* 22., 1992, 117 p.

improved fisheries management not only in Costa Rica but in other areas of the world. It has been introduced to researchers in central America, Argentina and Chile, and is currently being reviewed for use by the FAO Fisheries Department where it is being applied for the assessment of tropical marine fisheries stocks. The user-accessible software supplied with "Advances" will facilitate the application of the CASA methodology.

Important social and institutional impacts made by the CRSP include reinforcement at the host country universities of the use of the scientific method, and the introduction of new analytical approaches and techniques. The fisheries stock assessment CRSP has been especially effective in supporting graduate students in the Philippines, essentially because of the on-site presence of Dr. J. McManus, the CRSP researcher. Most of the students associated with the CRSP have graduated with MS degrees, several have gone on to doctoral studies outside of the country, and most are still involved with fisheries-related matters at the university, in government positions or with ICLARM chapter H-4.

This is not to imply that an on-site researcher within a CRSP is the only approach to host country student and researcher development. Direct U.S.-host country teaching and mentor relationships have been very effective in bringing host country participants along, both in Costa Rica and the Philippines. It is unfortunate that budget cuts leading to limited foreign travel aborted the continuation proposal's request for maintaining the intensive UM/UW-UCR-CIMAR interchanges of each country's researchers. Early indications show that this interchange methodology is as effective as the on-site researcher mode for researcher training and development, but definitive data are not available. The empirical result, though, is that the fisheries stock assessment CRSP has had a greater positive impact on Philippine students than on Costa Rican students.

The institutional impact of the CRSP has been strong. In two separate instances, for example, one at University of Washington and the other at UPV, faculty research statisticians (Dr. Loveday Conquest and Dr. Sonia Formacion, respectively) each a member of her university's mathematics department, became involved with the CRSP studies. Each has made significant and innovative cross-over contributions to the analyses of fisheries statistics by bringing a outside viewpoint to the field. Both have been published in the fisheries literature and both remain interested and involved in fisheries statistics analyses. Dr. Formacion has just recently chaired a session on fisheries statistics at a conference sponsored by the Philippine Council on Research and Marine Development.

A lasting long-term impact which has resulted from the fisheries stock assessment CRSP has been the development of a number of network relations at the personal and formal institutional levels (see above, 2.5.).

The long-term sustainability of the results of the fisheries stock assessment CRSP is bolstered by:

- the formal and informal networks associated with the CRSP.
- the introduction of new theories and technologies for tropical marine fisheries management.
- the strengthening of university faculty, both current and potential.
- the demonstration and introduction of appropriate protocols for fisheries data collection and management, and procedures for data analysis, on a continuing basis, of tropical marine fisheries.
- "Advances" and its attendant software, as a source of data and methodology, and as a stimulus for continued discussion and research in the field.

4. List of Fisheries Stock Assessment Collaborative Research Support Program Working Papers

No.	Date	Title/Author(s)
1[a]	5/87	*An Empirical Approach to Multispecies Stock Assessment* Paul B. Saila and Karim Erzini
2[a]	5/87	*Geometric Programming Applied to Some Optimal Harvesting Problems* Saul B. Saila and Karim Erzini
3[a]	5/87	*A Comparison of the Relationship Between Optimal Harvesting Strategies and Reproductive Values in Four Marine Species with Different Life History Characteristics* Saul B. Saila and Karim Erzini
4[a]	6/87	*Status of Philippine Stocks: An Overview* G.T. Silvestre and S. Gananden
5[a]	6/87	*Effect of Incorporating Sigmoid Selection on Optimal Mesh Size Estimation for the Samar Sea Multispecies Trawl Fishery* G.T. Silvestre and M.L. Soriano
6[b]	5/87	*Feasibility of Relating Recruitment to Environmental Variables* B. Rothschild
7[b]	5/87	*Expert Systems, Microcomputers, and Operations Research* Arjang A. Assad and Bruce L. Golden
8[c]	5/87	*Some Impacts of Remote System Technology on Future Fisheries Management* R.E. Thorne
9[c]	5/87	*Hydroacoustics and Ground Truth* R.E. Thorne
10[c]	10/87	*The Use of Stationary Hydroacoustic Transducers to Study Deil and Tidal Influences of Fish Behavior* R.E. Thorne, John Hedgepeth and Jorge Campos

[a]University of Rhode Island/University of the Philippines
[b]University of Maryland/University of Costa Rica
[c]University of Washington/University of Costa Rica

11[c] 10/87 *Optimal Sampling for the Estimation of Age-Length Key: Analysis and the Program, "AGECOMP"*
Han-Lin Lai and V.F. Gallucci

12[c] 10/87 *User's Guide for the Program 'LCAN' (Length Cohort Analysis) and an Overview of the Underlying Analysis*
Han-Lin Lai and V.F. Gallucci

13[b] 12/87 *Comparison of Two Length Frequency-Based Packages Used to Obtain Growth and Mortality Parameters Using Simulated Samples with Varying Recruitment Patterns*
M. Castro and Karim Erzini

14[c] 12/87 *Hydroacoustic Observations of Fish Abundance and Behavior Around an Artificial Reef in Costa Rica*
R.E. Thorne, Gary L. Thomas and Jorge Campos

15[c] 12/87 *Hydroacoustic Observations of Fish Abundance and Behavior Around Reefs and Structures*
R.E. Thorne and Gary L. Thomas

16[a] 3/88 *Extreme Value Theory Applied to the Statistical Distribution of the Largest Length of Fish*
S.P. Formacion, J.M. Rongo and C. Sambilay

17[b] 3/88 *Report of Workshop: San Jose, Costa Rica, January 21-24, 1986*
C. Stagg and Jorge Campos

18[b] 3/88 *A Simulation Study of Marine Population Dynamics*
B.L. Golden, B.J. Rothschild and H. Trivedi

19[b] 3/88 *Continuum-Distribution Population Dynamics*
J.M. Gracia-Bondia

20[b] 3/88 *A Strategy for Organizing and Analyzing Golfo de Nicoya Fishery Data*
J. Campos and C. Stagg

21[b] 3/88 *A Bibliography of Optimization Models in Fisheries Management*
A.A. Assad and G.T. DiNardo

22[b] 3/88 *A Difference Equation Simulation Model of Marine Population Dynamics*
R.A. Estrada

23[b] 3/88 *A Simple Renewal Model of Larval Fish Feeding*
J. Lobo

24[b] 3/88 *Biodynamics of the Sea: Preliminary Observations on High Dimensionality*
B.J. Rothschild and T.R. Osborn

25[b] 3/88 *Fish Stock Assessment Programs for the IBM-PC and Compatibles*
V.R. Restrepo, D. Die, W.W. Fox, Jr. and J. Chavarria

26[b] 3/88 *A Discrete Dynamic Fisheries Utilization Model: Towards the Practical Application of Modern Fisheries Economics*
L.G. Anderson

27[b] 3/88 *Using Decision-Analysis to Manage Maryland's River Herring Fishery: An Application of AHP*
G.T. DiNardo, D. Levy and B.L. Golden

28[b] 3/88 *Spawning-Stock Biomass: A Source of Error in Recruitment-Stock Relationships and Management Advice*
B.J. Rothschild and M.J. Fogarty

29[b] 3/88 *The Physical Basis for Recruitment Variability in Fish Populations*
B.J. Rothschild, T.R. Osborn, T.D. Dickey and D.M. Farmer

30[b] 3/88 *Parameter Uncertainty and Simple Yield Per Recruit Analysis*
V.R. Restrepo and W.W. Fox

31[b] 3/88 *Program REPSIM: A REcruitment Pattern SIMulator*
D.Die, V.R. Restrepo and W.W. Fox, Jr.

32[b] 3/88 *The Spawning and Recruitment Patterns of Tropical Marine Fish Stocks*
J.S. Ault and W.W. Fox, Jr.

33[b] 3/88 *The Tropical Fishery System Model: CORECS: COntinuous RECruitment Simulation*
J.S. Ault and W.W. Fox Jr.

34[b] 3/88 *User's Guide to CORECS*
J.S. Ault and W.W. Fox, Jr.

35[b] 3/88 *Abundance/Density Equations for Age-Structured Multicohort Populations: MCON (Multiple COhort N-dimensional model)*
J.S. Ault and W.W. Fox, Jr.

36[b] 3/88 *User's Guide to MCON (Multiple COhort N-dimensional model)*
J.S. Ault and W.W. Fox, Jr.

37[b] 3/88 *On the Efficacy of Some Techniques to Assess the Tropical Fishery System*
J.S. Ault and W.W. Fox, Jr.

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38[b] 3/88 *Small-Scale Turbulence and Plankton Contact Rates*
B.J. Rothschild and T.R. Osborn

39[a] 4/88 *Philippine Coral Reef Fisheries Management*
J.W. McManus and C.C. Arida

40[b] 4/88 *The Significance of Physiologically Structured Models for Fish Stock Dynamics*
J.M. Gracia-Bondia and J.C. Varilly

41[a] 4/88 *Coral Reef Fisheries at Cape Bolinao, Philippines: An Assessment of Catch, Effort, and Yield*
A.R. Acosta and C.W. Recksiek

42[a] 5/88 *User's Manual for SIMULOP, a Program to Simulate Series of Length Frequency Distributions of an Exploited Fish Stock*
M. Castro

43[a] 6/88 *An Improved Method for Fitting Gillnet Selectivity Curves to Predetermined Distributions*
Saul B. Saila and Karim Erzini

44[a] 8/88 *Sigmoid Selection and the Beverton and Holt Yield Equation*
G.T. Silvestre, M. Seriano and D. Pauly

45[c] 12/88 *Effects of Parameter Variability on Length-Cohort Analysis*
Han-Lin Lai and V.F. Gallucci

46[c] 12/88 *Inferring the Distribution of the Parameters of the von Bertalanffy Growth Model from Length Moments*
R.L. Burr

47[c] 12/88 *Comparative Study of Postlarval Life-History Schedules in Four Sympatric Species of Cancer (Decapoda: Brachyura: Cancridae)*
J.M. Orensanz and V.F. Gallucci

48[a] 3/89 *Philippine Marine Capture Fisheries Exploitation, Potential, and Options for Sustainable Development*
G.T. Silvestre

49[a] 3/89 *Stock Assessment of the Bolinao Reef Flat Fishery: Yield Estimates and the Use of Dominant Species in Assessing Coastal Multispecies Resources*
W.L. Campos, J.B.P. Cabansag, A. del Norte, C.A. Nanola and R.B. Reyes, Jr.

50[a] 3/89 *Virtual Population Estimates of Monthly Recruitment in Biomass of*

Rabbitfish, Siganus canaliculatus, off Bolinao, Northern Philippines
A. del Norte and D. Pauly

51[a] 3/89 *Zonation Among Demersal Fishes of Southeast Asia: The Southwest Shelf of Indonesia*
J.W. McManus

52[a] 3/89 *Overfishing on a Philippine Coral Reef: A Glimpse into the Future*
A. del Norte C.L. Nanola, J.W.McManus, R.B. Reyes, W.L. Campos and J.B.P. Cabansag

53[c] 4/89 *Age Determination in Biology: A Retrospective and Presentation of Contemporary Methods*
Han-Lin Lai, V.F. Gallucci and D.R. Gunderson

54[a] 4/89 *A Study of Band Noise Associated with Landsat Bathemetric Images*
P.A. Roe

55[b] 5/89 *Development of a Sampling Expert System: FISHMAP*
B.J. Rothschild, G.T. DiNardo and M. Bhandary

56[b] 5/89 *Strategy for Management Modeling*
B.J. Rothschild and C.M. Stagg

57[a] 8/89 *A Village-Level Approach to Coastal Adaptive Management and Resource Assessment (CAMRA)*
J.W. McManus, E.M. Ferrer and W.L. Campos

58[a] 8/89 *Comparison Between Multi-Species Fish Assemblage Using Similarity Indices*
Saul B. Saila and J.E. McKenna

59[a] 8/89 *Spatio-Temporal Variations in Community Structure on a Heavily Fished Slope in Bolinao, Philippines*
C.L. Nola, Jr., J.W. McManus, W.L. Campos, A. del Norte, R.B. Reyes, Jr., J.B.P. Cabansag and J.N. Pasamonte

60[a] 8/89 *Earth Observing System and Coral Reef Fisheries*
J.W. McManus

61[a] 8/89 *On Measuring Ecological Stress: Variations on a Theme by R. M. Warwick*
J.W. McManus

62[a] 8/89 *The Logarithmic Series Distribution and Some Applications to the Analysis of Tropical Multispecies Fisheries Data*
Saul B. Saila and J.E. McKenna

63[a] 8/89 *Sample Size & Grouping of Data for Length Frequency Analysis*
Karim Erzini

64[c] 9/89 *Merging Aggregate Catch Data with Uncertain Prior Knowledge to Approximate Age and Size Distributions and Selectivity Functions*
R.L. Burr

65[c] 9/89 *Hydroacoustic Assessment of Fish Stocks in the Gulf of Nicoya, Costa Rica*
J.B. Hedgepeth, R.E. Thorne and V.F. Gallucci

66[c] 9/89 *A Catch-at-Length Analysis That Incorporates a Stochastic Model of Growth*
P.J. Sullivan, Han-Lin Lai and V.F. Gallucci

67[c] 9/89 *Age Determination and Growth for Two Corvinas Cynoscion stoltzmanni and Cynoscion squamipinnis, in the Gulf of Nicoya*
Han-Lin Lai and J. Campos

68[a] 6/90 *Ecological Computer Programs:The Importance of Being Friendly*
J.W. McManus

69[a] 6/90 *Preliminary Model Development for Coral Reef Fish Assemblage Recovery from Blast Fishing*
J. McLeavy and Saul B. Saila

70[a] 12/90 *Table Analysis by Classification of Ordinations (TACO) A Method for the Simultaneous Division*
J. McManus

71[c] 12/90 *User's Guide to Program "Cohort" Pope's Cohort Analysis*
B. Amjoun, Han-Lin Lai and V.F. Gallucci

72[c] 12/90 *Minimum Cross-Entropy Spectral Analysis of Time-Varying Biological Signals*
R.L. Burr and D.W. Lytle

73[c] 12/90 *Effects of Ageing Errors on Estimates of Growth, Mortality and Yield Per Receipt for Walleye Pollock (Theragra chalcogramma)*
Han-Lin Lai and D.R. Gunderson

74[c] 12/90 *Age Determination of Pacific Cod, Gadus macrocephalus, Using Five Ageing Methods*
Han-Lin Lai and D.R. Gunderson

75[c] 12/90 *User's Guide to program CASA A Catch-At-Size Analysis*
B. Amjoun, V.F. Gallucci and Han-Lin Lai

76[c] 12/90 *Improving Population Estimates Obtained from Highly Variable Trawl Data*
R.A. McConnaughey and L.L. Conquest

77[a] 3/91 *A Compilation of Data on Variability in Length-Age in Marine Fishes*
Karim Erzini

78[a] 4/91 *Application of Fuzzy Graph Theory to Successional Analysis of a Multispecies Fishery*
Saul B. Saila

79[a] 3/91 *Destructive Coral Reef Fishing:Seeking Perspectives*
J.W. McManus, C.L. Nanola and R.P. Reyes

80[a] 2/91 *Evaluation of Tuna Resources Potential in Indonesian Waters with Emphasis on East Indonesia*
Saul B. Saila and J. Uktolsega

81[b] 6/91 *FINMAN: A Fishery Institution Management Computer Model for Simulating the Decision-Making Environment in Tropical and Subtropical Regions*
J. Ault and W.W. Fox, Jr.

82[b] 6/91 *FINMAN: Simulated Decision Analysis with Multiple Objectives*
J. Ault and W.W. Fox, Jr.

83[b] 6/91 *Simulation of the Effects of Spawning and Recruitment Patterns in Tropical and Subtropical Fish Stocks on Traditional Management Assessments*
J. Ault and W.W. Fox, Jr.

84[b] 6/91 *The Decline of the Chesapeake Bay Oyster Population: A Century of Habitat Destruction and Overfishing*
B.J. Rothschild, J. Ault, P. Goulletquer, W.P. Jensen and M. Heral

85[b] 6/91 *Food Signal Theory: Population Regulation and the Functional Response*
B.J. Rothschild

86[b] 6/91 *Particulate Theory of the Upper Ocean, Stochastic Geometry, Patch Structure, and Coupling with Physical Processes*
B.J. Rothschild

87[b] 1/92 *Analysis of Two Length-Base Mortality Models Applied to Bounded Catch Length Frequencies*
N.M. Ehrhardt and J. Ault

88[b] 1/92 *Application of Stochastic Geometry Problems in Plankton Ecology*
B.J. Rothschild

89[a] 4/92 *Short-Term Forecasting and Detection in Fisheries Management*
Saul B. Saila

91[a] 9/92 *Ecological and Anthropogenic Consideration in the Design of the Proposed Bolinao Marine Reserve*
J.W. McManus, R.B. Reyes and C.L. Nanola

92[a] 9/92 *Oceanography and Fisheries: The Philippine Experience*
L.T. McManus and J.W. McManus

93[a] 9/92 *The Spratley Islands: A Marine Reserve Alternative*
J.W. McManus

94[a] 10/92 *An Extension of the Biogeographic Model of MacArthur and Wilson*
Saul B. Saila and V.L. Kocic

95[c] 3/93 *Indirect Estimation of Gillnet Selectivity*
B. Amjoun and V.F. Gallucci

96[c] 3/93 *Trawl Survey Estimation Using a Comparative Approach Based on Lognormal Theory*
R.A. McConnaughey and L.L. Conquest

97[c] 3/93 *A Note on the Optimal Sampling Design for Using the Age-Length Key to Estimate Age Composition of a Fish Population*
Han-Lin Lai

98[c] 3/93 *Management Strategies in the Tropical Corvina Reina (Cynoscion albus) in a Multimesh Size Gillnet Artisanal Fishery*
Han-Lin Lai, M. Mug Villanueva and V.F. Gallucci

99[c] 3/93 *Growth and Mortality of the Red Shrimp (Aristaeomorpha folicea)* in the *Sicilian Channel*
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100[c] 3/93 *A Multispecies Dynamic Model of a Marine Ecosystem Incorporating Constant and Density Dependent Harvesting*
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101[c] 3/93 *User's Guide to GILLNET, to Estimate Gillnet Selectivity*
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102[c] 3/93 *User's Guide to CASA, Catch-at-Size Analysis, Version 1.1, for the Micro-computer*
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103[c] 3/93 *Age Determination of Corvina Reina (Cynoscion albus) in the Gulf of*

Nicoya Based on Otolith Surface Readings and Microincrement Analysis
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6. Brief summary of book chapters from

"Advances in Stock Assessment of Artisanal Fisheries" ("Advances")

Chapter 1. Introduction

Chapter 2. Age Determination in Fisheries Biology

This chapter presents an overview of age determination methods and problems including sampling designs to pick a sample for age determination, the methodology for age determination, the construction of an age-length key and the consequences in fisheries stock assessment for errors in age determination.

The thrust of the work is to present an overall picture of age determination which includes, to an extent not generally recognized, the role that statistical considerations should play. Therefore, there is a lesser emphasis on techniques of doing an age determination, which are covered in the copious bibliography, and a greater emphasis on the need to introduce quantitative thinking into the process.

Chapter 3. Size-based methods

This chapter reflects the basis thrust of much of the work in developing country tropical environments in that it assumes that only minimum age-specific data are available but that size or length data are available. It reviews the concepts and methodologies that have been developed to provide stock assessment and management information. In most cases this means by providing the equations that can be used to estimate the parameters needed in mathematical models for stock assessment. There is a focus on the increasing mathematical sophistication of the models being employed, on the sophistication of the software programs that are available to carry out the methods and, finally, on the increasing sophistication of individuals in the developing countries.

Chapter 4. Coral Reef Sampling Methods Relevant to Fisheries Management

This chapter describes cost-effective ways of mapping the reef environment, monitoring the structure of the fish communities, identifying factors important in explaining existing patterns of abundance and distribution, and monitoring fishing effort in complex multi-gear, multispecies reef fisheries. Emphasis is directed toward the design of field studies based on clearly defined objectives, realistic in terms of accounting for variability in time and space, and oriented toward specific statistical analyses. Among the topics discussed are: microcomputer-based satellite image analyses, surveys by light plane and ultralight aircraft, pattern analysis and the design of underwater fish surveys, permanent marking of underwater transects, measuring scale-dependent surface heterogeneity in the field, estimating the effects of illegal

fishing, mapping of fishing effort, sampling of catch composition and data handling on microcomputers.

Chapter 5. Sampling Methods For Tropical Fisheries

The chapter begins with a review of some of the standard methods of sampling that can be found in introductory textbooks but in the context of an artisanal fisheries scenario. The focus is on the methods that are potentially useful in an artisanal fishery or which are fundamental to understanding simple random sampling, stratified sampling, systematic sampling and cluster sampling. Two sections are also presented on sampling methods which are not widely used at present but which appear to have significant potential for future use. One of these is line transect sampling, which will probably have its greatest use in estimation of fishing effort, as opposed to more intensive sampling methods. The other section introduces an adaptive sampling methodology, which is particularly useful in sampling dispersed groups with predetermined levels of precision.

Chapter 6. Hydroacoustic Methods

This chapter describes the use of acoustics for fish population assessment. The use of acoustics survey data is presented. There is a focus on size-based methods and the research is in this sense a companion to that on the size-based methods of stock assessment for tropical marine fisheries presented in Chapter 3. One of the methods presented therein called catch-at-size-analysis (CASA) is a stock assessment methodology which uses acoustic data for "tuning" purposes. This aspect of acoustics results is explored in some detail. Basic acoustic theory is presented, including presentation of the acoustic sonar equations, which provides the background for discussions about transducers, data processing and estimation methods. Selected sampling considerations and strategies are described.

Chapter 7. Time Series Analysis

In this chapter, an important class of advanced methods of data analysis is presented. Most fisheries data, including those describing both the biological and social components of a fishery, are gathered and reported at regular intervals of time, such as every month, season or year. These are called time series. Techniques for fitting this class of data to models of discrete time which express the value of the "present" point as a function of the fisheries catch in the previous years form the basis of this approach. Tests were undertaken of the ability of identification techniques to distinguish the correct model from among those presented by Box and Jenkins in a 1976 paper. A more simple and intuitive alternative to the traditional bivariate model of Box and Jenkins was shown to yield very satisfactory fits, statistically not different from the "true" test model for all cases examined. In addition, other important components of time series analysis, namely the estimation of missing values,

intervention analysis to accommodate single exogenous effects on the data such as extreme weather episodes, and spectral analysis methods for identifying periodicity and removing it are summarized in this chapter.

Chapter 8. Empirical Methods and Models for Multispecies Stock Assessment

Major emphasis in this chapter is placed on development and application of empirical models with particular attention given to multispecies stock assessment in tropical marine fisheries. However, it is believed that the applications of the methodology developed may have utility in other fisheries. The initial phases of the work involved developing computer-intensive methods for preliminary comparisons of multispecies assemblages using some similarity and diversity measures. Programs for estimated faunal similarity and for estimating faunal gradients in space or time were developed and illustrated with Philippine fisheries data. Similarity indices based on data for which repeated samples are available were also examined and another program for objective comparisons of this type of data was developed and tested with Philippine data.

Another phase of these studies involved development and testing of empirical models based on time-series of multispecies trawl catch data from various sources. A Markov transition probability matrix model was derived and tested from aggregated time-series data using a least squares estimator and quadratic programming.

Chapter 9. Expert Support Systems

Here, important analytical tools for constructing a decision support system are presented, including the most widely applied and well-known techniques for analyzing data for stock assessment. The programs that perform these data-analysis calculations have been compiled in a PC-based software package with a simple user interface, that is provided on diskettes. Also included are separate instructions for running each program module, which describes the purpose of each stock assessment method, the nature and format of input data employed and the output that each program generates. The classes of stock assessment methodologies in this system include length-based stock assessment, stock-recruitment analysis, cohort analysis, yield-per-recruit, and surplus production. Modeling tools are also provided.

Chapter 10. The Systems Science Approach

This chapter describes the basic structure of a fisheries stock assessment decision support system—a computer-based management information system linking one or more databases to computer software for exploitation and analysis of the data. Its purpose is to integrate information in various forms, or from various sources into a single description of the fishery.

Clearly, the amount of information available will be limited and incomplete and, by

the statistical nature of data collection, of finite precision. The methods of sampling, particularly the research survey under the control of fishery managers, can be chosen to maximize the quality of information derived. A feedback of refining each survey in the year to come, on the bases of the information about population abundance and geographical distribution learned in previous years, allows the picture of the fishery to be steadily refined. Upon this basis, correct management advice can be proffered.

7. Fisheries stock assessment CRSP theses

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Annex I

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Greg Varner
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Roberto Young

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Dan Brown
Patricia Conrad
Willy Cushwa
Montague Demmen
Gary Jansen
William Johnson
James Marois
Christina Menendez
Bennie Osburn

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Christuiano DosSantos
Robert Fridley
Robert Gilbertson
Phil Giovanni
Pablo Guzman
Charles Hess
Terri Hill
David Hill
Danielle Jamu
Raul Piedrahita
Edward Price
Calvin Qualset
Maria Rojas
Hakan Sakul
Jim Scott
Robert Shelton
Barbara Webster
Tilahun Yilma

University of Oregon (PD/A)

Shanda Addington
Judy Bacher
John Bolte
Wilfrido Contreras-Sanchez
Larry Curtis
Robert Duringer
Hillary Egna
Doug Ernst
Martin Fitzpatrick
Bill Gale
Brigitte Goetze

Bob Halvorsen

NFNG Kahn
George Keller
Clem LaCava
Marion McNamara
Shree Nath
Felicien Rwangano
Carl Schreck
Wayne Seim
NFNG Taylor
Beno Warkentin

NFNG Weidner

University of Washington

Benyounes Armjoun
Loveday Conquest
Robert Donnelly
Vincent Gallucci
John Hedgepeth
Han-Lin Lai
Marsha Lanbolt
Robert Stickney

University of Hawaii

NFNG Caldwell
NFNG Carr
NFNG Constantinides
NFNG Fownes
NFNG Friday
NFNG Guo
NFNG Hue
NFNG Kahn
N. Kefford
Harold Keyser
Paul Singleton
NFNG Taylor
NFNG Uehara
NFNG Yost

Collaborating host countries:

Mali

Senegal

Kane Amadou
Amadon Ba
Mbene Faye
Algenon Johnson

Mamudon Balde
Mansour Fall
Mbaye Ndraze
Samba Thiaw

Niger

Abdoulaye Adam
Mamadou Ouattara
Madicke Niang
Karl Harmsen

Kenya

Augusta Abate
Leyden Baker
Dale Bandy
Filmore Bender (farmer)
Mr. Char (farmer)
Thomas Dolan
Robert Eley
Lynn Gourley
Ross Gray
Mr. Kazungu (farmer)
Mr. Kihinda (farmer)
Mr. Kinda (farmer)
Joseph Kinsolu
Joseph Kogi
R.S. Malik
Mr. Malinga
Rachel Maske
Adiel Mbabu
Dennis McCarty (Mission ADO)
Chris Monthi (Botswana)
Adrian Mukhebi
Dr. Mureithi
Mr. Mwangola
M.B. Mwova
Anthony Muolu
D. J. Njuguna
Moses Onim
Mr. Otieno
Fred Rurangirwa
Paul Rwambo
Pedro Sanchez
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Indonesia

North Sumatra

Peter Barubara
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Simone Ginteng
Michelle Horne
Peter Horne
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Darwinsyah Lubis
Agus Mijadi
Akhmad Prabowo
Hardi Prasetyo
Djoko Santoso
Crystal Veefleind
Ida
Endang Triwulanningsih
NFNG Yoyo

Java

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Hardi Prasetyo
Atien Priyanti
M. Rangkuti
Tjeppy Soedjana
NFNG Subandriyo

NFNG Gejer
Soetatwo Hadiwigeno
Soleh Sukumano
Ruth Widjaja-Adhi

Thailand

NFNG Banyong
Nanatkorn Boonkerd
Winit Chinsuwan
Penkwan Chompreeda
Harvey Demaine
Peter Edwards
Vichai Haruthaithanasan
Tornkorn Hiranraks
Prasit Jaisil
Kitjar Jaiyen
Sanon Jogloy
Manochai Keerati-Kasikorn
Marc Latham
Wattana Leelapatra
Kwei Lin
NFNG Manochai
Lek Moncharven
Alastair North
Chintana Oupadissakoon
Aran Patanothai
NFNG Sanun
Turnjit Satayavirut
Gajendra Singh
Sophon Sinithuprama
Montien Somaphi
NFNG Somchintana
NFNG Sopone
Chanintorn Sritonsuk
James Szyper
NFNG Thannasak
Sitilarp Vasuvat
Pientipa Vichiensanth
Sarun Wattanastchariy
NFNG Winit
Sopone Wongknew

Philipines

Theresa Abello
Remedios Abilay
Miriam Balgos
F.A. Bernardo
Sadiqul Bhuiyan
Lisa Canlas
William Dar
Beatriz delRosario
Rolando Edra
NFNG Eliseo
Virqilo Garcia
Rodger Garner
T. George
Malou Gison
Edgardo Gomez
Kathleen Kesner
G. Khush
Ester Lopez
Ireneo Manquiat
Liana McManus
John McManus
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H. Neue
Virginia Ocampo
Cesaeio Pagdilao
Lutqarda Palomer
Cesar Paodilao
Jojo Payot
Rodolfo Reyes
Percy Rubio
Wanda Samson
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Eduardo Lopez

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Jose Montenegro B.
Becky Myton
Juan Rosas
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Fred Bliss
Frank Dazzo
Josias deFaria
Ester deMoura-Rios
Wencealau Goedert
Robert Henson
Paulo Lobo
Robert Schaffert
Aurino Simplicio
Edmar Vieira
Elaine Lopes
Arlooaldo Luchiari
Jamil Macedo
Benifacio Magalhaes
Richardo Silva-Araujo
Eneas Leite
Ederlon deOliveira
Jose Simeao-de-Rezende
Eric Stoner

Telephone Interviews

Duane Acker

Sonia Formacion
Robert Havenor
A.L. Pope
John Rowntree
Robert Zimbelman
Will Getz
Travis McGuire
Ned Raun
Saul Saila
Gordon Campbell

Other

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Ben Libby

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Keith T. Ingram, Ph.D., Assistant Director

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Dr. Daniel J. Gustafson, Program Director, Fisheries Stock Assessment CRSP

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Patterson Poll Samenye, Ph.D., Animal Science Advisor

Texas A&M University System
Gary N. Odvody, Ph.D., Associate Professor, Plant Pathology

Agriculture Research Service
George L. Hosfield, Research Geneticist

First The Seed
Donald W. Ator, Executive Vice-President

Texas Grain Sorghum Board
Wilbert Vorwerk, Vice Chairman

National Grian Sorghum Producers
Tim Lust, Director of Marketing and Research

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Adiel Knonge-Mbabu, Ph.D.
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John R. Westley, Ph.D.
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Dr. Augusta N. Abate
Assistant Director, Kari

Thailand

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Eneas R. Leite, Ph.D.
Nutricao em Pastagens Nativas

Niger

Mme Beidari Fatouma Seyni, Agropedologue

Annex J

Team Intinerary

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Table J.1
Itinerary for CRSP evaluation team—U.S. travel

		Team members								
University	**Date visited**	Swindale	Eriksen	Miller	Marlowe	Lal	Gray	Barrett	Trott	Jensen
UMCP	May 2	Y		Y		Y		Y		
UMCEES	May 3							Y	Y	
NCSU	May 4-5	Y	Y	Y	Y	Y	Y			
UG	May 6	Y	Y		Y					
AAMU	May 7				Y					
UN-L	May 9-10	Y	Y	Y	Y	Y				
TAMU	May 11-12	Y	Y	Y	Y	Y				
MSU	May 12-13	Y	Y	Y	Y					
Purdue U.	May 13-15?				Y					
UCD	May 16-17	Y	Y	Y			Y			Y
OSU	May 18-19	Y	Y	Y						Y
UW	May 20							Y		
U. Hawaii	May 26?	Y				Y				Y
UAPB	June 6-7									Y
Auburn U.	June 8									Y

Table J.2
Itinerary for CRSP evaluation team—international travel

		Team members							
Country	**Date visited**	Swindale	Eriksen	Miller	Marlowe	Gray	Lal	Barrett	Jensen
Mali	May 22-28			Y			Y		
Senegal	May 24-29	Y	Y		Y				
Niger	May 29-June 4	Y	Y	Y	Y		Y		
Kenya	June 5-11	Y	Y	Y		Y			
Indonesia	June 19-26	Y	Y	Y		Y	Y		
Thailand	June 26-July 3	Y	Y	Y	Y		Y		Y
Philippines	July 3-12	Y	Y	Y	Y			Y	Y
Honduras	July 9-17	Y	Y	Y	Y				Y
Brazil	July 18-23	Y		Y					

Annex K

Survey of CRSP Planning and Performance

Contents

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Annex Table K.1. Survey of CRSP Planning and Performance A-265

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1. Introduction

IN July 1994 the MEs and Tropical Research and Development, Inc., distributed a set of questionnaires developed by the evaluation team to many of the participants and stakeholders in the CRSPs. Separate questionnaires were developed for CRSP lead principal investigators in U.S. universities, the lead principal investigators in the host countries, for the USAID missions, for the international agricultural research centers, and for nongovernmental organizations. All were based upon the evaluation team's Statement of Work (included as annex A of this document), but the sets of questions were modified to suit the recipients. A separate questionnaire was sent to the management entities.

Responses were received from seven U.S. university principal investigators, six host-country principal investigators, seven USAID missions, ten international agricultural research centers, two nongovernmental organizations, and all seven management entities.

The questionnaires were designed to elicit written views and information for the evaluation. To summarize the result in tabular form, however, answers have been quantified, where possible, using a 4-point scale:

1 — very high, most valuable, most effective, or best;
2 — high, valuable, effective, or good;
3 — low, slightly valuable, marginally effective, or poor; and
4 — very low, not valuable, ineffective, or worst.

In making the tabulation (annex table K.1), responses to related questions were combined, and the responses from the two nongovernmental organizations were combined with those from the six host-country principal investigators. The responses from the management entities were not included in the tabulation

2. Results

The global goals of the CRSPs were well understood by U.S. principal investigators and the international agricultural research center respondents, but were not well understood either by host-country investigators or in the USAID missions. The appropriateness of CRSP activities was well regarded by host-country investigators and international agricultural research center respondents. Planning the activities was not considered to be effective by any of the respondent groups. Host-country contributions to planning, however, were well regarded by both U.S. and host-country principal investigators.

U.S. principal investigators and internatuional agricultural research center respondents considered that the CRSPs were addressing multisectoral, multidisciplinary issues satisfactorily, but the social sciences were not seen to be adequately involved by any of the respondent groups. Neither the USAID missions

nor the international agricultural research center respondents considered that gender issues were being adequately addressed.

Costs of CRSP programs were considered to be high by the U.S. principal investigators in comparison with other types of USAID programs, but fairly low by the USAID missions.

Impacts on agricultural practices and livelihoods and the involvement of the CRSP in the transfer of technology were judged to be inadequate by all respondent groups, although some of the individual principal investigators held more optimistic views. The availability and dissemination of research outputs was judged to be more satisfactory. Contacts with the USAID missions were considered to be less than adequate although the range of views was wide for all groups of respondents.

U.S. principal investigators and USAID missions considered that the foreign countries and prime sites were well selected and had proved to be effective in furthering CRSP objectives, but host-country investigators did not agree. Both groups of investigators held similar, slightly negative views of the equivalency between U.S. and host country institutions (the difference relating more to facilities and institutional strength than to scientist quality), but they held clearly different views on the value of expatriate scientists. USAID missions had views similar to those of host-country investigators on this issue.

The influence of the CRSPs on the planning capacities of the national agricultural research service was considered adequate at best by respondents. On a related issue, host-country principal investigators considered that CRSP activities were well integrated into their programs, but U.S. principal investigators and the USAID missions considered that integration had not been achieved. All respondent groups considered that the sustainability of networking between the U.S. institutions and the national agricultural research service was doubtful, with U.S. investigators having a particularly pessimistic view— related largely to declining CRSP funding and imminent terminations of grants.

International agricultural research center respondents and host-country investigators were satisfied with the linkages between the CRSPs and the centers, as were the national agricultural research services, who often acted as links between the two. U.S. investigators and the USAID missions considered the links with the international agricultural research centers were poor. Both the centers and host-country investigators were more pleased with the sharing of scientific credit than were the U.S. respondents, although the latter's range of views was wide.

Finally, the general view was that the involvement of the private sector in CRSP activities was inadequate or worse.

Annex Table K.1. Survey of CRSP planning and performance

Subject	Respondent Groups							
	U.S. Principal Investigators		HC Principal Investigator		AID Missions		IARCs	
	Means	Range	Means	Range	Means	Range	Means	Range
Understandin g of Crsp Goals	2.1	1-3	2.6	1-4	2.6	2-4	2.0	1.3
Activities suited to global and target group needs	2.4	2-3	1.8	1-3	2.5	1-4	1.9	1.5-2.5
Quality and effectiveness of planning mechanisms	2.5	1.5-3.3	3.0	2.3-4	2.5	1-4	2.4	2.3
HC contribution to CRSP planning	1.9	1-2	1.4	1-2				
Addressing multisectoral, multidisciplin ary constraints	2.0	1-3	2.8	1-4			2.3	1-3
Social science discipline involved	2.4	1-3	3.2	1-4			2.6	1-4
Gender issues addressed	2.3	1-3	2.0	1-2.5	3.3	2-4	2.8	1.5-4
Costs of CRSP programs	2.2	1-4			3.3	2-4		

Extent of changes to national agriculture	2.8	1.5-4	2.4	1.5-3	3.0	2-4	3.1	2.5-4
Impact assessments estimated in project proposals	3.0	1-4	3.3	1-4				
Success in extending research outputs to clientele	3.0	2-4	2.5	1-3	3.5	2-4	2.6	1-4
CRSP involvement in HC technology transfer	2.7	1-4	2.4	1-3	2.8	1-4		
Availability and dissemination of research outputs	2.3	1.5-4	2.1	1-3	2.5	1.5-4	2.0	1.5-2.5
Linkages with USAID missions	2.3	1-4	3.2	1-4	2.7	1-4		
Were appropriate criteria used in selecting HCs?	2.0	1-3	3.0	3	2.3	1-4		
Success in selecting and usefulness of "Prime" sites	1.8	1-2.5	2.6	2-3.5	1.8	1-2.5		

US/HC research capability equivalence	2.5	1-4	2.3	2-3				
Value of expatriate scientists	2.0	2	3.3	2-4	3.7	3-4	2.4	1-3
Influence of CRSP on NARS planning capacities	2.3	2-3	2.6	2-4	3.3	2-4	2.3	1-3
Integration of CRSP activities into NARS	3.3	2-4	1.6	1-2	3.3	2-4	2.0	1-3
Quality and durability of networks with NARS	3.6	3-4	2.5	1.5-3.5	2.5	1-3.5	3.0	2.5-4
Quality and strength of associations with IARCs	3.2	2.5-4	2.1	2-2.5	3.2	1.5-4	2.0	1-3
Sharing of credit among research collaborators	2.7	1-4	1.8	1-3			1.7	1-4
Involvement of private sector in CRSP	3.3	2.5-4	3.0	2-4	3.7	3-4		

Note: Scales are 1=high or best, 4=low or worst

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Costs of CRSP programs were considered to be high by the U.S. principal investigators in comparison with other types of USAID programs, but fairly low by the USAID missions.

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Involvement of private sector in CRSP	3.3	2.5-4	3.0	2-4	3.7	3-4		

Note: Scales are 1=high or best, 4=low or worst

Annex L

Samples of CRSP Program Logical Frameworks

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2. Sorghum Millet CRSP 1987 logical framework 270
   CRSP 931-1254
   Grant No. AID/DAN-1254-GG-SS-5065-00
   Life of Project: FY 1979 to FY Indef.
   Date Proposed: July 1987
3. Sorghum Millet CRSP 1989 logical framework 272
   CRSP 931-1254
   Grant No. AID/DAN-1254-GG-SS-5065-00
   Life of Project: FY 1979 to FY 1989
   Date Proposed: Nov. 1, 1988

Bean/Cowpea CRSP Log Frame FY 92B–97A

Narrative Summary	Objectively Verifiable Indicators	Means of verification	Important Assumptions
Program Goal	Measures of Goal Achievements:	Verifiers	Assumptions for achieving goals
Make significant improvements in the living conditions of the rural and urban poor, and small farm producers in developing countries and increase the availability of low cost, nutritious food in the marketplace.	Development of important research results addressing identified constraints. Stronger national research program addressing identified constraints. CRSP products accepted by farmers, extension agents, host country private initiatives in ways that will advance goal Increased participation of women	Annual reports and positive TC/ERP reviews of progress Increased overall size of national program research team with greater multidisciplinary competence and host country investment in the project. Adaptation of findings by external agents: farmers, IARCs, extension agents, commercial interests. Increased male and especially female CRSP graduates in the professional pipeline.	Food and nutrition problems in the developing nations can be solved in part through research. Collaboration between U.S. and host countries can be of mutual benefit. Achievement from this program can reach the rural and urban poor. Achievements of this program can contribute to development in ways that do not increase the marginalization of women and their families.
Project Purpose	Conditions that will indicate purpose has been achieved:	Verifiers	Assumption for achieving purpose:
Organize and mobilize financial and human resources necessary for mounting a major multi-institutional U.S. and host country collaborative effort in research and training. Provide the knowledge base necessary to achieve significant advances in alleviating the principal constraints to improved production, marketing and utilization of beans and cowpeas in host countries. Improve the capabilities of host country institutions to generate, adopt and apply improved knowledge to local conditions.	U.S. and host country administrative support of projects U.S. and host country teams establishing good working relationships Research teams operating with effective level of equipment, supplies, and technical support Effective communications among all participants especially among those working on the same constraints across projects. Mechanism established for the identification and support of U.S. and host country male and female CRSP students, Useful secondary data identified. Improved research infrastructure with laboratory and field research in process	Smooth management with good communication with management office U.S. and host country quarterly and annual reports Formal commitment of participants Consistent pattern of student training established Documentation of secondary data Primary data analyses available in reports and publications Host country contributions to CRSP documented in each year's budget analysis	Host country will maintain interest in the commodity and in CRSP participation Coups and other forms of political or social disturbances will not be of a magnitude at project sites as to severely and insurmountably affect progress Necessary basic equipment, facilities and supplies will be available or acquirable within reasonable time frame There is a sufficiently large pool of students from which to draw for advanced training at least at the secondary school graduate level.

Outputs	Objectively verifiable indicators	Verifiers	Assumptions
Strong, better quality yields produced under stressful conditions Greater understanding by U.S. and host country collaborators of the sociocultural and the agricultural environment Products of research packaged appropriately for consumer use Information dissemination for a variety of audiences Production and utilization research finding useful for the wider research community Many male and female graduates of the training program	Yield increase under an array of stressful conditions to which produced varieties are awry. Multidisciplinary research generated Informational materials available Interest of wider international; and national research and development community in products Better health among those making use of project outputs Male and especially female graduates returning to host country research institutions	Yield data from local and national census Reports of projects incorporate and integrate sociocultural with agricultural information Material acknowledged as received by many groups and increased consumer demand Requests from professional community for information and products increased Site visits CRSP graduates identified in host country research positions Increased numbers of male and female students continually in short-term and long-term training	There exists in the host country at least a skeletal infrastructure for information dissemination There are U.S. and host country women interested in advanced education and professional employment to work their way through the system when it is opened to them.
Inputs	**Objectively verifiable indicators**	**Verifiers**	**Assumptions**
Necessary long-term and short-term personnel from U.S. and host country institutions who can communicate with each other Financial contributions from AID, U.S. and host country institutions Vehicles, lab, field and office equipment Facilities and supplies for U.S. and host country teams Management support from management office, U.S. and host country institution administrations Information and support from external groups	Annual allocation from AID CRSP funds flowing on regular basis to U.S. and host country research teams Annual work plan and budget document with U.S. and host country contributions Frequent and regular communication among AID, management office, U.S. and host country Participation in CRSP research and training activity by external groups (AID-sponsor FSR teams, IARCs, USAID missions)	Increase in communications initiated by participants with one another Review of annual documents by technical committee and board AID letter of credit authorizing funds Regular reimbursement requests with quarterly reports AID approvals to purchase indicated equipment received Site visits Meetings and other forms of communication with external agents	AID will generate necessary approvals in a timely fashion AID will have funds available for use by the CRSP All parties making input will continue to feel the mutual benefits worth the investments

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Sorghum Millet CRSP Log Frame FY 79-FY Indef.

Narrative Summary	Objectively verifiable indicators	Means of Verification	Important Assumptions
Program Goal To increase grain Sorghum/Pearl Millet (GS/PM) production in those countries where they are a principal food crop. This is to be achieved by research and training in conjunction with LDC scientists, the international and regional research centers and other government and private development agencies.	Measures of Goal Achievements Research institutions staffed by competent researchers and managers producing improved technology that is adopted by farmers. Increased units of GS/PM produced and marketed by small farmers. Increased purchase of production inputs and consumer goods by small farmers. Close collaboration between the LDC research institutions, the international and regional research centers and the private sector.	Research staff trained and research results published and extended. Data on commercial markets collected and analyzed. Values of purchases and items sold by farmers using new technology compared to those using traditional production practices. Comparison of research publications and news releases of cooperating institutions.	Assumptions for achieving goal targets: That constraints currently limiting GS/PM productivity can be solved. That research results are adopted by LDC farmers. That research and training will improve the competency of LDC and US scientists. That farmers react to a profitable market by increasing food consumption and consumer goods purchased. That research institutes find collaborative research mutually beneficial.
Project Purpose Organize and mobilize financial and human resources necessary for mounting a major multi-institutional US-LDC collaborative effort which in turn is expected to provide the knowledge base necessary to achieve significant advances in alleviating the principal constraints to improved production, marketing, and utilization of GS/PM in LDCs. Improved capabilities of appropriate LDC institutions to generate, adapt, and apply improved knowledge on GM/PM to local conditions.	Conditions that will indicate purpose has been achieved: End of project status. Viable and functioning GS/PM collaborative research institutions in the US and LDCs. Identifiable personnel trained in the LDCs and US able to sustain in-country programs. Improvement in GS/PM productivity in major project sites. More efficient processing and increased utilization of improved quality GS/PM products. Four principal research sites fully developed and functional with an interlinked network of secondary sites in each selected region.	Means of Verification Annual report for each subproject. A consolidated annual report by the Management Entity on the GS/PM CRSP achievements. Annual review by the External Evaluation Panel of grant activities. Annual review of project accomplishments by an independent AID committee. Market volume and quality studies of principal research areas. Principal and secondary research sites' annual reports.	Assumptions for achieving purpose That the goals and objectives of the GS/PM-CRSP are appropriate in the regional context of where collaboration takes place. That the constraints to production in LDCs are positively related to the disciplined identified by the GS/PM-CRSP. That market incentives will be available to encourage LDC farmers to adopt new production technology. That LDC interest will be sufficiently high in AID regions to support a principal site institution. That surrounding countries with similar environments will see benefit of networking to gain access to new technology.

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Output:	Magnitude of Output	Means of Verification	Assumptions for achieving output:
Packages of validated improved technological practices developed in specific locations by readily adaptable to other areas. Documented knowledge on interacting forces constraining efficient sorghum/millet production. The practical application and implementation of knowledge gained and its dissemination via publication, workshops, trained technicians, and demonstrations. Multiresistant germ plasm available for LDC GS/PM breeding programs. Improved commercial varieties of G/PM developed for various ecosystems in use by LDC farmers.	Develop sound production systems for four major ecosystems of humid tropics, dry tropics, high altitude temperate, and semiarid subtropics. Develop germ plasm for four major ecosystems. Provide commercial varieties to fit consumer preference at four principal research sites. Publications on major production systems, which include problems and solutions as known. Research staff working with LDC extension staff to extend technology to farmers at four principal sites. Implement baseline and evaluation studies, and develop models for stimulating smallholder production conditions.	Review of data output, participation by subgrantee staff in workshops, seminars, and training programs. Evaluation of publication, management, and application of research results. Number and quality of LDC staff trained by the project and job held on return to home country. Evaluation of GS/PM breeding program in LDCs and survey of commercial varieties available and used by farmers.	That LDCs will utilize new knowledge developed and apply it through their local extension facilities to field conditions. That LDC facilities, staff, and collaborators are eager to work with GS/PM-CRSP subgrantees in related fields. That candidates will be available for training in appropriate disciplines and return to appropriate jobs. That joint efforts of US and LDC plant breeders can evolve breedings lines and varieties suitable to LDC conditions.
Inputs:	**Implementation target (type/qual).**	**Means of Verification**	**Assumptions for providing inputs:**
Grant No. AID/DAN-1254-G-SS-5065-00 the University of Nebraska. 25 percent minimum cost sharing by each participating US institution. Qualified students from US and LDC institutions for appropriate training. Expertise of US and LDC staff to conduct required research. LDC resources supporting AID grants. Other donor agency and private-sector support for GS/PM production and utilization program.	Implementation of sixth-year funding through subgrants effective 7/1/84. Implementation in years 7, 8, 9, through annual renewal of subgrant agreements approved by the Board of Institutional Representatives and administrated by the management entity. 50 formally trained and 150 participants involved in short-term training on various aspects of GS/PM production and processing each year.	Annual reports and periodic evaluation by External Evaluation Panel, USAID, JCARD, and BIFAD to summarize progress and to plan for future direction. Audit of each subgrantee, the Management Entity, and the GS/PM-CRSP as a whole. Participant training records. Reports of LDC and/or project donors on participating in the GS/PM-CRSP.	That the GS/PM-CRSP will receive adequate funding by AID. The overseas collaborating institutions will continue to receive domestic funding and adhere to the terms and conditions of the Memoranda of Understanding. That US institutions and their faculties will continue to retain an active interest in the GS/PM-CRSP, contribute at least 25% of total project costs, and provide staff for LDC assignments. That LDC staff will be nominated for training positions and be accepted by appropriate training institutions.

Sorghum Millet CRSP Log Frame FY 79—FY 89

Narrative Summary	Objectively Verifiable Indicators	Means of verification	Important Assumptions
Program or Sector Goal: The broader objective to which this project contributes:	Measures of Goal Achievements:	Target area baseline and evaluation statistics on:	Assumptions for achieving goal targets:
To improve the overall quality of life both economically and nutritionally in LDCs where sorghum and/or millet are principal food crops through increasing sustainable production of these crops. This will be achieved by research and training in collaboration with LDC scientists, international, and regional research centers and other government and private development agencies.	Higher per capita incomes in rural agricultural sector.	Rural agricultural sector incomes	That constraints currently limiting S/M productivity can be alleviated.
	Increased purchase of production inputs and other consumer goods.	Trends in small farmer consumer purchasing practices.	That USAID and LDC place high priority on Agriculture Research.
	Increased production statistics for sorghum and millet.	Annual production statistics from FAO, World Bank, USAID, and LDC Ministry sources.	That increased, sustainable production of S/M will stabilize and stimulate the market and therefore the economy.
	Greater sustainablity and stability of production.	Ratio of farmers using new technology to those not.	That LDC agriculture policies promote rural development.
	Increased research activity in National LDC research departments in sorghum and millet improvement.	Number of scientists with MS and Ph.D. degrees working in S/M improvement.	That farmers react to a profitable market by increasing food consumption and consumer goods purchased.
	Increase in trained scientific staff in National LDC research departments.	Capacity of LDC research institutions to conduct meaningful and effective quality research.	That research institutes find collaborative research mutually beneficial.
		Annual reports of LDC research institutions.	That appropriate linkages exist between research and farmer.

Project Purpose	Conditions that will indicate purpose has been achieved:	**Means of Verification**	Assumption for achieving purpose:
Establish and maintain a dynamic, multi-institutional and multidisciplinary US-LDC collaborative research program that enhances the research capabilities of LDC institutions to alleviate constraints to S/M production, marketing, and utilization through the development of appropriate and sustainable technology.	Existence of effective S/M research networks and linkages among LDC institutions, US institutions, international centers, and other research organizations. Presence of highly trained, competent S/M research staff in above mentioned institutions with emphasis on LDC institutions. Higher priorities given to S/M research demonstrated as an increase in LDC research budget. Absence of diminished effect of contraints to S/M production. Increase S/M production and market stability if technologies adapted. Increased value to S/M through alternative product utilization schemes if technology adopted.	Examination of annual reports from US, LDC, IARC, and other related research scientists, institutions, and organizations. External Evaluation reports Comparison of preproject number of M.S. and Ph.D. level scientists in LDC research institutions with number at any given date after project initiation. Annual review of project accomplishments by an independent IAD committee. Research publication, research conferences, newsletters, magazines, newspaper articles, television coverage, research brochures on special relevate topics, and trip reports. Examination and monitorig of LDC research institution budget for S/M research On-site visits	Market incentives will be available to encourage LDC farmers to adopt new technology. Constraints to S/M production in a given area have been properly identified and addressed. Collaborative research efforts directed at the development of LDCs assist in the accomplishment of U.S. research goals. LDC agriculture policies support agriculture reseach.

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Outputs:	Magnitudes of outputs:	Means of verification	Assumptions for achieving outputs:
Presence of dynamic, multi-institutional, and multidisciplinary US-LDC collaborative research network that enhances S/M research capabilities of LDC and US institutions to alleviate constraints to S/M production and utilization.	Existence of six prime site countries in which strong collaborative research progrma have nbeen established in conjunction with 28 U.S. scientists from five American Land Grant Universities.	Examination or research reports and publications	Training participants for advanced degrees are available.
Collaborative technology-producing research by discipline:	Presence of strong effectrive ties between INTSORMIL, ICRISAT, CIAT, CIMMYAT, EAP, SAFGRAD and SADCC for global and regional S/M research coordination.	Examiniation of laymen articles describing new technologies available for extension	Political and economical climates are conducive to conduct agricultural research.
Sustainable production systems	Publication of technology-evaluation results, including techniques.	Survey of germplasm in any affiliate institution	LDC institution has capactity to absorb enhancements and collaborative research approach.
Improved titlage and other agronomic schemes to minimize sorghum and millet establishment problem.	Suggestions for better agricultural policy	Survey of varieties grown around the world	Adequate support from AID, LDC, and other donor institutions continues.
Development of water harvesting technology through micro and macro catchments to increase limiting water supply to S/M.	Use of survey information by researchers.	Trip reports	
Development of crop residue practices to increase soil moisture and fertility.	Germplams enhancement and conservation	Site visits	
Development of improved crop rotation and legume intercropping schemes to maximize water and fertility use efficiency thus increasing and stabilizing yields.	Release of 1-5 cultivars/3-4 years throughout world.	Annual LDC reports	
Development of mid- and late season field moisture stress screening techniques to assist breeders develop drought tolerant varieties.	Release of 10-100 advanced breedings lines, populations and other germplasm per year.	Proceedings from workshops, seminars, and conferences	
Development of improved cultural practices to reduce erosion, improve infiltration, and increase yields.	Release of 40-100 exoiting Plant introductions/year.	Numbers of trained scientific staff and pre and post CRSP	
Development of appropriate models to evaluate technology at farm-level.	Publication of 1-5 scientific articles/year describing mechanisms of resistance, heritabilities, etc.	Inventory of equipment, operational budget, supplies, etc.	
Proposal of suggestions for better agricultural policy.	Sustainable Plant Protection Systems	Sustainable Production Systems	
	Publication of 1-2 scientific articles/year descriing mechanisms of resistance, amangement schedmes, population synamics, etc.	Publication of 1-4 scientific articles/year outlining various methods of agronomic improvement schemes.	
	At least 1-2 management schemes per major insect pest where appropriate	Several (3-7) appropriate and sustainable agronomic tillage, water harvesting, and crop residue management practices for Southern and West Africa.	
		Atleast two water stress sceening techniques for Africa, U.S. and South America.	
		Several agronomic cropping schemes for West and Southern Africa.	

Outputs (continued):	Magnitudes of Outputs (continued)
Germplasm enhancement and conservation:	Crop Utilization and Marketing
Development and release of improved S/M varieties, hybrids, populations, and advanced breeding lines with the following characteristics:	Presence of small effective food quality labs in Mali, Niger, Sudan, and Honduras.
	Publication of all methodologies and technologies for processing S/M into food.
-Higher human food quality traits for use in leavened and unleavened breads or porridges. -striga resistance -drought tolerance -resistance to major diseases -resistance to major insect pests -higher water and nutrient efficiencies -tolerance to low pHs and high soil aluminum -good stand establishment ability -collection identification and introduction of desirable exotic germplasm into US from LDCs, and from LDCs to LDCs.	Existence of expanded S/M markets due to new food alternative utilization.
	Training
	Advanced degree programs:
	Approximately 12 LDC advanced degree recipeints/year among 8 disciplines.
	Approximately 5 U.S. advanced degree recipients/year.
	Short-term program:
Sustainable plant protection systems:	
Development of S/M insect/mite management practices	1-4 candidates per year for special training in pathological techniques, food quality research techniques, breeding techniques, etc.
Development of S/M insect/mite resistant germplasm.	4-5 scientist participate in 2-4 seminars/year.
	1-3 major worshops held/year with participation of about 30-60 scientists each.
	1-2 conferences are attended by 30-100 scientists each.

Crop Utilization and Marketing

Development of new technologies for processing S/M into food.

Simple procedures for parboiling sorghum.

Standardization of S/M laboratory malting techniques.

Methodologies to evaluate composite flours in different foods.

Establishment of small food quality lab(s) in selected sites.

Development of techniques to improve protein digestibility in sorghum.

Development of a quantitative assay for sorgoleone.

Development of biochemical procedures to reduce Striga infestation.

Understanding the role of tannins in Human/Animal Nutrition and pest resistance.

Training

Long-term advanced degree programs for LDC and US particiopants
Masters in PhDs in following disciplines:

-Agronomy	-Biochemistry
-Breeding	-Entomology
-Economics	-Food Science
-Pathology	-Physiology

Short term technical training.

-Plant Pathology	-Food Science
-Breeding	-Physiology
-Entomology	-Economics

Seminars, workshops, and conferences.

Inputs.	Implementation Target	Means of verification	Assumptions for providing inputs:
		Annual reports and periodic evaluation by external evaluation panel, USAID, JCARD, and BIFAD to summarize progress and to plan for future direction.	That the GS/PM-CRSP will receive adequate AID funding.
		Audit of each subgrantee, the management entity and the GS/PM-CRSP as a whole.	The oveseas collaborating institutions will continue receiving domestic funding and adhere to the terms and conditions of the Memoranda of Understanding.
		Participant training records.	That US institutions and their faculties continue to retain an active interest in the GS/PM-CRSP, contribute at least 25 percent to total designated project costs, and provide staff for LDC assignments.
		Reports of LDC and/or project donors on participating in the GS/PM-CRSP.	Other donor organization agencies will continue to support INTSORMIL.

Table 1. Inputs by Discipline Component: FY 1988 Budget (in thousands)*

Component	S&T Agriculture		Missions		Non-AID		TOTAL	
	%	Amt.	%	Amt.	%	Amt.	%	Amt.
Sustainable Production Systems	18	485	30	60	-	-	17	560
Germplasm Enhancement and Conservation	35	935	70	135	100	144	41	1,199
Sustainable Plant Protection Systems	13	335	-	-	-	-	11	335
Crop Utilization and Marketing	9	254	-	-	-	-	8	254
Management, Evaluation, and Networking	14	391	-	-	-	-	13	391
Host Country Enhancement	11	300	-	-	-	-	10	300
TOTAL	100	2,700	100	-	-	-	100	3,039

**Honduras Recursos & EAP Botswana ATIP Project*
*** Colombia Occidental Oil, etc.*

Table 2. Inputs by Line Item. FY 1988 Budget (in thousands)*

Component	S&T Agriculture		Missions		Non-AID		TOTAL	
	%	Amt.	%	Amt.	%	Amt.	%	Amt.
Equipment	3	82	5	10	8	12	3	104
Fringe Benefits	3	92	3	5	-	-	3	97
Grad students	9	240	5	10	-	-	8	250
Other Direct Costs	9	236	26	50	14	20	10	306
Other Salaries	6	172	16	32	19	28	8	232
Overhead	23	624	-	-	-	-	20	624
Post Doctorates	6	170	7	13	15	22	7	205
Staff Benefits	4	93	8	15	-	-	4	106
Supplies	8	211	8	16	11	14	8	251
Travel	13	340	7	14	11	16	12	360
University Staff	16	440	15	30	22	32	17	502
Total	100	2,700	100	195	100	144	100	3,039

**FY Budget identical to FY 1989*

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Annex M

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Annex N

Glossary of Terms

AAAP	Asian-Australasian Association of Animal Production
AACC	American Association of Cereal Chemists
A/AID	Office of the Administrator, AID Washington
AARD	Agency for Agricultural Research and Development, Indonesia
ACIAR	Australian Centre for International Agricultural Research
ADIN	Nursery for Disease and Insect Resistance
ADSS	Acidity Decision Support System
AEZ	Agroecological zone
AFR	Bureau for Africa
AFRNET	African Feed Resources Network
AGR	Office of Agriculture
AID	Agency for International Development
AID/S&T	Agency for International Development/Science and Technology
AIT	Asian Institute of Technology
ALCON	Aquaculture for Local Community Development
ALES	Automated Land Evaluation Systems
ALS	Angular leaf spot
AMR	Administrative Management Reviews
ANDAH	A Honduran private association of shrimp enterprises p. 62, Eval. Rep.
ANE	Bureau for Asia and the Near East
ANOVA	Analysis of variance
AOAC	Association of Official Analytical Chemists
APHIS	Animal and Plant Health Inspection Service, U.S.
APRES	American Peanut Research and Education Society
ARS	Agricultural Research Service
ASA	American Society of Agronomy
ASAS	American Society of Animal Science p. A-41, Annexes
ASEAN	Association of Southeast Asian Nations
ATIP	Agricultural Technology improvement Project
ATP	Adenosine Triphosphate
AU	Auburn University
AUS-ASEAN	Australia-Association of Southeast Asian Nations
BCMV	Bean Common Mosic Virus
B/CP	Bean/cowpea
BDMV	Bean Dwarf Mosaic Virus
BGMV	Bean Golden Mosaic Virus

BIC	Bean Improvement Cooperative
BIFAD	Board for International Food and Agricultural Development (renamed to BIFADEC)
BIFADEC	Board for International Food and Agricultural Development and Economic Cooperation (formerly BIFAD)
BNF	Biological nitrogen fixation
BOA	Basic Ordering Agreement
BOD	Board of Directors
CAE	Caprine arthritis encephalitis
CAMRA	Coastal Adaptive Management and Resource Assessment
CalPoly	California Polytechnic Institute
CARDI	Caribbean Agricultural Research and Development Institute
CASA	Catch-at-size analysis
CATIE	Centro Agronomico Tropical de Investigación y Ensenaza
CCPP	Contagious Caprine Pleuropneumonia
CDBN	Cooperative Dry Bean Nursery
CDIE	Center for Development Information and Evaluation
CEDA	Centro de Ensenanza y Adiestramiento, SRN, Honduras
CEDIA	Agricultural Research Center, Honduras
CGIAR	Consultative Group for International Agricultural Research
CIAT	Centro International de Agricultura Tropical
CIDA	Canadian International Development Agency
CIFAD	Consortium for Fisheries and Aquaculture Development
CIMMYT	International Maize and Wheat Improvement Center (Centro Internacional de Meframento de Maiz y bigo)
CIPEA	Centre International pour l'Everage en Afrique
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement
CISRO	Coordinating Research Institute for Animal Science (Australia)
CLAIS	Consejo Latin Americana de Investigadores en Songho
CLRP	Coastal Living Resources Project of Australia–Association of Southeast Asian Nations
CLSU	Central Luzon State University
CNRA	Centre National de Recherches Agronomiques
CNRA	National Center for Agricultural Research, Senegal
CORAF	Conference des Responsables Africains et Francais de la Recherche Agronomique, France
CRIA	Central Research Institute of Agriculture
CRIAS	Central Research Institute for Animal Science (Indonesia)
CRSP	Collaborative Research Support Program
CS	Collaborating Scientist
CSU	Colorado State University, Fort Collins
CU	Cornell University
DANIDA	Danish International Development Agency
DAST	Data Analysis and Synthesis Team
DGIP	Division for Global and Interregional Projects (of UNDP)

DNA	Deoxyribonucleic acid
DOF	Department of Fisheries
DR	Dominican Republic
EAP	Escuela Agricola Pan Americana (Zamorano, Honduras)
EEC	European Economic Community
EEP	External ealuation panel
EG	Economics and gowth custer
ELISA	Enzyme-lnked imunosorbent assay
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria (Brazil)
EMBRAPA-CNPMS	EMBRAPA–Centro-Nacional para Maize e Sorgo
EMS	Ethyl methane sulfate: mutation BRGG
ENA	National School of Agriculture, Honduras
ERS	Economic Research Service
EZC	Ecogeographic Zone Council
FAIME	Financial Analsis for Inoculant Manufacturing Enterprise
FAO	Food and Agricultural Organization of the United Nations
FCC	Fertility capability classification system
FHIA	Fundacion Hondurena de Investigacion Agricola, Honduras
FISHMAP	A sampling expert system (softward), in development
FPX	Federation of Agricultural and Agroindustrial Producers and Exporters
FSA-CRSP	Fish Stock Assessment Collaborative Research Support Program
FSR	Farming Systems Research
FSR/E	Farming Systems Research and Extension
FTE	Full-time equivalent
G	Global
G/EG/AGR	Bureau for Global Programs, Field Support and Research/Economics Growth Cluster/Office of Agriculture (USAID)
GIFT	Genetic improvement of farmed tilapias
GLIP	Grain Legume Improvement Program
GMIT	Genetic manipulations for improved tilapia
GMT	Genetically male tilapia
GOBr	Government of Brazil
GOBo	Government of Bolivia
GOI	Government of Indonesia
GOK	Government of Kenya
GOM	Government of Morocco
GOP	Government of Peru
GTZ	German Agency for Technical Cooperation
HB	Halo Blight
HBCU	Historic Black Colleges and Universities
HC	Host Country
HTC	Hard to Cook

IAEC	International Atomic Energy Commission
IARC	International Agricultural Research Center
IAV	Institut Agronomique et Veterinaire Hassan II (Morocco)
IBA	Indole butyric acid
IBP	Bogor Agriculural University, Indonesia
IBPGR	International Board of Plant Genetic Resources
IBSNAT	International Benchmark Site Network for Agro Technology Transfer
IBSRAM	International Board for Soil Resources and Management
IBTA	Bolivian Institute for Agricultural Research (Instituto Boliviano de Technologia Agropecuaria, Bolivia
ICA	Instituto Colombiano Agropecuaria, Colombia
ICAR	Indian Council for Agricultural Research
ICARDA	International Center for Agricultural Research in Dry Areas
ICLARM	International Center for Living Aquatic Marine Resources Management
ICRAF	International Centre for Research on Agroforestry
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IDRC	International Development Research Centre, Canada
IER	Institut de Economie Rurale, Mali
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
IFT	International Food Technology
IG	Office of the Inspector General
IGA	International Goat Association
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
ILRI	International Livestock Research Institute (new IARC to be formed 1/1/95
IMT-GT	Indonesia-Malaysia-Thailand growth triangle
INAP	National Agricultural Research Institute, Ecuador
INCAP	Instituto de Nutricion de Centro America y Panama
INIA	Instituto Nacional de Investigación Agrarias (Peru and Ecuador)
INI-ANSREDEF	Indonesia International Animal Science Research and Development
INIPA	Instituto Nacional de Investigación y Promoción Agropecuaria (Peru)
INRA	Institut National de Recherche Agronomiques, Niger
INRAN	Institute Nigerien du Recherche Agronomic, Niger (replacing ILCA and ILRAD)
INTSORMIL	Cooperative Research Support Program for sorghum and millet
IPAL	Integrated Project for Arid Lands
IPGRI	International Plant Genetics Research Institute
IPM	Integrated Pest Management
IPRC	Insect Pathology Resource Center
IQC	Indefinite quantity contract (USAID)
IRA	Institut de la Recherche Agronomique
IRAT	Institute of Tropical Agriculture and Food Crop Institute
IRHO	French Institute for Oilseeds Research, France
IRRI	International Rice Research Institute

ISC	ICRISAT Sahelien Center, Niamey, Niger
ISNAR	International Support to National Agricultural Research
ISP	Institut Superior Poltechnique
ISPAN	Irrigation Support Project for Asia and the Near East
ISRA	Institute of Agricultural Research, Senegal
ISRN	Indonesian Small Ruminant Network
ITA	Institut de Technologie Alimentaire, Senegal
JCARD	Joint Committee on Agricultural Research and Development (formerly JRC)
JCORD	Joint Committee on Research and Development
JRC	Joint Research Committee (renamed in 1991 to JCORD)
KARI	Kenya Agricultural Research Institute
KIRDI	Kenya Industrial Research and Development Institute
KSU	Kansas State University
LAC	Bureau for Latin America and the Caribbean
LDC(s)	Lesser developed country (countries)
LIFE	League for International Food Education
LUPE	Land Use and Productivity Enhancement
ME	Management entity
MIAC	Mid-America International Agricultural Consortium
MNR	Ministry of Natural Resources
MO	Management office
MOA	Memorandum of Agreement
MOAgr	Ministry of Agriculture
MOU	Memorandum of Understanding
MSTAT	Microcomputer statistical and data management package
MSU	Michigan State University
MSU	Montana State University, Bozeman
NACA	Network of Aquaculture Centers in the Asia-Pacific
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NAS	National Academy of Science
NCRE	National Cereals Research and Extension Project
NCSU	North Carolina State University, Raleigh
NFTA	Nitrogen Fixing Tree Association (University of Hawaii)
NGO	Nongovernmental organization
NifTAL	Nitrogen Fixation by Tropical Agricultural Legumes
NIH	National Institute of Health
NMFS	National Marine Fisheries Service
NSF	National Science Foundation
NSH	Narrow sense heritabilities
NSSL	National Seed Storage Laboratory

OAS	Organization of American States
OAU	Organization of African Unity
ODA	Overseas Development Administration
OECD	Organisation for Economic Cooperation and Development
OIAP	**[see tables in Evaluation report]**
OICD	Office of International Cooperation and Development
OIRD	Office of International Research and Development
OPC	Ovine pulmonary carcinoma
OPP	Outreach Pilot Project, Java, Indonesia
OPP	Ovine progressive pneumonia
ORP	Outreach Research Project, North Sumatra, Indonesia
OSU	Ohio State University, Columbus
OSU	Oregon State University, Corvallis
PANESA	Pasture Network for Eastern and Southern Africa
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PCARRD	Philippine Council for Agriculture, Forestry, and Natural Resources Research and Development, Los Banos
PCCMCA	Programa Cooperative Centroamericano par el Mejoramiento de Cultivos Alimenticios
PCR	Polymerase Chain Reaction
PD/A-CRSP	Pond Dynamics/Aquaculture Collaborative Research Support Program
PDSS	Phosphorus Decision Support System
PHA	Phytohemagglutinin
PI	Principal investigator
PL480	Public Law No. 480
PMO	Program Management Office
PONDCLASS	An expert system software program used in aquaculture
PRF	Purdue Research Foundation
PROFRIJOL	Research Network of Latin American & Caribbean Countries
PU	Purdue University
PVO	Private Voluntary Organization
RA	Research associate
RAPD	Random amplified polymorphic DNA
REPSIM	A Recuitment Pattern Simulator
RerumNet	Latin American Network of the small ruminant CRSP
RFLP	Restriction fragment length polymorphism
RFP	Request for proposal
RISTROP	Red de Investigación de Suelos Tropicales
ROCAFEMI	Reseau ouest et centre Africain de Reserche sur le mil
ROCARS	Reseau Ouest-Central Afrique pour la Recherche du Sorgho
RTI	Research Triangle Institute
S&T/AGR	Science and Technology/Agriculture
SACCAR	Southern African Centre for Cooperation in Agricultural Research
SADCC	Southern African Development Coordination Conference

SAFGRAD	Semi-Arid Food Grains Research and Development Project
SANREM	Sustainable Agriculture and Natural Resource Management
SAT	Semi-Arid Tropics
SBPT	Sub Balai Penelitian Ternak, Sei Putih, Indonesia
SCS	Soil Conservation Service (USDA)
SDM	Sorghum downy mildew
SEA	Secretaria de Estado de Agricultura, Dominican Republic
SEAFDEC	Southeast Asian Fisheries Development Center
SEARCA	Southeast Asian Research Center Agriculture
SIDA	Swedish International Development Agency
SM-CRSP	Soil Management Collaborative Research Support Program
SMSS	Soil management support services
SODECOM	Corporate cotton parastatal organization
SR-CRSP	Small Ruminant Collaborative Research Support Program
SRI	Soils Research Institute
SRNET	African Small Ruminant Research Network
SRUPNA	Small Ruminant Network for Asia
TAD	Technology Adaptation and Development
TAES	Texas Agricultural Experiment Station
TAMU	Texas A&M University, College Station
TARS	Tropical Agriculture Research Station
TC	Technical Committee
Techpacks	Technological packages
TI	Tuskegee Institute
TLU	Training liaison unit
TropSoils	Soil Management Collaborative Research Support Program (SM-CRSP)
TSMM	Technology for Soil Moisture Management Program
TSBF	Tropical Soil Biology and Fertility Program
TSP	Texturized Soy Protein
TTU	Texas Tech University, Lubbock
UAPB	University of Arkansas, Pine Bluff
UCD	University of California, Davis
UCR-CIMAR	University of Costa Rica Centro de Investigaciones en Ciencias del Mar y Limnología
UDEL	University of Delaware
UG	University of Georgia
UH	University of Hawaii
UK	University of Kentucky
UMIAMI	University of Miami
UMC	University of Missouri-Columbia
UMCEES	University of Maryland Center for Environmental and Estuarine Studies
UMCP	University of Maryland-College Park
UMCP-CBM	University of Maryland College Park-College of Business and Management
UNDP	United Nations Development Programme
UN-L	University of Nebraska

UPLB	University of the Philippines at Los Banos
UPMSI	University of the Philippines Marine Sciences Institute
UPR	University of Puerto Rico
UPVCF	University of the Philippines in the Visayas College of Fisheries
URI	University of Rhode Island
USAID	United States Agency for International Development
USAID/W	United States Agency for International Development/Washington
USDA	United States Department of Agriculture
USDA/ARS	U.S. Department of Agriculture/Agricultural Research Station
USLE	Universal soil loss equation
USU	Utah State University, Logan
UW	University of Washington
UW-M	University of Wisconsin, Madison
WSARP	Western Sudan Agricultural Research Project
WASIP	West African Sorghum Improvement Program
WID	Women in international development
Winrock	Winrock International Institute for Agricultural Development, Morrilton, Arkansas
WSU	Washington State University, Pullman
YSA	Yield system analysis